



QUANTIFICATION PROTOCOL FOR NITROUS OXIDE ABATEMENT PROJECTS

(Draft)

Submitted to:

Alberta Environment
Protocol Development

Submitted by:

EPCOR Utilities Inc.
&
Orica Canada Inc.

Table of Contents

1.0 Project and Methodology Scope and Description.....	2
1.1 Protocol Scope and Description.....	2
1.2 Glossary of New Terms	6
2.0 Quantification Development and Justification.....	7
The following sections outline the quantification development and justification.	7
2.1 Identification of Sources and Sinks (SS's) for the Project	7
2.2 Identification of Baseline.....	11
2.3 Identification of SS's for the Baseline	12
2.4 Selection of Relevant Project and Baseline SS's.....	16
2.5 Quantification of Reductions, Removals, and Reversals of Relevant SS's.....	19
2.5.1 Quantification Approaches	19
2.5.2 Contingent Data Approaches	22
2.6 Management of Data Quality.....	22
2.6.1 Record Keeping	22
2.6.2 Quality Assurance/Quality Control (QA/QC)	23

LIST OF FIGURES

Figure 1.1	Process Flow Diagram for Project Condition
Figure 1.2	Process Flow Diagram for Baseline Condition
Figure 2.1	Project Element Life Cycle Chart
Figure 2.2	Baseline Element Life Cycle Chart

LIST OF TABLES

Table 2.1	Project SS's
Table 2.2	Baseline SS's
Table 2.3	Comparison of SS's
Table 2.4	Quantification Procedures

1.0 Project and Methodology Scope and Description

This quantification protocol for nitrous oxide abatement from nitric acid production is written for the nitric acid production operator or nitric acid N₂O abatement project developer. Some familiarity with, or general understanding of the operation of a nitric acid production facility is assumed.

The opportunity for generating carbon offsets with this protocol arise from the quantification of reductions in greenhouse gas (GHG) emissions resulting from the installation of a dedicated N₂O abatement catalyst inside the ammonia burner of a nitric acid plant that catalytically reduces N₂O, once it has been formed in the Ammonia Oxidation Reactor.

1.1 Protocol Scope and Description

This protocol quantifies emission reductions created by the abatement of nitrous oxide during the production of nitric acid through the oxidization of ammonia on precious metal catalyst gauze in the ammonia burner of a nitric acid plant. The project boundary encompasses the physical and geographical site of the plant and the equipment for the entire production process. The only GHG emission relevant to the project activity is N₂O in the waste stream to stack. Figure 1.1 offsets a process flow diagram for a typical project.

Protocol Approach:

This protocol applies to projects where the nitrous oxide would otherwise have been released into the atmosphere during the production of nitric acid as it does not have any economic value or toxicity at emission levels typical of nitric acid manufacture.

This protocol serves as a generic 'recipe' for project developers to follow in order to meet the measurement, monitoring and GHG quantification requirements.

The baseline condition has been identified as the release of the greenhouse gases created during the production of nitric acid through the oxidation of ammonia on precious metal catalyst gauze in the ammonia burner of a nitric acid plant for one campaign or primary catalyst run before project implementation. For illustration purposes, the process flow diagrams Figure 1.1 and 1.2 for the baseline and project condition.

Figure 1.1: Process flow diagram for Project SS's

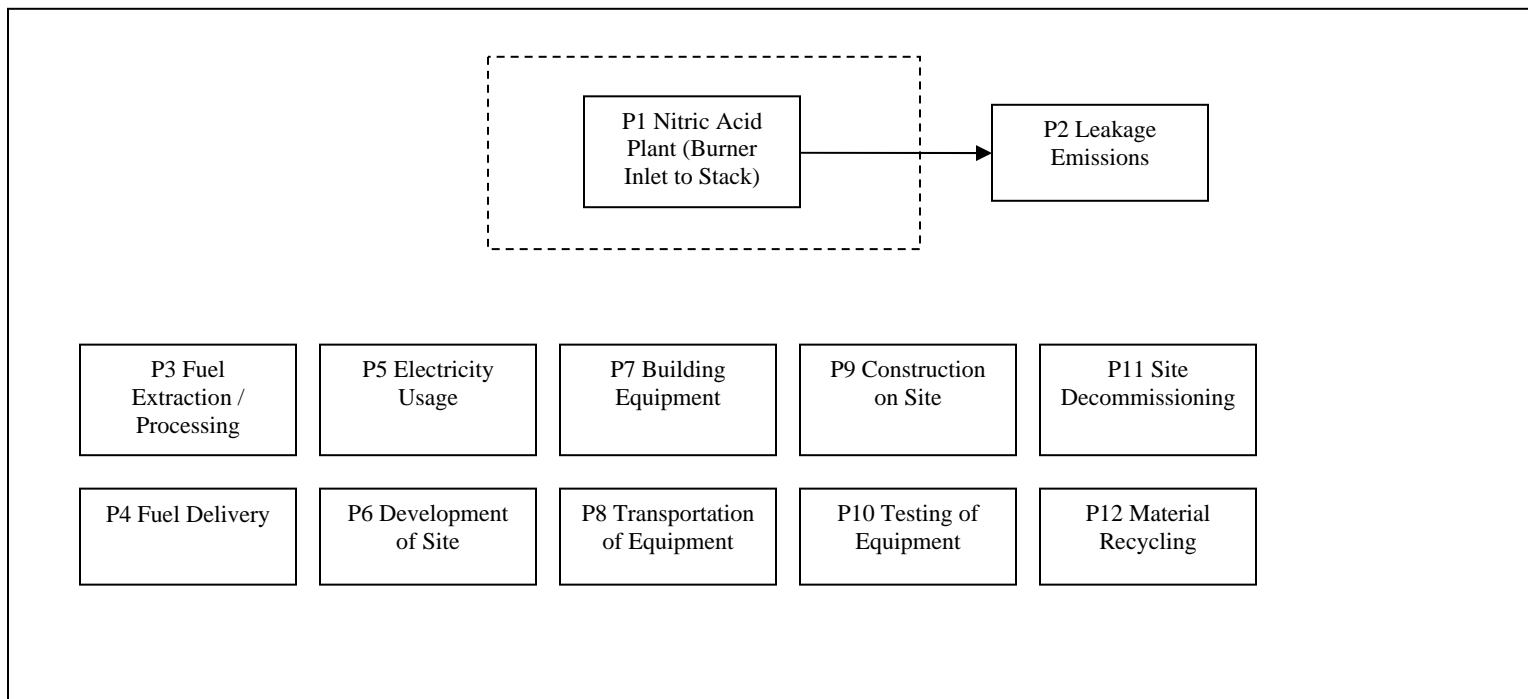
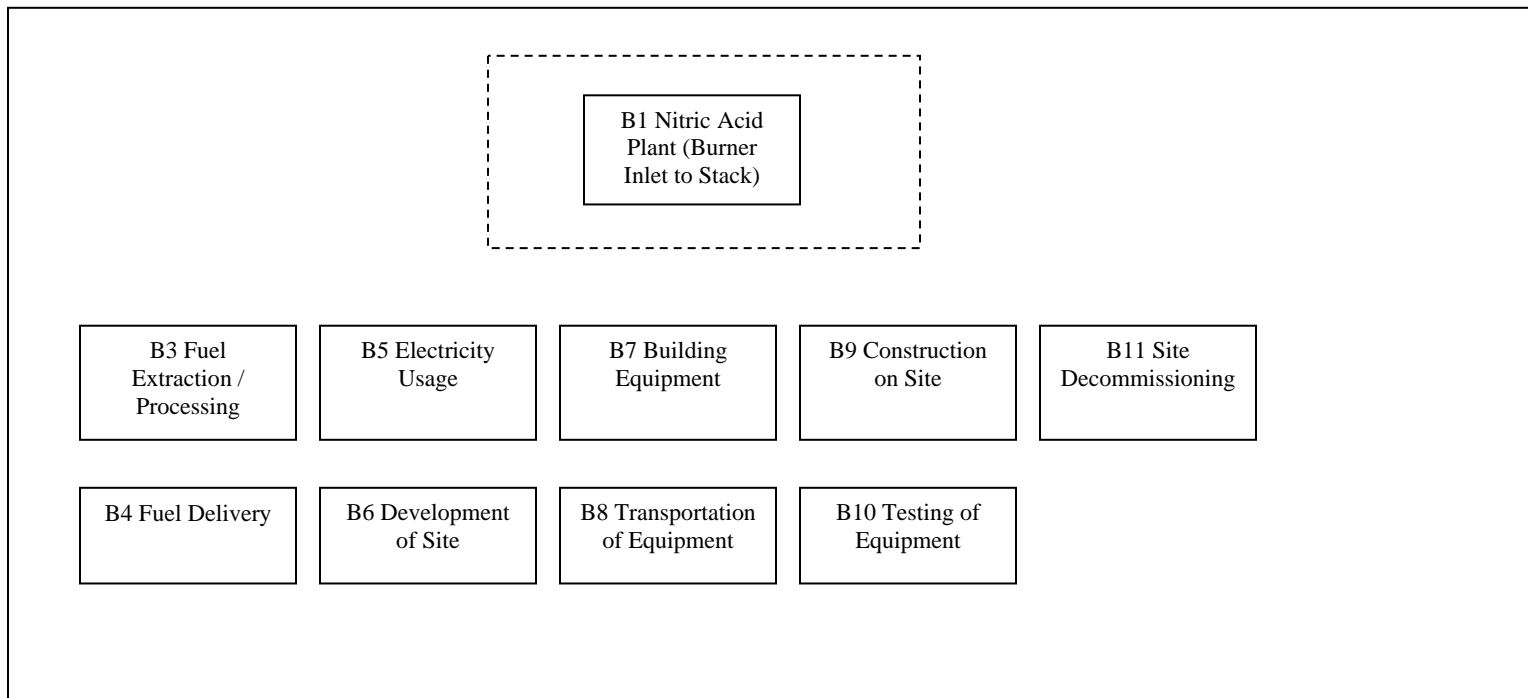


