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DAQP-061-21

July 27, 2021

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Dear Mr. Hartman and Mr. Wetzel,

The DAQ has received your four-factor analyses for the US Magnesium Rowley Power Plant prepared for the second planning period of Utah's Regional Haze State Implementation Plan. Enclosed is an engineering review of each analysis outlining some outstanding issues for you to be aware of. Please provide the DAQ with amendments or reasoning for these issues by **August 31st, 2021**. If you have any questions please contact John Jenks at jjenks@utah.gov or (385) 306-6510.

Sincerely,

Chelsea Cancino

Chelsea Cancino
Environmental Scientist

RNC:CC:GS:jf

Regional Haze – Second Planning Period
SIP Evaluation Report:

US Magnesium LLC - Rowley Plant

Utah Division of Air Quality

July 30, 2021

SIP EVALUATION REPORT

US Magnesium LLC - Rowley Plant

1.0 Introduction

The following is part of the Technical Support Documentation for the Second Planning Period of the Regional Haze SIP (aka the Visibility SIP). This document specifically serves as an evaluation of the US Magnesium LLC - Rowley Plant facility.

1.1 Facility Identification

Name: Rowley Plant
Address: 12819 North Skull Valley Road 15 Miles North Exit 77, I-80, Rowley, Utah
Owner/Operator: US Magnesium LLC
UTM coordinates: 4,530,490 m Northing, 354,141 m Easting, Zone 12

1.2 Facility Process Summary

US Magnesium LLC (USM) operates a primary magnesium production facility at its Rowley Plant, located in Tooele County, Utah. USM produces magnesium metal from the waters of the Great Salt Lake. Some of the water is evaporated in a system of solar evaporation ponds and the resulting brine solution is purified and dried to a powder in spray dryers. The powder is then melted and further purified in the melt reactor before going through an electrolytic process to separate magnesium metal from chlorine. The metal is then refined and/or alloyed and cast into molds. The chlorine from the melt reactor is combusted with natural gas in the chlorine reduction burner (CRB) and converted into hydrochloric acid (HCl). The HCl is removed from the gas stream through a scrubber train. The chlorine that is generated at the electrolytic cells is collected and piped to the chlorine plant where it is liquefied for reuse or sale.

USM Rowley Plant is a PSD source for CO, NO_X, PM10, PM2.5, and VOCs.

1.3 Facility Criteria Air Pollutant Emissions Sources

The source consists of the following emission units:

- Three (3) gas turbines/generators and duct/process burners (natural gas/fuel oil)
- Chlorine reduction burner (CRB), and associated equipment
- Riley Boiler, 60 MMBtu/hr (natural gas)
- Solar pond diesel engines, 30 engines rated between 90 and 420 hp
- Fire pump engine, one additional diesel engine rated at 292 hp

1.4 Facility Current Potential to Emit

The current PTE values for the Rowley Plant, as established by the most recent NSR permit issued to the source (DAQE-AN107160050-20) are as follows:

Table 2: Current Potential to Emit

Pollutant	Potential to Emit (Tons/Year)
SO2	24.10
NO_X	1,260.99

2.0 Four Factor Review Methodology

Each source reviewed in this second planning period submitted a report on the available control technologies for SO2 and NO_X emission reductions and the application of each technology to that facility. The information on available controls should consider the following four factors when analyzing the possible emission reductions:

1. Factor 1 – The Costs of Compliance
2. Factor 2 – Time Necessary for Compliance
3. Factor 3 – Energy and Non-Air Quality Environmental Impacts of Compliance
4. Factor 4 – Remaining Useful Life of the Source

Although not specifically required, the recommended approach was to follow a step-wise review of possible emission reduction options in a “top-down” fashion similar to U.S. EPA’s guidelines for review of BART or Best Available Retrofit Technology (as found in 40 CFR 51, Section 308 amendments, pub. July 5, 2005). The steps involved are as follows:

Step 1. Identify all available retrofit control technologies
Step 2. Eliminate technically infeasible control technologies
Step 3. Evaluate the control effectiveness of remaining control technologies
Step 4. Evaluate impacts and document results

The process is inherently similar to that used in selecting BACT (Best Available Control Technology) under the NSR/PSD (Title I) permitting program. DAQ evaluated the submissions from each source following the methodology outlined above. Where a particular submission may have differed from the recommended process, DAQ will make note, and provide additional information as necessary.

3.0 Analysis for SO2 Emission Reductions

USM has provided the following emissions information for SO2. The emissions represent actual emissions at their facility for the 2018 calendar year and are based on a combination of actual fuel use, stack testing, operational hours, or production rates. The Lithium Plant was permitted in 2020 and actual emissions are not yet available, for this reason potential to emit totals were included in the table below for this plant’s emissions instead of actuals.

Annual SO2 Baseline Actual Emission Rates (tons/yr)

Equipment	SO2 Baseline Emissions (tons/yr)
Turbines | Duct Burners	1.66
Chlorine Reduction Burner	0.07
Riley Boiler	0.14
Diesel Engines	0.03
HCl Plant	0.03
Cast House	7.29

Lithium Plant	0.75*
Other Sources	0.06
Mobile Sources	0.05
Total	10.08

*Lithium Plant emissions are listed as PTE emissions, as it was not in operation in 2018.

Due to the insignificant amount of sulfur dioxide emissions coming from USM, a decision was made in the fall of 2019 during a meeting with DAQ to omit sulfur dioxide from the upcoming BART analysis. Any reductions in SO2 would not result in any reasonable progress goals and would also likely be cost prohibitive given the minimal impacts of additional controls. No further discussion or analysis was performed for SO2.

DAQ agrees with this analysis as stated above. No further review of SO2 emissions is necessary.

4.0 Analysis for NO_X Emission Reductions

USM has provided the following emissions information for NO_X. The emissions represent actual emissions at their facility for the 2018 calendar year and are based on a combination of actual fuel use, stack testing, operational hours, or production rates. The Lithium Plant was permitted in 2020 and actual emissions are not yet available, for this reason potential to emit totals were included in the table below for this plant's emissions instead of actuals.

