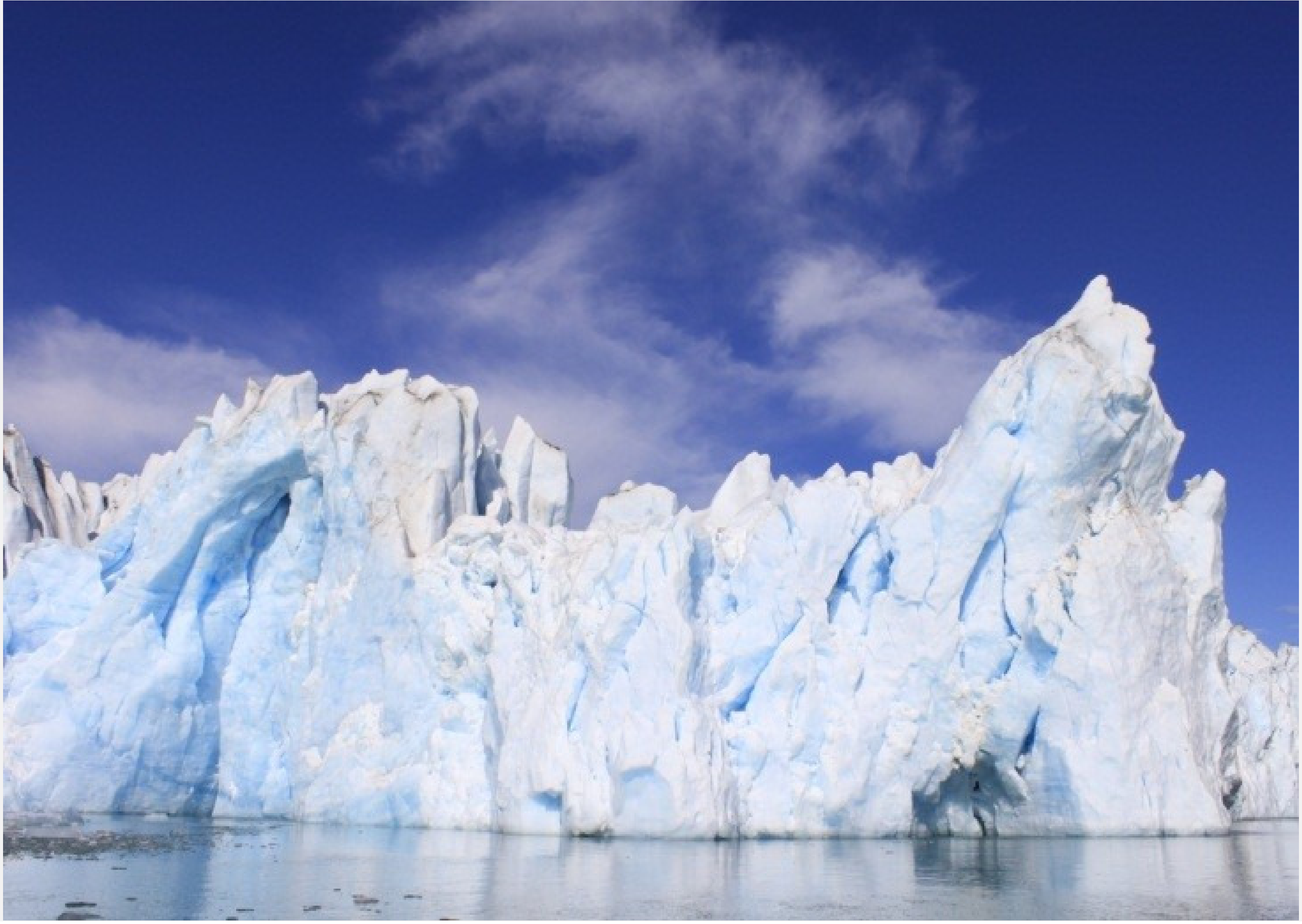

Agrium Kenai, Alaska

Primary Reformer BACT Analysis Update

Kenai Nitrogen Operation

5 August 2019

Project No.: 0497868

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Primary Reformer BACT Analysis Update