Figure 1.2: Process flow diagram for Baseline SS's



Protocol Applicability:

To demonstrate that a project meets the requirements under this protocol, the project developer must provide evidence that:

1. The abatement process is carried out under controlled conditions as demonstrated by a description of technology in use;
2. The quantification of reductions achieved by the project is based on actual measurement and monitoring (except where indicated in this protocol) as indicated by the proper application of this protocol; and
3. The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System.
4. The project activity will not result in the shutdown of any existing N₂O destruction or abatement facility or equipment in the plant;
5. The project activity shall not affect the level of nitric acid production
6. Continuous real-time measurements of N₂O concentration and total gas volume flow can be carried out in the stack:
 - a. Prior to the installation of the secondary catalyst for one campaign, and
 - b. After the installation of the secondary catalyst throughout the project activity

Protocol Flexibility:

Flexibility in applying the quantification protocol is provided to project developers in the following ways:

1. Project developers may use alternative monitoring methodologies and/or equipment rather than the methodologies and/or equipment described in this protocol. The proponent must justify that the chosen methodology and/or equipment provides equivalent, more accurate or more conservative data than the specified methodology and/or equipment;

If applicable, the proponent must indicate and justify why flexibility provisions have been used.

1.2 Glossary of New Terms

Campaign

The length of one campaign is defined as the total number of metric tonnes of nitric acid at 100% concentration produced with one set of primary gauze. A campaign can run between 60-365 days prior to changing out the catalyst.

Catalyst Gauze

A material composed of precious metals (platinum/rhodium) used in the production of nitric acid.

CEMS

Continuous Emission Monitoring Systems

European Norm 14181 (2004)

Stationary Source Emissions – The European standard for the quality assurance procedures required to ensure that automated measurement systems (AMS), installed to measure emissions to air, are capable of meeting legislative requirements arising out of EU Directives.

Nitrous Oxide (N₂O)

Greenhouse gas; global warming potential of 310

2.0 Quantification Development and Justification

The following sections outline the quantification development and justification.

2.1 Identification of Sources and Sinks (SS's) for the Project

Based on the process flow diagrams provided in FIGURE 1.1, the project SS's were organized into life system categories in FIGURE 2.1. Descriptions of each of the SS's and their classification as 'controlled', 'related', or 'affected' are provided in TABLE 2.1.