Annual NO_X Baseline Actual Emission Rates (tons/yr)

Equipment	NO_X Baseline Emissions (tons/yr)
Turbines | Duct Burners	813.58
Chlorine Reduction Burner	11.66
Riley Boiler	45.25
Diesel Engines	71.65
HCl Plant	4.32
Cast House	14.70
Lithium Plant	26.61*
Other Sources	0.02
Mobile Sources	73.01
Total	1,060.79

*Lithium Plant emissions are listed as PTE emissions, as it was not in operation in 2018.

The values listed above will be utilized in determining actual reductions to emissions because of any additional retrofit control technology. The same assumptions of operation that were employed to calculate annual emissions in 2018 will be employed to determine any reductions from add-on equipment because of the ensuing BART analysis.

All the NO_X generated at USM is a result of the fuel combustion process. Two primary formation mechanisms are responsible, thermal NO_X, when atmospheric nitrogen and oxygen disassociate in the combustion zone and form NO_X, or fuel NO_X when nitrogen present in the fuel interacts with atmospheric oxygen in the combustion zone. USM utilizes natural gas as a fuel source except during times of curtailment, natural gas and diesel have little to no nitrogen content resulting in the majority of NO_X formation being thermal in origin.

Control strategies for NO_X formation fall into one of two categories, combustion controls or post-combustion controls. Combustion control technologies focus on reducing the peak flame temperature and excess air in the combustion zone resulting in reduced NO_X formation. Post-combustion controls focus on reducing NO_X after it has formed in the exhaust stream – usually by utilizing a catalyst.

4.1 Turbines and Duct Burners

Step 1: Identify All Potentially Available Retrofit NO_X Control Technologies

The turbines at USM are utilized for electrical generation as an integrated part of the production process. The exhaust from the turbines is routed to a duct burner to increase the temperature before being routed to a spray dryer. The heated exhaust is used to dry the magnesium chloride slurry into a magnesium chloride powder. For the spray dryer to work properly the inlet temperature of the exhaust steam needs to reach 1,000 ^oF. The exhaust temperature from the turbines is 900 ^oF, and the duct burners boost the temperature to 1,000 ^oF.

The duct burners take the exhaust from the turbines and continue to heat it to the desired temperature. NO_X control strategies for this type of equipment does not exist, inlet temperatures and exit temperatures prohibit the use of combustion controls, and post combustion controls are similarly prohibitive, as exhaust temperatures need to reach 1,000 ^oF. The duct burners emissions are incorporated with the turbines emissions and were included here for completeness.

Common control technologies for reduction of NO_X emissions in natural gas turbines, identified by the EPA are: Water or Steam Injection, Dry Low-NO_X, Selective Catalytic Reduction (SCR).

Water or Steam Injection
Water and or steam injection is commonly termed wet control for gas turbines. Steam or water injection controls the formation of NO_X emissions by decreasing the peak flame temperature. It is an effective tool for reducing the formation of thermal NO_X in all but regenerative cycle combustors. Evaporation of the water reduces the cycle efficiency of a few percent but increases power output by double that reduction. This is caused by the steam formed or injected in the combustor raising the mass flow rate through the turbine therefore increasing power. NO_X emission reductions of generally 60-70% can be achieved using water or steam injection at water-to-fuel ratios of 0.2:1 to 1:1. It is important to utilize water or steam free of contaminants, so a water treatment system is an integral component of a wet control system.

Several mechanical limits exist when it comes to water or steam injection systems. Some examples of this are combustion operating instabilities, increased CO, heat rate penalties, combustion flame blow-off or flame-out. These limitations can decrease the efficiency of the water or steam injection system and increase the maintenance required on the turbine.

Dry Low-NO_X
NO_X emission control techniques that are performed without the injection of water or steam are referred to as dry controls, but the method for emissions reductions is the same, reducing the peak flame temperature. This is generally accomplished by lean combustion or staged combustion. Lean combustion refers to a technique that reduces the air/fuel ratio beyond that of normal stoichiometric operation (equivalence ratio = 1) to an air/fuel equivalence ratio of 2, i.e. very lean. This reduces the combustion temperature by reducing the air required for combustion below stoichiometric levels. This method is only achievable under normal load range, during periods of startup or low load a transition program with higher air/fuel ratios is required. This results in

increased NOx emissions during periods of startup or low load situations. Staged combustion is another technique to lower NOx emissions, this strategy utilizes multiple combustion zones, usually two. The first zone operates lean or rich, but the second zone always operates lean. The incomplete combustion that results in the first combustion zone is further combusted in the lean second combustion zone resulting in reduced NOx formation.

Selective Catalytic Reduction (SCR)
In the SCR process, ammonia is injected in the gas turbines exhaust gas stream reacting with NOx in the presence of a catalyst to form molecular nitrogen and water. SCR works best in base loaded combined cycle gas turbine applications where the turbine is fueled with natural gas. SCR is capable of NOx removal efficiencies between 70% and 90%. The catalytic NOx-ammonia reaction takes place over a limited temperature range, 600-750 ^{o}F, anything above ~850 ^{o}F and the catalyst is damaged irreversibly. Ammonia slip is also a concern when utilizing an SCR for NOx emission reductions, as well as ammonia storage, and costs of disposal of spent catalysts.

Step 2: Eliminate Technically Infeasible Options

To evaluate if the above NOx controls are technically feasible it is important to understand the role of the turbines at USM. The turbines are utilized for electrical generation and are integral to the production process. The exhaust coupled with a duct burner is used in a spray dryer to dry the magnesium chloride slurry into a magnesium chloride powder. For the spray dryer to work properly the exhaust temperature of turbines needs to reach 1,000 ^{o}F. This is achieved by utilizing an inline duct burner to boost the temperature from 900 ^{o}F to 1,000 ^{o}F. The magnesium chloride powder is then sent to the melt reactor for further processing.