Kenai Nitrogen Operation

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CONTENTS

1. BEST AVAILABLE CONTROL TECHNOLOGY (BACT) BACKGROUND

1.1 Introduction

Agrium U.S. Inc. (Agrium) was issued Air Quality Control Construction Permit AQ0083CPT06 on 6 January 2015 for the proposed restart of a portion of it fertilizer production facility (Facility) at the Kenai Nitrogen Operation in Kenai, Alaska. In a letter dated 4 March 2016, the Alaska Department of Environmental Conservation (ADEC) extended the deadline by which construction must commence by eighteen (18) months until 6 January 2018. In a second letter dated 3 October 2017, the ADEC extended the deadline by which construction must commence by an additional eighteen (18) months until 6 July 2019.

Since the issuance of the ADEC letter dated 3 October 2017, Agrium has decided to replace the five (5) existing 37.6 MMBtu/hr Solar Turbines identified as Units 55, 56, 57, 58, and 59. The replacement Solar Turbines will each have a maximum rated heat input capacity of 55.443 MMBtu/hr. The new Solar Turbines will utilize the existing Waste Heat Boilers (Units 50, 51, 52, 53, and 54) for heat recovery. Due to the increase in heat input capacities of the new Solar Turbines, the required supplemental heat input capacity of the 50.0 MMBtu/hr Waste Heat Boilers have decreased. The Waste Heat Boilers once integrated with the new Solar Turbines, will now only have heat input capacities of 46.729 MMBtu/hr, each. Since the heat input capacities of the Waste Heat Boilers are changing, as are the potential emissions, Agrium is providing updated top-down Best Available Control Technology (BACT) analyses for these affected units, in addition to the top-down BACT analyses for the new Solar Turbines.

In addition, Agrium is proposing to install Selective Catalytic Reduction (SCR) for Nitrogen Oxides (NOx) control on the Package Boilers (Units 44, 48, and 49). These emission units went through Prevention of Significant Deterioration (PSD) BACT as part of the permitting for AQ0083CPT06. Under the Air Quality Control Construction Permit, BACT for NOx was identified as use of ultra low NOx burners. SCR is considered to provide the same, if not a higher, control efficiency than the use of ultra low NOx burners.

The BACT reviews for the affected units identified above at the Facility i were included as Attachment C to the 2019 PSD permit application.

In an email dated 26 July 2019, Mr. Dave Jones, Environmental Engineering Assistant I, ADEC – Air Quality – Juneau, requested an updated BACT for the Primary Reformer. The ADEC identified a stationary source in the RACT/BACT/LAER Clearinghouse (RBLC) (Emberclear Gas to Liquids, RBLC ID No. MS-0092) with a steam methane reformer using an oxidation catalyst to control carbon monoxide (CO) emissions down to 5 ppmv at 3% oxygen. RBLC ID No. MS-0092 had not been entered in to the RBLC at the time of the initial permitting for AQ0083CPT06. During the initial PSD permitting, oxidation catalysts were determined to be not technically feasible. Since an oxidation catalyst can also be used as control for volatile organic compound (VOC) emissions, and RBLC ID No. MS-0092 included a limit based on the use of catalytic oxidation for this pollutant, a VOC BACT analysis has been included in this document. Section 3.0 of this document contains the CO and VOC BACT analyses for the Primary Reformer (Unit 12). Section 4.0 contains an evaluation of new RBLC results for PM, PM_{10}, $PM_{2.5}$, NOx, and CO_2e control requirements associated with permits issued since the original PSD permit was issued in January 2015.

1.2 Regulatory Basis for BACT Analysis

Section 163(3) of the Clean Air Act (CAA) defines Best Available Control Technology (BACT) as:

> *"An emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under [the CAA] emitted from or which results from any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and*

techniques, including fuel cleaning, clean fuels, or treatment or innovative fuel combustion techniques for control of each such pollutant."