FIGURE 2.1: Project Element Life Cycle Chart

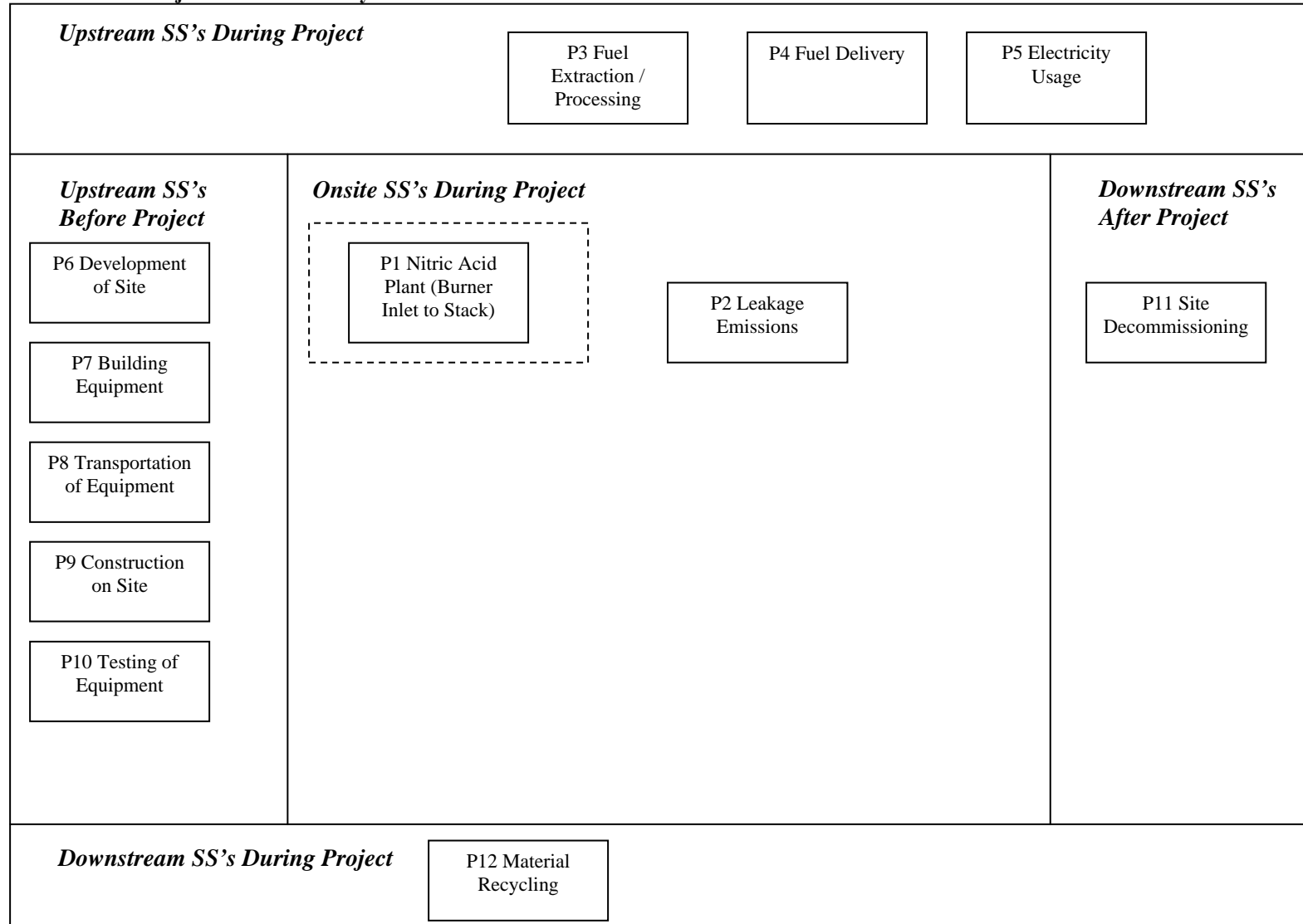


TABLE 2.1: Project SS's

1. SS	2. Description	3. Controlled, Related, or Affected
Upstream SS's during Project Operation		
P3 Fuel Extraction/Processing	Each of the fuels used throughout the on-site component of the project will need to be sourced and processed. The total volumes of fuel for each of the on-site SS's are considered under this SS. Volumes and types of fuels are the important characteristics to be tracked.	Related
P4 Fuel Delivery	Each of the fuels used throughout the on-site component of the project will need to be transported to the site. This includes the delivery of liquid ammonia, which may be shipped by rail, or tanker, resulting in emissions of greenhouse gases. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other SS's.	Related
P5 Electricity Usage	Electricity may be produced off-site. Measurement of the quantity of electricity required by the facility would need to be tracked.	Related
On-site SS's during Project Operation		
P1 Nitric Acid Plant (Burner Inlet to Stack)	The spatial extent of the project boundary shall cover the facility and equipment for the complete nitric acid production process from the inlet to the ammonia burner to the stack. This includes all compressors, tail gas expander turbines and any N ₂ O abatement equipment installed. Volumes, flow rates, temperatures and pressures must all be monitored and tracked.	Controlled
P2 Leakage Emissions	Leakages that occur from the replacement of the used catalyst with the new catalyst.	Related
Downstream SS's during Project Operation		
P12 Material Recycling	The end of life of the N ₂ O abatement catalyst will require the used catalyst to be refined, recycled and properly disposed of according to prevailing standards.	Related
Other		
P6 Development of Site	Development of the site could include clearing, grading, building access roads as well as civil infrastructure such as access to electricity, gas, water supply and water treatment. Building and structures on the site including offices, storage facilities, storm water drainage, and structures to enclose, support and house equipment may need to be developed. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site.	Related
P7 Building Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, and system control and safety systems. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related

P8 Transportation of Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, and control and safety systems. These may be sources as pre-made standard equipment or custom built to specification. Greenhouse gas emission would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction or implementation of the raw material, processing, fabricating and assembly. Also included may be the transportation of the replacement gauze required for each new campaign, and replacement raschig rings.	Related
P9 Construction on Site	The process of construction at the site will require a variety of heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emissions from the use of fossil fuels and electricity.	Related
P10 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
P11 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

2.2 Identification of Baseline

The baseline condition for projects applying this protocol is defined as the operating condition prior to the implementation of the N₂O abatement project. Baseline Emissions are determined by measuring nitrous oxide concentration and total flow rate in the tail gas of the nitric acid plant. The measurements are for the duration of one entire campaign prior to the implementation of the N₂O abatement project, and are used to determine a plant-specific baseline emission factor. A permitted range of parameters that influence the level of N₂O formation is established during the baseline campaign which must be demonstrated to be within the specifications of the plant. Appendix A provides justification for the selection of the baseline selection.

2.3 Identification of SS's for the Baseline

According to the baseline scenario identified above and on the process flow diagrams provided in FIGURE 1.2, the project SS's were organized in life system categories in FIGURE 2.2. Descriptions of each of the SS's and their classification as 'controlled', 'related', or 'affected' is provided in TABLE 2.2.