Water or Steam Injection
This control technology given its strategy for reducing peak flame temperature is adding water to the combustion zone directly conflicts with the magnesium chloride powder production. Moisture in the exhaust stream will most definitely affect the ability of the spray dryers to operate as designed. This method is considered technically infeasible given the operational requirements of the spray dryers and will not be considered further.

Dry Low-NOx
Reducing peak flame temperatures and lowering the temperature of the exhaust gas would require a larger duct burner be installed. A larger duct burner would create just as much NOx as the reduction, possibly more. For this reason both the lean combustion and staged combustion methods are considered technically infeasible, as the operational requirements for the spray dryers would be negatively impacted to a point where they would conflict with the production of magnesium product, as a result this will not be considered further.

Selective Catalytic Reduction (SCR)
An SCR system requires a specific operating temperature to be effective at NOx removal, that temperature hovers around 750 ^{o}F. The duct burners take the exhaust from the turbines at roughly 900 ^{o}F and heat it to 1,000 ^{o}F. An SCR system is not technically feasible at these operating temperatures and will not be considered further in this analysis.

Step 3: Rank Remaining Control Technologies by Control Effectiveness

Step 3 of the review process is to rank the technically feasible options by how effective they are at removing NOx emissions. As no control technologies are technically feasible for the specific operations at USM, no ranking is possible.

Step 4: Evaluate Most Effective Controls and Document Conclusions

Step 4 of the review process is to evaluate the most effective controls and document conclusions; this is completed by considering the following:

- Cost of compliance
- Timing for compliance
- Energy and other impacts not related to air quality
- The remaining useful life of the source

As no remaining retrofit control technologies are technically feasible, analysis of the above list is not possible.

Summary and Conclusions
USM requires specific temperatures from their exhaust stream for their proper operation of the spray dryers, any changes to the turbine or duct burners would require significant alterations to the spray dryers. The turbines and duct burners, in 2018, emitted 813.58 tons of NOx emissions. Although this is a significant source of NOx emissions, no technically feasible retrofit technologies were found during the BART analysis. USM will continue to operate the turbines and duct burners as they are currently configured.

4.2 Chlorine Reduction Burner

Step 1: Identify All Potentially Available Retrofit NOx Control Technologies

USM operates the only primary magnesium metal production facility in the United States. As such it is the only facility that operates a chlorine reduction burner (CRB) in the United States. The CRB is a control device for chlorine gas emissions. It is designed to take the chlorine gas that is generated in the melt reactor process and as tail-gas from the chlorine (purification) plant, and in the presence of heat and methane, produce CO2 and hydrochloric acid (HCl). The HCl is scrubbed and recovered as hydrochloric acid liquid prior to the exhaust stream being further scrubbed and then vented to the atmosphere.

Combustion techniques that lower the formation of thermal NOx by lowering the peak flame temperature are not a viable option for control as they would impact the CRB's main function of reducing the chlorine emissions that are emitted to the atmosphere. The CRB requires an operating temperature of no less than 1,650 ºF and no more than 2,000 ºF for proper operation and has strict monitoring requirements listed in their Title V operating permit. Post-combustion techniques involving a catalyst would foul the packed scrubbers that remove the HCl acid from the exhaust stream, which could violate the emission requirements found in 40 CFR 63 Subpart TTTTT.

Given the unique operating parameters involved in the CRB no control technologies exist for the reduction of NOx emissions. Therefore, no additional analysis was performed for the CRB.

Step 2: Eliminate Technically Infeasible Options

No NOx emission reduction retrofit controls are available for the CRB.

Step 3: Rank Remaining Control Technologies by Control Effectiveness

Step 3 of the review process is to rank the technically feasible options by how effective they are at removing NOX emissions. As no control technologies are technically feasible for the specific operations at USM, no ranking is possible.

Step 4: Evaluate Most Effective Controls and Document Conclusions

Step 4 of the review process is to evaluate the most effective controls and document conclusions; this is completed by considering the following:

- Cost of compliance
- Timing for compliance
- Energy and other impacts not related to air quality
- The remaining useful life of the source

As no remaining retrofit control technologies are technically feasible, analysis of the above list is not possible.

Summary and Conclusions
The CRB at USM is required to maintain an operating temperature of 1,650 to 2,000 ^{o}F, and as such combustion controls are not a viable option for controlling the formation of thermal NOx. Post-combustion controls are similarly disadvantageous, and the exhaust stream from the CRB passes through an absorber to recover HCL as hydrochloric acid liquid and then several packed bed scrubbers to remove PM. The addition of any catalyst to remove NOx emissions could interfere with the scrubber's operation and result in emissions that violate the emissions standards that are listed in the applicable MACT, Subpart TTTTT. The CRB at USM currently emits 11.66 tons of NOx annually. USM will continue to operate the CRB as it is currently configured.

4.3 Riley Boiler

Step 1: Identify All Potentially Available Retrofit NOx Control Technologies

USM utilizes a 60 MMBtu/hr boiler, referred to as the Riley boiler that was first installed prior to the plant beginning operation in 1972. The boiler utilizes natural gas as a combustion source and provides heat throughout the plant via the production of steam. The boiler is located in the middle of their facility, nestled between scrubbers, spray dryers, and various other equipment. Common NOx control strategies for a natural gas boiler are listed below:

Combustion Controls:
Flue Gas Recirculation (FGR)
Low NOx Burners
Ultra-Low NOx Burners

Post-Combustion Controls:
Selective Catalytic Reduction (SCR)
Selective Non-Catalytic Reduction (SNCR)

The RBLC of the EPA Clean Air Technology Center as well as EPA's, "Nitrogen Oxides (NOx), Why and How They are Controlled" were utilized in determining control technologies for evaluation.