Based on projected potential emission rates, BACT is required for the following criteria pollutants:

- Nitrogen Oxides (NO_X)
- Carbon Monoxide (CO)
- Volatile Organic Compounds (VOC)
- Particulate Matter (PM)
- Particulate Matter ≤ 10 microns in aerodynamic diameter (PM_{10})
- Particulate Matter ≤ 2.5 microns in aerodynamic diameter ($PM_{2.5}$)

In addition, the proposed project is subject to a BACT review for the greenhouse gas (GHG) pollutants under EPA's Tailoring Rule. The regulated GHGs include the following:

- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Carbon Dioxide Equivalent (CO_2e)

Where CO2e represents the CO2 equivalence of the emissions. CO2e emissions are calculated as the sum of the mass emissions of each individual GHGs adjusted for its respective global warming potential (GWP). The GWP values are included in Table A-1 of the Greenhouse Gas Mandatory Reporting Rule found in 40 CFR 98, Subpart A.

1.3 Five-Step Top-Down BACT Process

This BACT analysis is conducted following EPA's "top-down" BACT approach, as described in EPA's *Draft New Source Review Workshop Manual* (EPA 1990). The five basic steps of a top-down BACT analysis are listed below:

Step 1: Identify potential control technologies
Step 2: Eliminate technically infeasible options
Step 3: Rank remaining control technologies by control effectiveness
Step 4: Evaluate the most effective controls and document results
Step 5: Select BACT

The first step is to identify potentially "available" control options for each emission unit triggering PSD, for each pollutant under review. Available options consist of a comprehensive list of those technologies with a potentially practical application to the emission unit in question. The list includes technologies used to satisfy BACT requirements, innovative technologies, and controls applied to similar source categories.

For this analysis, the following sources were investigated to identify potentially available control technologies:

- EPA's RACT/BACT/LAER Clearinghouse (RBLC) database.
- EPA's New Source Review website.
- In-house experts.
- State air regulatory agency contacts.
- Technical articles and publications.
- A number of permits issued for similar sources that have not yet been entered into the RBLC.
- Guidance documents and personal communications with federal and state agencies.

After identifying potential technologies, the second step is to eliminate technically infeasible options from further consideration. To be considered feasible for BACT, a technology must be commercially available and applicable to a given emission unit.

The third step is to rank the technologies not eliminated in Step 2 in order of descending control effectiveness for each pollutant of concern. If the highest ranked technology is proposed as BACT, it is not necessary to perform technical or economic evaluation of the selected or less effective control technologies identified as outlined in Step 4. Potential adverse impacts, however, must still be identified and evaluated.

The fourth step entails an evaluation of energy, environmental, and economic impacts for determining a final level of control. The evaluation begins with the most stringent control option and continues until a technology under consideration cannot be eliminated based on adverse energy, environmental, or economic impacts. The economic or “cost-effectiveness” analysis is conducted in a manner consistent with EPA’s *OAQPS Control Cost Manual, Sixth Edition1* and subsequent revisions.

Cost effectiveness is expressed in terms of dollars per ton of pollutant removed ($/ton). The costs in the numerator of that expression are determined by adding the annualized capital cost and the annual operation and maintenance costs of a given control device under evaluation. Annualized costs are determined by the following equation:

Annualized equipment cost in $/yr = PV(i / [1 - (1 + i) -n])

Where:
PV = Present value of the equipment;
i = Interest rate (cost of money); and
n = Number of years of the life of the equipment.

The annual mass (ton) of pollutant removed is determined by multiplying the annual uncontrolled emission rate by the expected control efficiency. The uncontrolled emission rate may, in some cases, be the rate after some level of control. In addition, the annual emission rate may be the potential to emit, or a level based on limited hours of operation.

The fifth and final step is to select as BACT the emission limit from application of the most effective of the remaining technologies under consideration for each pollutant of concern.