FIGURE 2.2: Baseline Element Life Cycle Chart

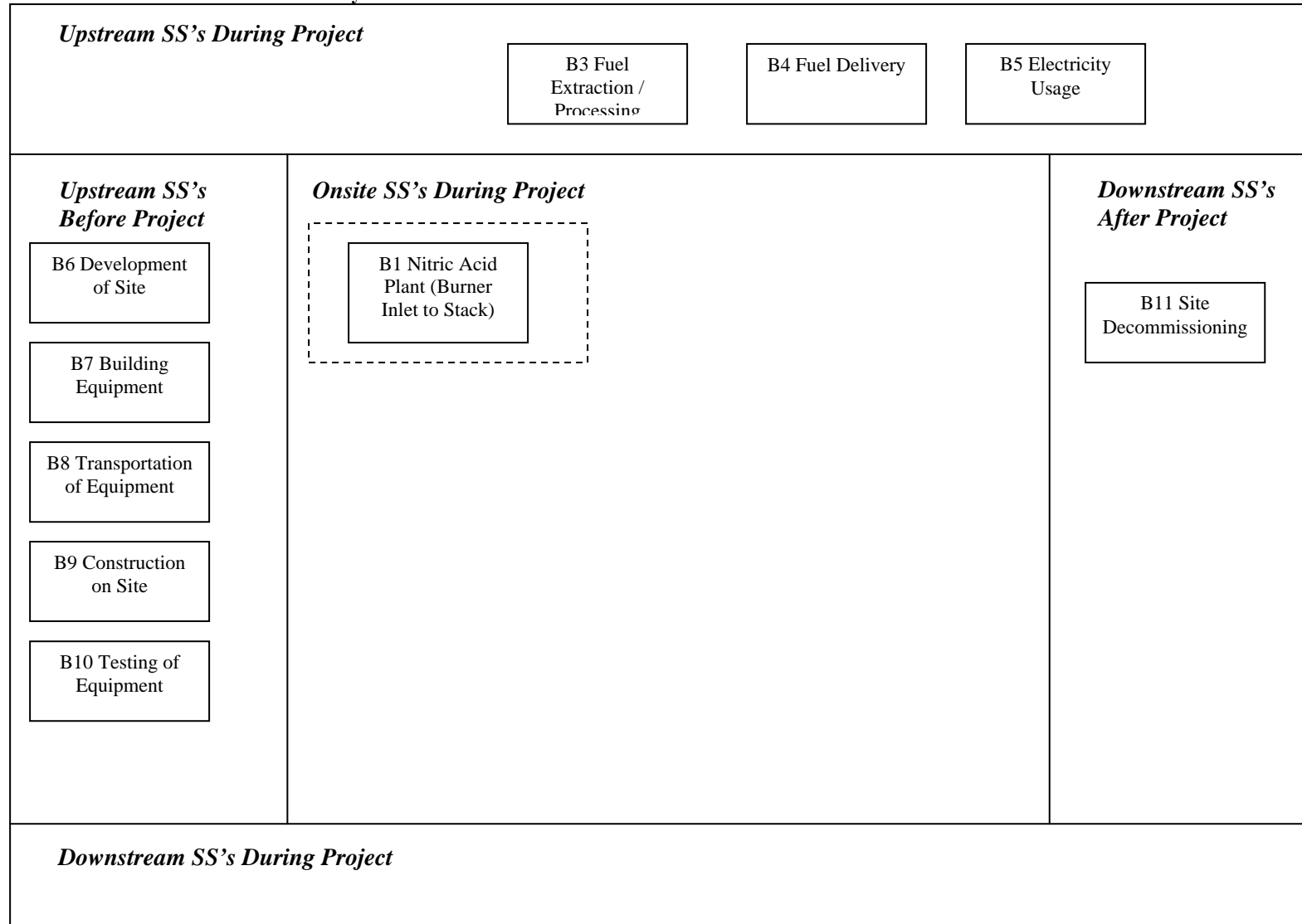


Table 2.2: Baseline SS's

1. SS	2. Description	3. Controlled, Related, or Affected
Upstream SS's during Project Operation		
B3 Fuel Extraction/Processing	Each of the fuels used throughout the on-site component of the project will need to be sourced and processed. The total volumes of fuel for each of the on-site SS's are considered under this SS. Volumes and types of fuels are the important characteristics to be tracked.	Related
B4 Fuel Delivery	Each of the fuels used throughout the on-site component of the project will need to be transported to the site. This includes the delivery of liquid ammonia, which may be shipped by rail, or tanker, resulting in emissions of greenhouse gases. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fueling station as the fuel used to take the equipment to the site is captured under other SS's.	Related
B5 Electricity Usage	Electricity may be produced off-site. Measurement of the quantity of electricity required by the facility would need to be tracked.	Related
On-site SS's during Project Operation		
B1 Nitric Acid Plant (Burner Inlet to Stack)	The spatial extent of the project boundary shall cover the facility and equipment for the complete nitric acid production process from the inlet to the ammonia burner to the stack. This includes all compressors, tail gas expander turbines and any N ₂ O abatement equipment installed. Volumes, flow rates, temperatures and pressures must all be monitored and tracked.	Controlled
B2 Leakage Emissions	Leakages that occur from production, transport, operation, and decommissioning of the catalyst	Related
Downstream SS's during Project Operation		
	NONE	
Other		
B6 Development of Site	Development of the site could include clearing, grading, building access roads as well as civil infrastructure such as access to electricity, gas, water supply and water treatment. Building and structures on the site including offices, storage facilities, storm water drainage, and structures to enclose, support and house equipment may need to be developed. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site.	Related
B7 Building Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, and system control and safety systems. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related
B8 Transportation of	Equipment may need to be built either on-site or off-site. This includes all of the components of	Related

Equipment	the storage, handling, processing, combustion, air quality control, and system control and safety systems. These may be sources as pre-made standard equipment or custom built to specification. Greenhouse gas emission would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction or implementation of the raw material, processing, fabricating and assembly. Also included may be the transportation of the replacement gauze required for each new campaign, and replacement rasching rings.	
B9 Construction on Site	The process of construction at the site will require a variety of heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emission from the use of fossil fuels and electricity.	Related
B10 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
B11 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

2.4 Selection of Relevant Project and Baseline SS's

Each of the SS's from the project and baseline condition were compared and evaluated as to their relevancy using the guidance provided in Canada's Offset System for Greenhouse Gases – Guide to Protocol Developers (August 2008 – Draft version), and the guidance of the approved Clean Development Mechanism methodology AM0034v2 “Catalytic reduction of N₂O inside the ammonia burner of nitric acid plants. The justification for the inclusion, exclusion, or conditions upon which SS's may be excluded is provided in **TABLE 2.3** below.

TABLE 2.3 Comparison of SS's

1. Identified SS	2. Baseline (C, R, A)	3. Project (C, R, A)	4. Included or Excluded from Quantification	5. Justification for Exclusion
Upstream SS's				
B3 Fuel Extraction/Processing	Related	N/A	Excluded	Excluded as emissions from fuel extraction/processing are not impacted by the implementation of the project and as such baseline and project conditions for this SS are similar.
P3 Fuel Extraction/Processing	N/A	Related	Excluded	
B4 Fuel Delivery	Related	N/A	Excluded	Excluded as emissions from fuel delivery are not impacted by the implementation of the project and as such baseline and project conditions related to this SS are similar.
P4 Fuel Delivery	N/A	Related	Excluded	
B5 Electricity Usage	Related	N/A	Excluded	Excluded as these SS's activity levels are not impacted by the implementation of this project and as such baseline and project conditions for this SS are similar.
P5 Electricity Usage	N/A	Related	Excluded	
Onsite SS's				
B1 Nitric Acid Plant (Burner Inlet to Stack)	Controlled	N/A	Included	N/A
P1 Nitric Acid Plant (Burner Inlet to Stack)	N/A	Controlled	Included	
P2 Leakage Emissions	N/A	Related	Excluded	Excluded as no leakage emissions are expected. Existing good practice guidance (CDM methodology AM0034 / Version 2 "Catalytic reduction of N ₂ O inside the ammonia burner of nitric acid plants") excludes this source.
Downstream SS's				
P12 Material Recycling	N/A	Related	Excluded	Excluded as these emissions are not material to the life of the project, and the minimal change outs of the catalyst.
Other				
B6 Development of Site	Related	N/A	Excluded	Excluded as emissions from site development are not material to the implementation of this project, as no changes to the site are required to implement this project.
P6 Development of Site	N/A	Related	Excluded	
B7 Building Equipment	Related	N/A	Excluded	Emissions from building equipment are not material given the long project life, and the minimal building equipment typically required. In this case, the only difference in building equipment between the baseline and the project is the catalyst. The GHG emissions associated with this new catalyst are presented in Appendix A and demonstrate that this source is not significant.
P7 Building Equipment	N/A	Related	Excluded	