Flue Gas Recirculation (FGR)
Flue gas recirculation consists of recirculating a portion of the flue gas to the combustion zone to lower the peak flame temperature and lowers the percentage of oxygen in the combustion zone, thereby reducing thermal NOx formation. FGR is one of the main NOx reduction strategies for low NOx and ultra-low NOx burners. Standalone FGR systems can achieve up to 50% NOx reductions.

Low NOx burners (LNB)
LNB reduce the formation of thermal NOx by utilizing multiple technologies coupled with staged combustion. Many variations of a low NOx burner exist, almost all of them utilizing staged combustion for controlling fuel to air ratios to limit the peak flame temperature. Controlling fuel and air mixing at the burner creates larger and more branching flames, making LNB have a larger footprint than a standard boiler like the one installed at USM. LNB can reduce NOx emissions by up to 80% from a standard combustion unit and are considered common place and often the starting point of new boiler installations.

Ultra-Low NOx burners (ULNB)
ULNB improve upon the design of a low NOx burner usually by lowering combustion temperatures even more by modifying the burners further. The lower temperatures require larger volumes of fuel as the combustion process is not complete, this also increases CO emissions while reducing NOx emissions. Depending on the provider of the ultra-low unit, technology varies but they are generally capable of meeting NOx emission limits of 9 ppm.

Post-Combustion Controls
Selective Catalytic Reduction (SCR)
In the SCR process, ammonia is injected into the exhaust stream reacting with NOx in the presence of a catalyst to form molecular nitrogen and water. SCR works best in stable conditions, units that fluctuate in operation and therefore temperature do not achieve optimal NOx reduction rates. SCR is capable of NOx removal efficiencies between 80% and 90%8. The catalytic NOx-ammonia reaction takes place over a limited temperature range, 600-750 ^{o}F, anything about ~850 ^{o}F and the catalyst is damaged irreversibly. Ammonia slip is also a concern when utilizing an SCR for NOx emission reductions, as well as ammonia storage, and costs of disposal of spent catalysts.

Selective Non-Catalytic Reduction (SNCR)
SNCR is a similar process to SCR in that it utilizes ammonia as a reductant to reduce NOx compounds to molecular N2 and water, however the technology does not utilize a catalyst. The ammonia in injected directly into the primary combustion zone where temperatures reach 1,400-2,000 ^{o}F. NOx reduction in SNCR is only effective at high temperatures (1,600-2,100 ^{o}F), so additional heating of the emissions stream may be required to meet optimal operating temperatures. SNCR NOx removal efficiencies vary between 30% and 50%.

Step 2: Eliminate Technically Infeasible Options

Flue Gas Recirculation (FGR)
FGR increases the maintenance required and can result in fouled air intake systems, combustion chamber deposits, and increased wear rates, but it is technically feasible as a retrofit option.

Low NOx Burners (LNB)
To convert the standard burners currently installed in the Riley boiler to LNB would require substantial modifications and would not really fit the definition of a retrofit. The additional space requirement due to the staged combustion a low NOx unit requires would be challenging to fit into the existing space. This would require modifications to other systems to accommodate the additional size, and as a result has been ruled out as a technically feasible option. LNB have been ruled out as a retrofit option and not evaluated further.

Ultra-Low NOX Burners (ULNB)
An ULNB was similarly ruled out as technically feasible as a retrofit option as it would require a near complete replacement of the existing boiler. Additionally, the space requirements would require the same modifications as installing LNB. The ULNB have been ruled out as a retrofit option and were not evaluated further.

Selective Catalytic Reduction (SCR)
An SCR system is an effective way at reducing NOx formation in a stationary combustion unit like the boiler utilized at USM. They do present additional safety concerns with the use of ammonia and ammonia storage. An SCR system is considered a technically feasible retrofit option for the boiler.

Selective Non-Catalytic Reduction (SNCR)
This boiler at USM was built in the 1970's and has had general maintenance and replacement of some of the burner units and housing as it has aged but is largely unchanged. The required operating temperatures for an SNCR system to work properly (1,600 – 2,000 ^{o}F) are not within the boilers operating range. As a result, a SNCR system has been ruled out as a retrofit option for the Riley boiler, and was not evaluated further.

Step 3: Rank Remaining Control Technologies by Control Effectiveness

Step 3 is the ranking of the remaining commonly available retrofit control technologies by control effectiveness.

Selective Catalytic Reduction (SCR): Up to 90%
Flue Gas Recirculation (FGR): Up to 50%

Step 4: Evaluate Most Effective Controls and Document Conclusions

Step 4 of the review process is to evaluate the most effective controls and document conclusions; this is completed by considering the following:

- Cost of compliance
- Timing for compliance
- Energy and other impacts not related to air quality
- The remaining useful life of the source

Cost of Compliance
The Riley boiler operating at USM was installed in 1972 and has no add-on equipment. The cost analysis below is based on the baseline emissions calculated using AP-42 and a full-time operating schedule, generating 45.25 tons of NOx annually.

Selective Catalytic Reduction (SCR)
Evaluating the costs for an SCR unit on an existing boiler of this small size is challenging. The EPA's Air Pollution Control Cost Estimation Spreadsheet for Selective Catalytic Reduction (SCR) was used to estimate the costs of retrofitting the boiler; the cost values are based on the 2018 annual average Chemical Engineering Plant Cost Index (CEPCI) value of 603.1. The detailed inputs and outputs of the EPA cost estimation tool can be found in Appendix A of USM's submission. The cost effectiveness based on 2018 dollars is $9,726/ton of NOx removed. The costs associated with installing an SCR system on a boiler of this age would be not be considered economically feasible. As a result, the use of an SCR system for NOx control has been ruled out as a viable retrofit option for NOx control.

The costs associated with installing an SCR system on a boiler of this age would not be considered economically feasible. As a result, the use of an SCR system for NOx control has been ruled out as a viable retrofit option for NOx control.