[1] USEPA, *OAQPS Control Cost Manual, Sixth Edition* (Research Triangle Park, NC, 2002)

2. SUMMARY OF AFFECTED EMISSION UNITS AND POLLUTANTS

2.1 Brief Facility Description

Air Quality Control Construction Permit AQ0083CPT06 permitted Agrium to construct a facility consisting of an agricultural fertilizer production facility. The facility will consist of three (3) distinct plants:

1. Plant 4 – Ammonia Plant
2. Plant 5 – Urea Plant
3. Plant 6 – Supporting Utility Plant

Each plant within the permitted facility includes several emission units. In the synthetic ammonia production process, natural gas molecules are reduced to carbon and hydrogen. The hydrogen is then purified and reacted with nitrogen to produce ammonia. Ammonia is synthesized by reacting hydrogen with nitrogen at a molar ratio of 3 to 1, then compressing and cooling the gas. Nitrogen is obtained from the air, while hydrogen is obtained from the catalytic steam reforming of natural gas.

Generally, there are six process steps to produce synthetic ammonia using the catalytic steam reforming process as follows:

1. Natural gas desulfurization,
2. Catalytic steam reforming,
3. Carbon monoxide (CO) shift,
4. Carbon dioxide (CO2) removal,
5. Methanation, and
6. Ammonia synthesis.

The synthetic ammonia produced at the Ammonia Plant is used as feedstock for the Urea Plant at the facility and will also be sold as a product. In the Urea Plant, urea is produced by reacting ammonia and CO_2.

A more detailed description of the permitted facility and associated air emission units is provided in the Appendix A of the original BACT analysis.

2.2 Primary Reformer (Unit 12)

In the reformer process, desulfurized natural gas is mixed with process steam and preheated. The mixture of steam and gas enters the primary reformer tubes filled with a nickel-based reforming catalyst. The primary reformer is fired with a combination of natural gas and fuel gas (tail gas). The combustion occurs outside of catalyst packed tubes to provide indirect heat exchange to the feedstock passing through the tubes. In the primary reformer approximately 70 percent of the methane is converted to hydrogen, carbon monoxide and carbon dioxide. This process gas is then sent to the secondary reformer, where it is mixed with compressed, preheated air. Sufficient air is added to produce a final synthesis gas having a hydrogen-to-nitrogen mole ratio of 3 to 1. The gas leaving the secondary reformer is then cooled in a heat recovery boiler. The heat recovery boiler produces steam for the reformer process inlet and to drive compressors. Emissions of regulated pollutants from the Reformer include:

- Nitrogen Oxides (NOx)
- Carbon Monoxide (CO)
- Volatile Organic Compounds (VOC)
- Particulate Matter (PM)
- Particulate Matter ≤ 10 microns in aerodynamic diameter (PM_{10})
- Particulate Matter ≤ 2.5 microns in aerodynamic diameter ($PM_{2.5}$)
- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Carbon Dioxide Equivalent (CO_2e)

3. CRITERIA POLLUTANT BEST AVAILABLE CONTROL TECHNOLOGY (BACT) ANALYSIS

Criteria pollutants subject to BACT Analysis for this project include:

- Carbon Monoxide (CO)
- Nitrogen Oxides (NOx)
- Volatile Organic Compounds (VOC)
- Particulate Matter (PM)
- Particulate Matter ≤ 10 microns in aerodynamic diameter (PM_{10})
- Particulate Matter ≤ 2.5 microns in aerodynamic diameter ($PM_{2.5}$)
- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)

Generally, these pollutants are the result of natural gas combustion at the planned facility; although, sources other than combustion sources are included at the facility. The sections below include a BACT Analysis for CO and VOC. No changes were identified in the RBLC for the control of PM, PM_{10}, $PM_{2.5}$, NOx, or CO_2e. These pollutants are addressed in Section 4.0 of this document.

3.1 Primary Reformer (Unit 12)

As described in Section 2.2, the emissions from the Reformer unit result from natural gas combustion in the Primary Reformer. The following subsections present the step-by-step BACT review for the Primary Reformer for CO and VOC.

The auxiliary section of the Primary Reformer is subject to NSPS Subpart D, under terms of 1998 Consent Decree. EPA determined that even though the primary function of the reformer is to reform process gas, the auxiliary section is a discrete unit whose primary function is to produce steam.