B8 Transportation of Equipment	Related	N/A	Excluded	Emissions from transportation of equipment are not material given the long project life, and the minimal transportation of equipment typically required. The GHG emissions associated with this new catalyst are presented in Appendix A and demonstrate that this source is not significant. Refer to appendix A for more details.
P8 Transportation of Equipment	N/A	Related	Excluded	
B9 Construction on Site	Related	N/A	Excluded	Excluded as emissions from site development are not material to the implementation of this project, as no changes to the site are required to implement this project.
P9 Construction on Site	N/A	Related	Excluded	
B10 Testing of Equipment	Related	N/A	Excluded	Emissions from testing of equipment are not material given the minimal testing of equipment typically required.
P10 Testing of Equipment	N/A	Related	Excluded	
B11 Site Decommissioning	Related	N/A	Excluded	Emissions from decommissioning are not material given the long project life, and the minimal decommissioning typically required (catalyst only). Refer to appendix A for more details.
P11 Site Decommissioning	N/A	Related	Excluded	

2.5 Quantification of Reductions, Removals, and Reversals of Relevant SS's

2.5.1 Quantification Approaches

Quantification of the reductions, removals and reversals of relevant SS's for each of the greenhouse gases will be completed using the methodologies outlined in **TABLE 2.4**, below. The quantification methodologies are based on guidance from the UNFCCC approved CDM methodology AM0034 Version 02 provided in **APPENDIX B**. The quantification approach presented in this protocol differs from the CDM methodology AM0034 Version 2 in the following two areas:

1. The CDM methodology AM0034 requires that the monitoring installed must follow the European Norm 14181 (2004). In this protocol the monitoring system installed will follow an independently validated N₂O Meter Code based on the Alberta CEMS Code 1998 and the Canadian EPS 1/PG/7.
2. The CDM methodology AM0034 requires users to derive a moving average emission factor, after each project campaign and a project emission factor for the campaign. The lowest value between the campaign project emission factor and the moving average emission factor must be used when performing the GHG quantification for that specific project period. This protocol requires that the GHG quantification be performed using the calculated project emission factor for the relevant period, no moving average project emission factor is required.

The calculation methodologies presented in CDM methodology AM0034 serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

$$\text{Emission Reduction} = (\text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}})$$

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions Factor}_{\text{Baseline}} * \text{NAP} * \text{GWP}_{\text{N}_2\text{O}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions Factor}_{\text{Project}} * \text{NAP} * \text{GWP}_{\text{N}_2\text{O}}$$

Where:

Emissions_{Baseline} = the sum of the GHG emissions under the baseline condition (tCO₂e)

Emissions Factor_{Baseline} = calculated emissions factor under the baseline conditions (tN₂O/tHNO₃)

NAP = Nitric acid production for the project campaign (tHNO₃).

GWP_{N₂O} = Global Warming Potential of N₂O (tCO₂e/tN₂O)

Emissions_{Project} = the sum of the GHG emissions under the project condition (tCO₂e)

Emissions Factor_{Project} = calculated emissions factor under the project conditions (tN₂O/tHNO₃)

NAP = Nitric acid production for the project campaign (tHNO₃).

GWP_{N₂O} = Global Warming Potential of N₂O (tCO₂e/tN₂O)

Table 2.4: Quantification Procedures.

1.0 Project SS	2. Parameter/ Variable	3. Unit	4. Measured/ Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
Project SS's						
P1 Nitric Acid Plant (Burner Inlet to Stack)	Emissions Factor_{Project} = [(VSG_{Project} * NCSG_{Project} * 10⁻⁹ * OH_{Project}) / Project NAP] * (1 - Uncertainty/100);					
	Where: Emissions Factor is calculated leveraging the UNFCCC approved CDM methodology AM0034 v.02 – provided in Appendix A					
	Emissions Factor _{Project}	tN ₂ O/tHNO ₃	N/A	Modified from the UNFCCC approved CDM methodology AM0034 v.02, Appendix B	N/A	Emission Factor calculated on project emissions factor and not on the moving average project emission factor
	VSG = Mean stack gas volume flow rate	m ³ /hr	Measured	Sick Flow Sick Model 107	Continuous Monitoring 5-10 Second Intervals	Measured using an Analyzer meeting the Alberta CEMS Code
	NCSG = Mean concentration of N ₂ O emissions	mg N ₂ O/m ³	Measured	N2O Analyzer Procal P-200	Continuous Monitoring 5-10 Second Intervals	Measured using an Analyzer meeting the N ₂ O Meter Code (Appendix D) or the EN14181 Standard
	OH = operating hours in nth project campaign	hrs	Measured	Measure by the time clock, DCS, and plant NH3 flow rate.	Daily, compiled for entire campaign	Hours of production creating emissions
	Uncertainty	kg/h	Estimated	European Norm 14181	Calculated at implementation of monitoring system	Uncertainty Calculation Using EN14181 – Supported in Appendix C
Project NAP	tonnes of HNO ₃	Measured	Measure using a mass flow meter.	Daily, compiled for entire campaign	Total output quantity in nth project campaign	

1.0 Baseline SS	2. Parameter/ Variable	3. Unit	4. Measured/ Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
Baseline SS's						
B1 Nitric Acid Plant (Burner Inlet to Stack)	Emissions Factor_{Baseline} = [(VSG_{Baseline} * NCSG_{Baseline} * 10⁻⁹ * OH_{Baseline}) / Baseline NAP] * (1-Uncertainty/100)					
	Where: Emissions Factor is calculated leveraging the UNFCCC approved CDM methodology AM0034 v.02 – provided in Appendix A					
	Emissions Factor _{Baseline}	tN ₂ O/tHNO ₃	N/A	From the UNFCCC approved CDM methodology AM0034 v.02, Appendix B	N/A	Emission Factor calculated based on one full campaign prior to project implementation.
	VSG = Mean stack gas volume flow rate	m ³ /hr	Measured	Sick Flow Sick Model 107	Continuous Monitoring 5-10 Second Intervals	Measured using an Analyzer meeting the Alberta CEMS Code
	NCSG = Mean concentration of N ₂ O emissions	mg N ₂ O/m ³	Measured	N2O Analyzer Procal P-200	Continuous Monitoring 5-10 Second Intervals	Measured using an Analyzer meeting the N ₂ O Meter Code (Appendix D) or the EN14181 Standard
	OH = operating hours in baseline campaign	hrs	Measured	Measure by the time clock, DCS, and plant NH3 flow rate.	Daily, compiled for entire campaign	Hours of production creating emissions
	Uncertainty	kg/h	Estimated	European Norm 14181	Calculated at implementation of monitoring system	Uncertainty Calculation Using EN14181 – Supported in Appendix B
Baseline NAP	tonnes of HNO ₃	Measured	Measure using a mass flow meter.	Daily, compiled for entire campaign	Total output quantity	

2.5.2 Contingent Data Approaches

Contingent means for calculating or estimating the required data for the equations outlined in section 2.5.1 are included in the N₂O Meter Code. More specifically the following section applies to contingent data approaches.

Section 2.4.4 of the N₂O Meter Code states:

2.4.4. Backfilling and Substitution for Missing Data

Emission data that are missing due to a malfunction of the CEMS may be substituted for a period up to 120 hours for any single episode by averaging the previous 120 hours of data. Reference Method test data or data obtained from a monitor previously certified for the application may also be used for substituting data.

The technique used to obtain substitute data must be fully described in the QAP developed for each CEMS.

When a CEMS malfunction extends beyond 120 hours for any single episode, data must be generated by another authorized CEMS or valid Reference Method.

Other CEMS used for this purpose must meet all design and performance specifications given in this Code. When using another system, the effluent stream sample shall be extracted from the sample port used for the Reference method during certification of the installed CEMS.