Flue Gas Recirculation (FGR)
The cost analysis for a FGR system on an existing boiler needs to be done by specific vendors and engineered for the specific boiler, especially for older units like the one at USM's facility. However, general cost guidelines can be used to estimate the costs for an appropriate FGR system. A general cost for an FGR system is somewhere in the range of $8-35/kW, in specific cases some can be as low as $3/kW.10 This would put the cost range of an addon FGR for the 60 MMBtu/hr Riley boiler somewhere between $52,740 and $615,300. It is important to note that these cost estimates were from EPA studies done in the 1990's, and as such the cost per ton removed analysis was performed using the high end of the range, $615,300.

Assuming a 50% NOx emissions control efficiency from a FGR system, a reduction of 22.6 tons of NOx annually would result from the installation. Based on the factored cost estimate evaluated, an FGR system may be reasonable given the amount of NOx control achieved, and the estimated cost per ton removed of $2,708.

Timing for Compliance
Although additional evaluation will be necessary, installation of an FGR system on the Riley boiler may be feasible before the end of 2028, the end of the second long-term strategy for regional haze.

Energy and Other Impact Not Related to Air Quality
The biggest concern related to the installation of a FGR system would be the increase in CO that is associated with the decrease in burner efficiency because of incomplete combustion. No other negative impacts are related to energy or other environmental issues.

Remaining Useful Life of the Source
The boiler has been well maintained and parts have been replaced over the years. It is reasonable to assume that the boiler will continue to operate for the foreseeable future. Given that the boiler was built and installed in 1972, it is approximately 48 years old, the remaining useful life is speculative, but given proper maintenance and replacement of worn out parts of the boiler its anticipated the boiler will last another 10 to 20 years.

Summary and Conclusions
USM has determined that a potentially viable retrofit control technology for NOx control of the Riley boiler is the installation of an FGR system. The system would reduce NOx emissions by approximately 22.6 tons, with an estimated cost per ton removed of $2,708. Although additional

evaluation will be necessary, USM incorporating this control strategy into the Riley boilers current layout may be feasible before the end of 2028.

4.4 Diesel Engines
Step 1: Identify All Potentially Available Retrofit NOX Control Technologies

The diesel engines used onsite at USM are mostly comprised of modified Caterpillar engines that run direct drive water pumps for movement of fluids from one evaporation cell to another through various channels and trenches. The diesel engines are the second largest point source category for NOx emissions, this is due to the number of engines, 31, that are utilized onsite. Of these 31 engines, one is a 292 hp fire pump engine that charges their fire suppression system under emergency conditions (e.g., a plant fire during a power outage). Control technologies for that engine have not been analyzed as part of this analysis, as it is an emergency fire water pump engine that has very minimal run times. The remaining 30 engines are all equipped with aftermarket catalytic oxidizers to comply with the emission standards listed in 40 CFR 63 Subpart ZZZZ.

Although the engines utilized at USM facility consist of different sized motors, the control technologies for NOx are similar. The following control technologies applicability to the engines was evaluated regardless of engine size, as the only difference will be evaluated in Step 4 when looking at the implementation costs. Common control technologies for reduction of NOx emissions in diesel engines have been identified by EPA's Control Techniques Guidelines and manufacturers, and are listed below:

Combustion Controls: Exhaust Gas Recirculation (EGR)
Post-Combustion Controls: Selective Catalytic Reduction (SCR), Lean NOx Catalysts

Exhaust Gas Recirculation (EGR)
Utilizing EGR is an effective method for reducing NOx emissions from a diesel engine. Low-pressure and high-pressure EGR systems exist but for retrofitting purposes a low-pressure system is almost always utilized as it does not require extensive engine modifications. EGR recirculates a portion of the engine's exhaust back to the intake manifold, in most cases an intercooler lowers the temperature of the recirculated gases. The cooled recirculated gases, which have a higher heat capacity than air and contain less oxygen than air, lower the combustion temperature of the engine, resulting in less thermal NOx forming. Diesel particulate filters are required when utilizing a low-pressure EGR system to ensure that large amounts of particulates are not recirculated to the engine. An EGR system can reduce NOx emissions, by lowering the combustion temperature of the engine, by up to 40%.

Selective Catalytic Reduction (SCR)
SCR is an established method for controlling NOx emissions from stationary sources. A SCR system uses a catalyst and a chemical reductant to convert NOx emissions to molecular nitrogen and oxygen in oxygen-rich exhaust streams common to diesel engines. The chemical reductant of choice is generally ammonia and it is injected based on the amount of NOx present in the exhaust stream that is calculated via algorithm. As the exhaust air and the ammonia pass over the SCR catalyst, a chemical reaction occurs that reduces NOx emissions to nitrogen and oxygen. SCR systems on stationary sources can control 95% of NOx emissions.

Lean NOx Catalysts

Diesel engines are designed to run lean, which makes controlling NOx emissions challenging. Reducing NOx to molecular nitrogen in the oxygen-rich diesel exhaust environment requires a reductant (typically a hydrocarbon or carbon moNOxide) and under normal operating conditions reductants are generally not present. Lean NOx catalyst systems typically inject a small amount of diesel fuel or other reductant into the exhaust upstream of the catalyst. The reductant serves as the reducing agent for the catalytic conversion of NOx to N2. Some systems operate passively without added reductant reduced NOx conversion rates. A lean NOx catalyst consists of a porous material with a highly ordered channel structure, along with either a precious metal or base metal catalyst. The added fuel and the catalyst are capable of peak NOx control efficiencies ranging from 10 to 30 percent, which the higher control percent correlating to increased fuel injection rates.

Step 2: Eliminate Technically Infeasible Options

Exhaust Gas Recirculation (EGR)
Although EGR increases engine maintenance and can result in fouled air intake systems, combustion chamber deposits, and increased engine wear rates, it is technically feasible as a retrofit option.