3.1.1 BACT Evaluation for CO Emissions from the Primary Reformer

Step 1 – Identify All Available Control Technologies

Review of the RBLC database identified two control technologies for control of CO emissions from reformers. The use of Good Combustion Practices (GCP) is cited as BACT for nearly every entry; however, the use of an oxidation catalyst is cited in a single RBLC entry (Emberclear Gas to Liquids (Emberclear), RBLC ID No. MS-0092). Emission limits range from 0.0194 lb/mmBtu to 0.06 lb/mmBtu for natural gas combustion using GCP. The CO limit for the one unit equipped with an oxidation catalyst was identified as 5 ppmv at 3% O_2. Available control technologies for the control of CO emissions include good combustion practices, oxidation catalyst, and thermal oxidation.

Step 2 – Eliminate Technically Infeasible Options

<u>Oxidation Catalyst</u>

Oxidation catalysts use a noble metal catalyst to reduce the activation energy of the oxidation reaction:

$$2CO + O_2 \rightarrow 2CO_2$$

Although oxidation catalysts are used to reduce CO emissions from natural gas-fired combustion turbines, they have limited demonstration in reducing CO emissions from natural gas-fired boilers and have not been demonstrated for natural gas reformers. The note in the RBLC for Emberclear's steam methane reformer's oxidation catalyst BACT verification status states that demonstration of compliance with the CO emission limitation has not been verified; however, this technology is carried forward for control of CO emissions from the Primary Reformer.

Thermal Oxidation

Thermal oxidation has never been required nor used on a natural gas-fired reformer, and the effectiveness of the technology in reducing CO emissions from natural gas-fired reformer is questionable. Thermal oxidation would involve injecting additional air into the flue gas and heating the oxygen enriched mixture to approximately 1,500 ℉ to oxidize CO to carbon dioxide. However, since the combustion of the reheat fuel would itself result in CO emissions, there is no evidence that thermal oxidation would result in overall reductions in CO emission.

Since thermal oxidation has never been demonstrated on a natural gas-fired reformer, and because there is no evidence that it could reduce CO emissions, thermal oxidation is not a technically feasible CO control technology for the Primary Reformer.

Good Combustion Practices

GCPs typically include the following elements:

1. Sufficient residence time to complete combustion
2. Providing and Maintaining proper air/fuel ratio
3. High temperatures and low oxygen levels in the primary combustion zone
4. High enough overall excess oxygen levels to complete combustion and maximize thermal efficiency
5. Proper fuel gas supply system designed to minimize effects of contaminants or fluctuations in pressure and flow on the fuel gas delivered

Combustion efficiency is dependent on the gas residence time, the combustion temperature, and the amount of mixing in the combustion zone. Each of these parameters is incorporated into the design of the burners and the combustion zones of the Primary Reformer to optimize combustion and minimize fuel consumption. In addition to the above parameters the level of oxygen in the Primary Reformer is important to GCP. Therefore, combustion control is accomplished primarily through reformer design as it relates to time, temperature, mixing, and through reformer operation as it relates to excess oxygen levels. Combustion design for modern reformers is intended to simultaneously minimize formation of CO and NOx emissions. This is a difficult task, since emissions of NOx and emissions of CO are inversely related. That is, measures used to reduce NOx emissions often lead to increases in CO emissions. Therefore, the reformer design to minimize CO emissions is interrelated with the reformer design to minimize NOx formation.

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

GCPs are planned for the Primary Reformer at the facility and represent the baseline BACT for the Primary Reformer; therefore, an oxidation catalyst represents the highest ranked level of control for CO emissions from the Primary Reformer.

Step 4 – Evaluate Most Effective Controls and Document Results

A cost evaluation for a catalytic oxidizer on the Primary Reformer is has been performed as part of this BACT analysis. The estimate results in a cost per ton of CO removed of $16,200 per ton. This level of cost is considered to be economically infeasible; therefore, catalytic oxidation is eliminated for consideration as representing BACT for CO emissions.

Step 5 – Select BACT

Agrium proposes the use of Good Combustion Practices as the BACT for CO emissions from the Primary Reformer. CO Emissions from the Primary Reformer will be limited to 43.45 lb/mmcf for a 3-hour average. Initial compliance with the proposed emission limit will be demonstrated by conducting a stack test.