Data substitution shall be limited to a maximum of 120 hours per calendar month.

2.6 Management of Data Quality

In general, data quality management must include sufficient data capture such that the mass and energy balances may be easily performed with the need for minimal assumptions and use of contingency procedures. The data should be of sufficient quality to fulfill the quantification requirements and be substantiated by company records for the purpose of verification.

The project proponent shall establish and apply quality management procedures to manage data and information. Written procedures should be established for each measurement task outlining responsibility, timing and record location requirements. The greater the rigour of the management system for the data, the more easily an audit will be to conduct for the project.

2.6.1 Record Keeping

Record keeping practises should include:

- a. Electronic recording of values of logged primary parameters measurement interval;

- b. Printing of monthly back-up hard copies of all captured data;
- c. Written logs of operations and maintenance of the project system notation of all shut-downs, start-ups and process adjustments;
- d. Retention of copies of logs and all logged data for a period of 7 years;
- e. Keeping all records available for review by a verification body.

2.6.2 Quality Assurance/Quality Control (QA/QC)

QA/QC can also be applied to add confidence that all measurements and calculations have been made correctly. These include, but are not limited to:

- a. Protecting monitoring equipment;
- b. Protecting records of monitored data (hard copy and electronic storage);
- c. Checking data integrity on a regular and periodic basis (manual assessment, comparing redundant metered data, and detection of outstanding data/records);
- d. Automatically zeroing N₂O meters on a daily basis
- e. Comparing current estimates with previous estimates as a 'reality check';
- f. Provide sufficient training to operators to perform maintenance and calibration of monitoring devices;
- g. Establish minimum experience and requirements for operators in charge of project and monitoring; and
- h. Performing recalculations to make sure no mathematical errors have been made.

Appendix A

Baseline Selection Justification
&
Estimated GHG Emissions Associated
With Transportation of Catalyst

Baseline Selection Justification

The baseline selected in this protocol is the campaign occurring previous to project implementation. A key issue to address when determining the baseline scenario is what other technologies are available to achieve N₂O abatement in nitric acid plants and could they be considered business as usual or common industry practice.

The United States Environmental Protection Agency’s “U.S. Adipic Acid and Nitric Acid Nitrous Oxide Emissions 1990-2020: Inventories, Projections and Opportunities for Reduction”, 2001 report presents the following findings and forecasts.

Nitric Acid

Currently, the nitric acid industry controls for NO_x, using both non-selective catalytic reduction (NSCR) and selective catalytic reduction (SCR) technologies. NSCR has the co-benefit of also reducing N₂O while SCR can actually increase N₂O emissions.

Exhibit 4 provides a description of the abatement options.

Exhibit 4. N₂O and NO_x Destruction Factors for NO_x Abatement Technologies

Abatement Technology	N ₂ O Destruction Factor ^a	NO _x Destruction Factor ^b	Extent of Implementation in the U.S.	Description
Non-Selective Catalytic Reduction	80-90%	94.7 to 99.1%	Widely installed in plants in the U.S. & Canada built between 1971-1977 (currently Approximately 20% in the U.S.).	Uses a fuel and a catalyst to consume free oxygen in the tail gas and to convert NO _x to elemental nitrogen. The gas from the NO _x abatement is passed through a gas expander for energy recovery.
Selective Catalytic Reduction	0%	86%	Approximately 80% of plants in the U.S. use either SCR or extended absorption.	Uses a catalyst and ammonia in the presence of oxygen to reduce NO _x to elemental nitrogen.
Extended Absorption	0%	93.5-97%	Approximately 80% of plants in the U.S. use either SCR or extended absorption.	Reduces NO _x emissions by increasing absorption efficiency and is achieved by extending the height of an existing tower or by adding a new tower.

a. IPCC, 2000

b. EPA, 1991

NSCR units were widely installed in nitric acid plants built between 1971 and 1977, because although they consume significant amounts of energy, energy was relatively cheap during that time. Nitric acid plants built in more recent years (i.e. post 1977) chose to abate NO_x emission through SCRs instead of NSCRs because of high-energy costs and

associated high flue gas temperatures. NSCR uses a fuel and a catalyst to consume free oxygen in the tail gas and convert NO_x to elemental nitrogen (Chartier, 1999). The gas from the NO_x abatement is passed through a gas expander for energy recovery. NSCR units produce stack gases in the 1000°F to 1100°F range that require more exotic materials for constructing the expander and have higher maintenance costs. NSCR can reduce N₂O emissions by 80 to 90 percent. Due to the high fuel consumption and high exhaust temperatures, it is estimated that only 20 percent of nitric acid plants in the U.S. currently use NSCR (Choe, et al., 1993). The remaining 80 percent of nitric acid plants use SCR or extended absorption units, neither of which is known to reduce N₂O emissions.

In addition, the Choe, et al. report also states:

Nitric Acid Forecast through 2020

Since the main end-uses for nitric acid are as components of fertilizer, explosives, and adipic acid, nitric acid production trends are closely correlated with the consumption/production trends of these three products. The nitric acid production growth estimates are calculated by taking a composite of the growth estimates for ammonium nitrate, aniline and toluene, and adipic acid, weighted by their respective production share. Ammonium nitrate production comprises 80 percent of nitric acid produced, adipic acid production 9 percent, and aniline and toluene production 11 percent. Ammonium nitrate production did not increase between 1998-1999 and is considered to have stabilized. It is estimated to grow at a rate of 0.3 percent between 2000-2020. The production of adipic acid and aniline and toluene are both estimated to grow at rate of 3% in this same time period (SRI, 1999 and Laurient, 2000). By multiplying the growth estimates of the end- uses by their production share, nitric acid emissions are projected to grow at a rate of 0.8 percent annually. Nitrous oxide emissions from nitric acid production will be influenced by the degree and type of NO_x emission control efforts that are applied in both new and existing nitric acid plants. The forecast assumes that no additional plants will be equipped with non-selective catalytic reduction (NSCR) or N₂O-specific control technologies through 2020.

The EPA report support the assumption that NSCR technology is not business as usual for nitric acid production facilities and will not be in the near future. Therefore for nitric acid plant that do not have NSCR technology installed at the facility, the baseline scenario can be defined as the operating condition prior to the implementation of the N₂O abatement project. The baseline scenario measurements are for the duration of one entire campaign prior to the implementation of the N₂O abatement project, and are used to determine a plant-specific baseline emission factor as per the CDM methodology AM0034 version 2.

Estimated GHG Emissions from Catalyst Transportation

GHG emissions will arise from the transportation of the catalyst both from the manufacturer to the project site, as well as from the project site to the manufacturer for recycling purposes. GHG emissions from this source, however, are expected to be quite minimal compared to total project GHG emissions reductions and, therefore, are excluded from quantification. Justification is provided below.

Method of Transportation

The catalyst is manufactured and packaged at a facility located in Germany. From the facility it is transported to Vancouver, BC, Canada by marine freight and delivered to the project location (Carseland, AB, Canada) by rail. At its end-of-life, the catalyst is shipped back to Germany using the same methods for recycling. Distances between these locations are provided below in Table 1. Any freight by trucking has been assumed to be minimal.