Selective Catalytic Reduction (SCR)
SCR systems are an effective way at reducing NOx formation, they do present additional safety concerns with the use of ammonia or urea, and ammonia or urea storage. Additionally, the physical footprint of the SCR which can range from 50% to 60% the size of the engine is a real concern. It would likely mean extensive modifications to some of the existing pump stations to accommodate their size. However, given these concerns they remain a technically feasible retrofit option.

Lean NOx Catalysts
Lean NOx Catalysts are a relatively new addition to controlling NOx emissions. Although in theory they do appear to be technically feasible an extensive search through the RBL Clearinghouse and California's CARB database we were unable to find any stationary engines that utilized this control equipment. Therefore, this will not be considered a technically feasible control option for the diesel engines and will not be evaluated further.

Step 3: Rank Remaining Control Technologies by Control Effectiveness

Step 3 is the ranking of the remaining commonly available retrofit control technologies by control effectiveness.

Selective Catalytic Reduction (SCR): Up to 95%
Exhaust Gas Recirculation (EGR): Up to 40%

Step 4: Evaluate Most Effective Controls and Document Conclusions

Step 4 of the review process is to evaluate the most effective controls and document conclusions; this is completed by considering the following:

- Cost of compliance
- Timing for compliance
- Energy and other impacts not related to air quality
- The remaining useful life of the source

Cost of Compliance
Currently USM has installed catalytic oxidizers on all the diesel engines to meet the requirements in 40 CFR 63 Subpart ZZZZ, these controls are cost-effective. All additional costs calculation and cost evaluations are considered in addition to the currently controlled emission levels.

Selective Catalytic Reduction Cost Effectiveness
To simplify the costs associated with the SCR systems, the engines are treated as identical units, although this is a slight oversimplification the engines do fall within a similar size rating. Also the efficiency of an SCR system drops off the smaller the engine rating due to mixing in the exhaust stream, so although the SCR system may be slightly over priced for the smaller engines the increased urea consumption will make up for the bias.

The pumping stations where the engines are housed consist of platforms built over water canals at over one dozen different remote locations within the overall approximately 75,000 acre solar pond system. As ammonia presented too many safety concerns to be considered a viable option, the following cost analysis will look only at the use of urea as the chemical reagent.

An SCR system equipped with a 4,000-gallon urea storage tank fitted with a heating system to prevent urea freezing was analyzed. The costs provided in Table 5-10 below are estimates by Caterpillar based on systems they have in place for other engines of a similar size.

Continuing with the simplified model if each of the 30 engines play an equal role in 71.65 tons of NOx emitted annually from the diesel engines on site, then each engine would emit 2.39 tons. This leads to a cost effectiveness of $14,146/ton of NOx removed. The costs associated with the SCR exceed that which would be considered economically feasible. As a result, the use of SCR systems for NOx control has been ruled out as a viable retrofit option for NOx control.

Exhaust Gas Recirculation Cost Effectiveness
The estimated cost for a low-pressure exhaust gas recirculation system including a diesel particulate filter is somewhere in the range of $18,000 to $20,000. A detailed cost breakdown was not performed for an EGR system, the simple cost of the unit alone coupled with the increased ware on the engines regardless of maintenance makes these units not economical. The emissions reductions from this unit cannot make up the costs to purchase the units, not even considering the costs to install or maintain the engines once installed. The EGR units have been ruled out as a viable option for NOx control.

Timing for Compliance
USM believes that reasonable progress compliant controls are already in place, and any additional controls are unnecessary. However, if UDAQ determines that one of the control methods analyzed in this report is required to achieve reasonable progress, it is anticipated that this change would be implemented during the period of the second long-term strategy for regional haze (approximately ten years following the reasonable progress determination for this second planning period).

Energy and Other Impact Not Related to Air Quality
The biggest concern related to NOx control that lies outside of air quality impacts would be that of ammonia storage. Ammonia is a caustic substance that is harmful to organic life, storing large quantities of it has the potential safety issues for personnel and for spills that can cause adverse environmental and health impacts. The associated ammonia slip can also increase condensable PM2.5 which contributes directly to visibility impairments.

Remaining Useful Life of the Source
The engines remaining life varies, but with proper maintenance and overhaul the engines are expected to last at least an additional 20 years, a similar lifetime to that of the control equipment being considered in this analysis.

Summary and Conclusions
USM has determined that the available retrofit control technologies are too costly for consideration of use at their facility. The diesel engines will continue to emit roughly 71.65 tons of NOx annually. USM will continue to operate the diesel engines as they are currently configured.

4.5 Hydrochloric Acid Plant

Step 1: Identify All Potentially Available Retrofit NOx Control Technologies

USM produces a pure food grade hydrochloric acid (HCl) at their acid plant. The concentration of HCl is roughly ~36% and is generated in a similar fashion to how the chlorine reduction burner works, by combusting natural gas in the presence of purified chlorine gas. The chemical reaction below demonstrates HCl formation using the combustion process.

$$CH_4 + O_2 + 2Cl_2 \rightarrow CO_2 + 4HCl$$

The average annual usage for the HCl plant is assumed to be 4,380 hours annually, exactly half of the calendar year. The HCl plant operates only when USM has suppliers in need of food grade HCl. To date in 2020, the HCl plant has not been utilized onsite, but is anticipated to resume production in the fall of 2020.

NOx emissions associated with the HCl plant are generated through natural gas combustion in the burner. The unit is rated for less than 10 MMBtu/hr and generated 4.32 tons in 2018. Potentially available retrofit controls for the combustion unit are the same controls typically available to other natural gas combustion units.