3.1.2 BACT Evaluation for VOC Emissions from the Primary Reformer

Step 1 – Identify All Available Control Technologies

Review of the RBLC database identified two control technologies for control of VOC emissions from reformers. The use of Good Combustion Practices (GCP) is cited as BACT for nearly every entry; however, the use of an oxidation catalyst is cited in a single RBLC entry (Emberclear Gas to Liquids (Emberclear), RBLC ID No. MS-0092). Emission limits range from 0.0014 lb/mmBtu to 0.0055 lb/mmBtu for natural gas combustion using GCP. The VOC limit for the one unit equipped with an oxidation catalyst was identified as 5 ppmv at 3% O_2. Available control technologies for the control of VOC emissions include GCP, oxidation catalyst, and thermal oxidation.

Step 2 – Eliminate Technically Infeasible Options

For the same reasons given for CO control from the Primary Reformer exhaust, thermal oxidation is eliminated from further consideration.

The note in the RBLC for Emberclear's steam methane reformer's oxidation catalyst BACT verification status states that demonstration of compliance with the VOC emission limitation is unknown; however, this technology is carried forward for control of VOC emissions from the Primary Reformer.

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

GCPs are planned for the Primary Reformer at the facility and represent the baseline BACT for the Primary Reformer; therefore, an oxidation catalyst represents the highest ranked level of control for VOC emissions from the Primary Reformer.

Step 4 – Evaluate Most Effective Controls and Document Results

A cost evaluation for a catalytic oxidizer on the Primary Reformer is has been performed as part of this BACT analysis. The estimate results in a cost per ton of ~~CO~~VOC removed of $158,102 per ton. This level of cost is considered to be economically infeasible; therefore, catalytic oxidation is eliminated for consideration as representing BACT for VOC emissions.

Step 5 – Select BACT

Agrium proposes the use of Good Combustion Practices as the BACT for VOC emissions from the Primary Reformer. VOC emissions will be limited to 0.0055 lb/mmBtu. Compliance with the proposed emission limit will be demonstrated through the use of standard AP-42 emission factors for natural gas combustion. Agrium will record total fuel usage for the Reformer to ensure ongoing compliance.

4. BEST AVAILABLE CONTROL TECHNOLOGY (BACT) ANALYSIS UPDATES

This section of the analysis is provided as a supplement to the BACT analyses performed for the original PSD Construction Permit application for KNO, submitted in October 2014. This section provides an evaluation of RACT/BACT/LAER Clearinghouse (RBLC) results associated with permits issued since the original PSD permit was issued in January 2015. Based on the information provided below, KNO concludes that no new permits have been issued since the issuance of AQ0083COT06 that contain BACT limits for PM, PM_{10}, $PM_{2.5}$, NOx, and CO_2e that are inconsistent with the BACT determinations made for KNO as part of the original PSD Construction Permit.

Tables summarizing RBLC entries since the issuance of AQ0083COT06 were provided in Attachment B to the 2019 PSD permit application. The results of all three analyses for emission units contained in the KNO PSD permit are summarized below:

4.1 Primary Reformer (Unit 12)

Two permits were identified that have been issued since January 2015. The first was a permit issued to Topchem Pollock, LLC (RBLC ID LA-0306), which was issued 20 December 2016 and updated 8 August 2017. This permit contains limits for CO and $PM_{2.5}$ that were based on good combustion practices, with a limit for CO based on an emission rate of 0.0824 lb/mmBtu of natural gas combusted and a $PM_{2.5}$ emission rate of 0.00745 lb/mmBtu of natural gas combusted. This is consistent with the control technology selected as BACT for the Primary Reformer for KNO and is based on consistent emission factors for CO and $PM_{2.5}$. The Topchem permit also contained a limit for CO_2e emissions that was established at 363,287 tons per year using control technology described as "energy efficiency measure". The ton per year limit established in this permit is consistent with the emission factor utilized for CO_{2e} emissions in the KNO permit.

The other permit issued was for the Agrium facility in Borger, Texas (RBLC ID TX-0814). This permit contained a limit for CO_{2e} emissions of 564,019 tons per year utilizing "good engineering practices". This is consistent with the approach utilized by KNO.

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