Table 1 - Transportation Distances

Transportation Method	Distance† (km)	Source
Marine (Hamburg port to Vancouver port)	33773	http://www.distances.com/distance.php
Rail (Vancouver to Carseland)	2072	http://www.maps.google.ca/

†Round trip distances

Catalyst Shipping and Use Data

The data presented in Table 2 shows typical catalyst shipping and usage data, required to determine GHG emission from shipping.

Table 2 - Catalyst Shipping and Usage Data

Weight per Barrel	200 kg
Barrels per Shipment	8
Average Campaign Length	240 days
Use of catalyst Shipment (8 barrels)	2 years

GHG Emission Calculation

GHG emissions resulting from the shipping of the catalyst are presented below. Table 3 contains the transportation emission factors used for marine and rail shipping¹.

¹ Canada's Greenhouse Gas Inventory, Factsheet 3 (1990-1999)

Table 3 - Shipping Emission Factors

Mode of Transportation	Emission Factor (g CO ₂ e/tonne-km)
Marine	130.3
Rail	21.2

Marine GHG Emissions

The calculation of GHG emissions from marine transportation for a shipment of 8 barrels is presented below;

$$\begin{aligned}
 \text{GHG Emissions}_{\text{marine,campaign}} &= 130.3 \text{ g CO}_2\text{e/tonne} \cdot \text{km} \times 200 \text{ kg/barrel} \times 8 \text{ barrels} \\
 &\times 0.001 \text{ tonnes/kg} \times 33773 \text{ km} \times 0.000001 \text{ tonnes/g} \\
 &= 7.04 \text{ tonnes CO}_2\text{e}
 \end{aligned}$$

A shipment will be used over a 2 year period therefore the GHG emissions per year associated with marine transportation of the catalyst are:

3 tonnes CO₂e per year

Rail GHG Emissions

Similar equations to those above may be applied to determine the GHG emissions resulting from a rail shipment of 8 barrels is presented below;

$$\begin{aligned}
 \text{GHG Emissions}_{\text{rail,campaign}} &= 21.2 \text{ g CO}_2\text{e/tonne} \cdot \text{km} \times 200 \text{ kg/barrel} \times 8 \text{ barrels} \\
 &\times 0.001 \text{ tonnes/kg} \times 2072 \text{ km} \times 0.000001 \text{ tonnes/g} \\
 &= 0.07 \text{ tonnes CO}_2\text{e}
 \end{aligned}$$

Or 0.04 tonnes CO₂e per year

Total GHG Emissions

The total maximum GHG emissions per year attributable for the shipment of catalyst account for approximately 3 tonnes CO₂e. This value can be considered insignificant over the course of these types of projects.

Appendix B

Quantification Methodology

UNFCCC/CCNUCC
CDM-Executive Board
AM0034 / Version 2
Sectoral Scope: 05
EB27

“Catalytic reduction of N₂O inside the ammonia burner of nitric acid plants”

Source

This baseline methodology is based on the proposed methodology NM0143 “Baseline Methodology for the Catalytic Reduction of N₂O inside the Ammonia Burner of Nitric Acid Plants” submitted by Nerve Environmental Services GMBH with components from NM0164 “Baseline methodology for project activities involving secondary catalytic N₂O abatement at an existing nitric acid plant” prepared by MGM International Ltd.

For more information regarding this proposal and its consideration by the Executive Board please refer to <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>.

This methodology also refers to the latest version of the “Tool for the demonstration and assessment of additionality” and approved methodology AM0028 “Catalytic N₂O destruction in the tail gas of Nitric Acid Plants”

Summary

Nitric Acid (HNO₃) is produced through the oxidation of ammonia (NH₃) on precious *metal catalyst gauze* in the ammonia burner of a nitric acid plant. Nitrous Oxide (N₂O) is a by-product gas produced in the manufacture of nitric acid. Waste N₂O from nitric acid production is typically released into the atmosphere, as it does not have any economic value or toxicity at emission levels typical of nitric acid manufacture.

Nitric acid plants operate on discrete production runs called “campaigns”. The start of a campaign is characterized by the installation of a new set of primary catalyst gauzes in the oxidation reactor. A set of precious *metal gauzes* (generally a platinum-rhodium alloy) is designed to operate either for a specific number of days or for a specific output of nitric acid. Over time the gauze decomposes and become less selective for the formation of NO. The production efficiency, therefore, drops and the formation of byproducts increases. At the end of the design operating life of each gauze, the nitric acid plant is shut down and the gauze is replaced by new gauze. The period of time beginning from the installation of a new gauze pack until the subsequent plant shut down is defined as a *campaign*.

This methodology covers project activities involving the installation of a dedicated N₂O abatement catalyst inside the ammonia burner of a nitric acid plant that catalytically reduces N₂O, once it has been formed in the Ammonia Oxidation Reactor.

Baseline emissions are determined by measuring N₂O concentration and total flow rate in the tail gas of the nitric acid plant. These measurements are for the duration of one entire campaign, and are used to determine a plant-specific baseline emissions factor (tN₂O/t HNO₃). A permitted range for parameters that influence the level of N₂O formation (e.g., ammonia, ammonia-air input, temperature and pressure) is established during the baseline campaign to define the permitted range for which emission reduction credits can be claimed during the crediting period. These permitted ranges must also be demonstrated to be within the specifications of the plant.

During the project activity, the measurements of N₂O and other parameters are carried out on a continuous basis and new emissions factors are established for each project campaign.

Total emission reductions for the project for a specific campaign are calculated by subtracting the project emissions factor from the baseline emissions factor and multiplying the result by the number of tonnes of nitric acid produced in the particular campaign.

The methodology requires the installation of a complete N₂O monitoring system that includes both a gas volume flow meter and an infrared gas analyser to determine the concentration of N₂O. The total mass of N₂O emissions is determined by multiplying the total volume flow by the concentration of N₂O.

Statistical analysis is applied to both the baseline emissions factor and each campaign-specific project emissions factor. Only those N₂O measurements taken when the plant is operating within the permitted range will be considered in the calculation of baseline emissions. The level of uncertainty determined for the N₂O monitoring equipment will be deducted from the baseline emissions factor.

The project emissions factor is calculated as the ‘moving average’ of project emission factor of all the campaigns completed at that point in time. To determine the total emission reductions for a particular project campaign the project emissions factor is higher of the two values: (i) the moving average project emissions factor; and (ii) the project emission factor for that particular campaign. Also, to account for any N₂O emission reductions that may occur anyway as a consequence of potential platinum deposit build up inside the plant, the moving average factor is capped at the level of the lowest campaign specific emissions factor observed during the first 10 campaigns.