Combustion Controls: Water or Steam Injection, Dry Low-NOx
Post-Combustion Controls: Selective Catalytic Reduction (SCR)

Water or Steam Injection
Steam or water injection controls the formation of NOx emissions by decreasing the peak flame temperature. It is an effective tool for reducing the formation of thermal NOx in all but regenerative cycle combustors. NOx emission reductions of generally 60-70% can be achieved using water or steam injection at water-to-fuel ratios of 0.2:1 to 1:1. It is important to utilize water or steam free of contaminants, so a water treatment system is an integral component of a wet control system. Several mechanical limits exist when it comes to water or steam injection systems, things like combustion operating instabilities, increased CO, heat rate penalties, combustion flame blow-off or flame-out. These limitations can decrease the efficiency of the water or steam injection system and increase the maintenance required.

Dry Low-NOx
NOx emission control techniques that are performed without the injection of water or steam are referred to as dry controls, but the method for emissions reductions is the same, reducing the peak flame temperature. This is generally accomplished by lean combustion or staged combustion. Lean

combustion refers to a technique that reduces the air/fuel ratio beyond that of normal stoichiometric operation (equivalence ratio = 1) to an air/fuel equivalence ratio of 2, i.e. very lean.

This reduces the combustion temperature by reducing the air required for combustion below stoichiometric levels. This method is only achievable under normal load range, during periods of startup or low load a transition program with higher air/fuel ratios is required. This results in increased NOx emissions during periods of startup or low load situations.

Staged combustion is another technique to lower NOx emissions, this strategy utilizes multiple combustion zones, usually two. The first zone operates lean or rich, but the second zone always operates lean. The incomplete combustion that results in the first combustions zone is further combusted in the lean second combustion zone resulting in reduced NOx formation.

Selective Catalytic Reduction (SCR)
In the SCR process, ammonia or urea is injected in the exhaust gas stream reacting with NOx in the presence of a catalyst to form molecular nitrogen and water. A SCR system can achieve a 95% reduction of NOx emissions.

The catalytic NOx-ammonia reaction takes place over a limited temperature range, 600-750 ºF, anything about ~850 ºF and the catalyst is damaged irreversibly. Ammonia slip is also a concern when utilizing an SCR for NOx emission reductions, as well as ammonia or urea storage, and costs of disposal of spent catalysts can also be a concern.

Step 2: Eliminate Technically Infeasible Options

The combustion unit at the HCl plant is the primary generator of the HCl product, as a result the plants operation must be taken into consideration when talking about NOx controls for the combustion unit.

Combustion Controls
Both water or steam injection and dry low-NOx combustion controls are technically infeasible for the HCl plant. Both controls reduce the formation of thermal NOx by reducing peak flame temperatures, this reduction in peak flame temperature would alter the performance of the HCl plant and as a result neither option will not be evaluated further.

Selective Catalytic Reduction (SCR)
Although a SCR system is a feasible option, retrofitting the HCl plant sizing, installation space, and operating the unit would be so challenging it is not technically feasible. The RBLC lists a facility in Louisiana that has installed an SCR unit onto a HCl plant, but provided no cost verification, and listed the emission type as LAER, which exceeds the requirements of this BART analysis many times over.

Sizing the SCR unit is challenging because the burner rate is not static, and the run times can be quite short. USM only operates the HCl plant when they have a supplier in need of the product. Depending on the economy and availability this can be quite infrequent. The minimal operating schedule would also make operating the unit a challenge. Historically there have been operation times that vary from half a day to several weeks. Downtime of the plant can be up to 8 months or more, requiring additional maintenance to get the unit operational upon startup.

The installation space required for an SCR unit is not extremely large, however, the exhaust stack on the HCl plant sits inside the racking and piping for the plant itself, and although it is probably feasible it would be a challenging retrofit.

For the reasons listed above this control technology is not considered technically feasible as a retrofit option for the hydrochloric acid plant and was not evaluated further.

Step 3: Rank Remaining Control Technologies by Control Effectiveness
Step 3 of the review process is to rank the technically feasible options by how effective they are at removing NOx emissions. As no control technologies are technically feasible for the specific operations at USM, no ranking is possible.

Step 4: Evaluate Most Effective Controls and Document Conclusions

Step 4 of the review process is to evaluate the most effective controls and document conclusions; this is completed by considering the following:

- Cost of compliance
- Timing for compliance
- Energy and other impacts not related to air quality
- The remaining useful life of the source

As no remaining retrofit control technologies are technically feasible analysis of the above list is not possible.

Summary and Conclusions
The HCl plant at USM operates infrequently and has a minimal impact on the overall NOx emissions associated with the plant. In 2018, the HCl plant was responsible for 4.32 tons of NOx. No retrofit control options were technically feasible for the operations at USM. USM will continue to operate the HCl plant as it currently configured on an as needed basis.

4.6 Casting House

Step 1: Identify All Potentially Available Retrofit NOx Control Technologies

The cast house at USM operates eleven natural gas fired crucible furnaces. Each crucible furnace is equipped with six 1 MMBtu/hr burners, three in an upper horizontal angled array and three in a lower horizontal angled array, for a total heating rating of 6 MMBtu/hr per crucible furnace, for a total of 66 burners. After an extensive search of the RBLC database only two entries were found for crucible furnaces, both employing smaller burners in numerous quantities like operations at USM. Both the entries in the RBLC utilized AP-42 emission factors and operated with no emission controls. Given the smaller size of these natural gas burners, and their array and installation it is unlikely that any control technologies exist, it is even less likely that a retrofit control technology would exist. No additional analysis was performed for the burners associated with the crucible furnaces USM operates.

The cast house also utilizes tool heating boxes, they are top and open-faced boxes with four small bayonet style burners, these burners typically range from 0.1 to 0.25 MMBtu/hr. The tool heating boxes sole purpose is safety. The tools used in USM casting house are heated up to remove any potential for water vapor or condensation forming on the metal when it contacts the heated magnesium metal. Water and magnesium can result in the formation of hydrogen gas, which is very explosive. These tool heating boxes are an integral part of the process and perform mandatory safety tasks. Given their low burner rating no retrofit controls exist that would still allow the heating boxes to function as needed. No additional analysis was performed for the tool heating boxes at USM.

Step 2: Eliminate Technically Infeasible Options

No retrofit controls were identified for the 1 MMBtu/hr burners utilized in the casting house at USM. Similarly, no retrofit controls were identified for the tool heating boxes that utilize 0.1 to 0.25 MMBtu/hr burners.

Step 3: Rank Remaining Control Technologies by Control Effectiveness

Step 3 of the review process is to rank the technically feasible options by how effective they are at removing NOx emissions. As no control technologies are technically feasible for the specific operations at USM, no ranking is possible.

Step 4: Evaluate Most Effective Controls and Document Conclusions

Step 4 of the review process is to evaluate the most effective controls and document conclusions; this is completed by considering the following:

- Cost of compliance
- Timing for compliance
- Energy and other impacts not related to air quality
- The remaining useful life of the source

As no remaining retrofit control technologies are technically feasible analysis of the above list is not possible.

Summary and Conclusions
USM operates eleven crucible furnaces for the purposes of maintaining magnesium metal in a molten state and casting that molten magnesium into ingots. Each furnace utilizes six smaller burners rated at 1 MMBtu/hr each. Additionally, there are multiple tool heating racks placed strategically around the casting house that are used to heat tools that will be in contact with heated magnesium ore. The combination of these burner units combusting natural gas emit 14.70 tons of NOx emission annually. Given that there is a total of ~80 burners in the casting house, each contributing a minimal amount of NOx emissions. Controls for these small combustion devices are not readily available, and none were found during the BART analysis. USM will continue to operate the casting house as it is currently configured.

4.7 Lithium Plant

USM has recently constructed the lithium plant, which finished the permitting process on April 20, 2020. The lithium plant digests existing waste coupled with current waste streams to extract the available lithium ore. The NOX emissions from the plant come from natural gas combustion units. The plant consists of two boilers, a 63 and an 84 MMBtu/hr; and two evaporative burners, a 50 and a 100 MMBtu/hr. The analysis for the lithium plant was broken into two sections, a natural gas fired boiler section and an evaporative burner section.

Natural Gas Fired Boilers
The natural gas fired boilers were installed in early 2020 and went through a BACT analysis earlier this year. They are ultra-low-NOx units capable of meeting a concentration limit of 9 ppm NOx or less. As BACT is more inclusive than BART performing a BART analysis on these boilers would be redundant and would yield no results. No additional analysis was performed on the 62 MMBtu/hr or 84 MMBtu/hr natural gas fired boilers installed in 2020, however the NOx BACT analysis that was completed for USM's AO was included as additional information.

Evaporative Burners
The natural gas fired evaporative burners were similarly installed in early 2020 and went through a BACT analysis earlier this year. They are low-NOx units capable of meeting a concentration limit of 30 ppm NOx or less19. As BACT is more inclusive than BART performing a BART analysis on these evaporative burners would be redundant and would yield no results. No additional analysis was performed on the 50 MMBtu/hr or 100 MMBtu/hr evaporative burners installed in 2020. As with the natural gas fired boilers, the BACT analysis from USM's AO was included as additional information.

4.8 Conclusion

This outlines USM's evaluation of possible retrofit options for all NOx emitting units onsite at their Rowley Plant located in Tooele County, Utah, in an attempt at reducing their NOx emissions facility wide and reducing their impact on visibility impairment issues. The results of this report found that it is potentially technologically and economically feasible to install a flue gas recirculation unit on the Riley boiler, reducing their NOx emissions by an estimated 22.6 tons annually. Aside from this change, there were currently no other technically or economically feasible options available for USM's Rowley Plant. Pending further technological and cost refinement, the implementation schedule for the installation of the FGR unit may be installed prior to the end of 2028. Therefore, the emissions for the 2028 modeling scenario could be an estimated 22.6 tons less than the 2018 baseline year NOx emissions.

5.0 DAQ Conclusion

Several errors were made during the analysis of the various control options outlined in this document. While the errors ultimately do not change the outcome or results of the analysis, they should be corrected prior to final acceptance by DAQ. The following lists the errors noticed by DAQ and the resulting effect each error leads to in the final result:

Incorrect interest rate used for control cost calculation – rather than using the current bank prime rate of 3.25%, the source calculated all control costs with either an interest rate of 7% (used as the default in the control cost manual) or 5.5% (used as the default in the SCR control cost spreadsheet). Both calculations result in a higher control cost in $/ton.

Second, the source used only a 20-year expected life for application of an SCR, which is lower than the standard 30-year lifespan. Again, this would artificially inflate the control cost by increasing the annualized cost.

However, the overall cost of the SCR system as estimated by the source was lower than expected, with an initial cost of just $87,000. The low initial cost serves to lower the resulting control cost.

DAQ reanalyzed the use of SCR on the Riley Boiler under two different scenarios. Under PTE, assuming full load, the application of SCR might be expected to remove as much as 188 tons of NOx at a control cost of $4,073/ton of NOx removed – assuming the same 90% removal efficiency as did the source. However, the Riley Boiler did not operate at that high an output level – reporting just 45.25 tons of actual emissions in 2018. Adjusting the emission reduction for 90% of the actual emissions gives a removal of 40.7 tons of NOx (as opposed to the 38 tons suggested by the source), at a control cost of $18,800/ton of NOx removed.

Similar errors were made with respect to the FGR calculations on the Riley Boiler. The incorrect interest rate was used – 7% vs 3.25%. FGR systems typically have a potential lifespan of 15 years rather than the 20 years suggested by the source. DAQ recalculated the control costs correcting for these errors and obtained a modified value of 22.5 tons of NOx removed at a control cost of $1,880/ton of NOx removed.

None of the other equipment requires additional evaluation, as each is currently well controlled. While the same types of errors were made in the source's analysis, the resulting outcomes and conclusions remain unchanged.

DAQ recommends that FGR be considered for retrofit control application on the Riley boiler. Should the source increase utilization of the Riley boiler, then the application of SCR should be considered.