Applicability

This Baseline Methodology is applicable to project activities that install a secondary N₂O abatement catalyst inside the ammonia burner of a nitric acid plant, underneath the precious metal gauze pack. The methodology is applicable under the following conditions apply:

- The applicability is limited to the existing production capacity measured in tonnes of nitric acid, where the commercial production had began no later than 31 December 2005. Definition of “existing” production capacity is applied for the process with the existing ammonia oxidization reactor where N₂O is generated and not for the process with new ammonia oxidizer. Existing production “capacity” is defined as the designed capacity, measured in tons of nitric acid per year.
- The project activity will not result in the shut down of any existing N₂O destruction or abatement facility or equipment in the plant;
- The project activity shall not affect the level of nitric acid production
- There are currently no regulatory requirements or incentives to reduce levels of N₂O emissions from nitric acid plants in the host country.
- No N₂O abatement technology is currently installed in the plant.
- The project activity will not increase NO_x emissions.
- NO_x abatement catalyst installed, if any, prior to the start of the project activity is not a Non-Selective Catalytic Reduction (NSCR) DeNO_x unit.
- Operation of the secondary N₂O abatement catalyst installed under the project activity does not lead to any process emissions of greenhouse gases, directly or indirectly.
- Continuous real-time measurements of N₂O concentration and total gas volume flow can be carried out in the stack:
 - Prior to the installation of the secondary catalyst for one campaign, *and*

- After the installation of the secondary catalyst throughout the chosen crediting period of the project activity

This Baseline Methodology shall be used in conjunction with the proposed new monitoring methodology AM0034 (“Catalytic reduction of N₂O inside the ammonia burner of nitric acid plants”).

Project Boundary

The spatial extent of the project boundary shall cover the facility and equipment for the complete nitric acid production process from the inlet to the ammonia burner to the stack. This includes all compressors, tail gas expander turbines and any NO_x abatement equipment installed. The only greenhouse gas to be included is the N₂O contained in the waste stream exiting the stack..

Flow diagrams of different types of nitric acid plants (high, medium and low pressure; mono and dual pressure; plant constructor) differ substantially. Therefore, a plant specific flow diagram should be provided in the Project Design Document to demonstrate the project boundary of the particular nitric acid plants(s) involved in the project activity.

Table 1: Overview of emission sources included or excluded from the project boundary

	Source	Gas	Included?	Justification/Explanation
Baseline	Nitric Acid Plant (Burner Inlet to Stack)	CO ₂	Excluded	The project does not lead to any change in CO ₂ or CH ₄ emissions and, therefore, these are not included.
		CH ₄	Excluded	
		N ₂ O	Included	
Project Activity	Nitric Acid Plant (Burner Inlet to Stack)	CO ₂	Excluded	The project does not lead to any change CO ₂ or CH ₄ emissions
		CH ₄	Excluded	
		N ₂ O	Included	
	Leakage emissions from production, transport, operation and decommissioning of the catalyst.	CO ₂	Excluded	No leakage emissions are expected.
		CH ₄	Excluded	
		N ₂ O	Excluded	

Identification of baseline scenario

The baseline scenario shall be identified using procedure for Identification of the baseline scenario described in the approved methodology AM0028 “Catalytic N₂O destruction in the tail gas of Nitric Acid Plants”.

Additionality

The additionality of the project activity shall be demonstrated and assessed using the latest version of the “Tool for demonstration and assessment of additionality” agreed by the Executive Board.

Because of the similarity of both approaches used to determine the baseline scenario and the additionality tool, step 1 of the “Tool for demonstration and assessment of additionality” may be omitted while assessing the additionality.

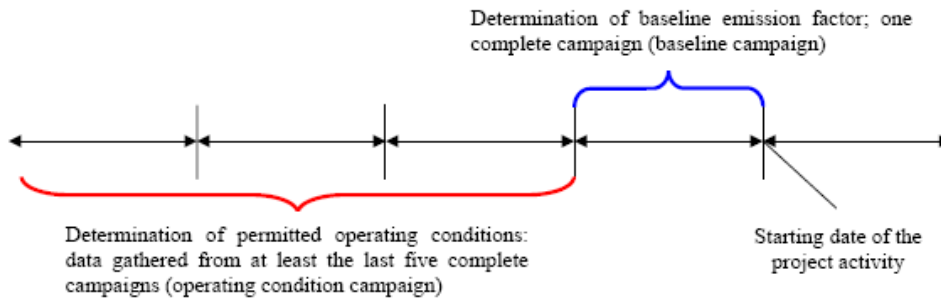
Consistency shall be ensured between the determination of the baseline scenario and the demonstration of additionality. The baseline scenario alternative selected in the previous section shall be used when applying steps 2 to 5 of the tool for demonstration and assessment of additionality.

In the event of re-assessment of the baseline scenario as a consequence of new NO_x regulations over the course of the crediting period of the proposed project activity, the re-assessment of baseline scenario shall be undertaken using the same 5 step process mentioned above. In such a case the additionality of the project too must be re-demonstrated.

Baseline Emissions

The baseline shall be established through continuous monitoring of both N₂O concentration and gas flow volume in the stack of the nitric acid plant for one complete campaign prior to project implementation.

The schematic of the procedure is as follows:



1. Determination of the permitted operating conditions of the nitric acid plant to avoid overestimation of baseline emissions:

In order to avoid the possibility that the operating conditions of the nitric acid production plant are modified in such a way that increases N₂O generation during the baseline campaign, the normal ranges for operating conditions shall be determined for the following parameters: (i) oxidation temperature; (ii) oxidation pressure; (iii) ammonia gas flow rate, and (iv) air input flow rates. The permitted range shall be established using the procedures described below. Note that data for these parameters is routinely logged in the process control systems of the plant.

i. Oxidation temperature and pressure:

Process parameters to be monitored are the following:

OT _h	Oxidation temperature for each hour	(°C)
OP _h	Oxidation pressure for each hour	(Pa)
OT _{normal}	Normal range for oxidation temperature	(°C)
OP _{normal}	Normal range for oxidation pressure	(Pa)

The “permitted range” for oxidation temperature and pressure is to be determined using one of the following sources:

- a) Historical data for the operating range of temperature and pressure from the previous five campaigns

- (or fewer, if the plant has not been operating for five campaigns); or, then
 b) If no data on historical temperatures and pressures is available, the range of temperature and pressure stipulated in the operating manual for the existing equipment; or,
 c) If no operating manual is available or the operating manual gives insufficient information, from an appropriate technical literature source¹.

If option a) is selected, the permitted range is determined through a statistical analysis of the historical data in which the time series data is to be interpreted as a sample for a stochastic variable. All data that falls within the upper and lower 2.5% percentiles of the sample distribution is defined as abnormal and shall be eliminated. The permitted range of operating temperature and pressure is then assigned as the historical minimum (value of parameter below which 2.5% of the observation lie) and maximum operating conditions (value of parameter exceeded by 2.5% of observations).

ii. Ammonia gas flow rates and ammonia to air ratio input into the ammonia oxidation reactor (AOR):

Parameters to be monitored

AFR	Ammonia gas flow rate to the AOR	(tNH ₃ /h)
AFR _{max}	Maximum ammonia gas flow rate to the AOR	(tNH ₃ /h)
AIFR _{__}	Ammonia to air ratio	(%)
AIFR _{max_}	Maximum ammonia to air ratio	(%)

The upper limits for ammonia flow and ammonia to air ratio shall be determined using one of the following three options, in preferential order:

- a. Historical maximum operating data for hourly ammonia gas and ammonia to air ratio for the previous five campaigns (or fewer, if the plant has not been operating for five campaigns; excluding abnormal campaigns; or,
- b. If no data is available, calculation of the maximum permitted ammonia gas flow rates and ammonia to air ratio as specified by the ammonia oxidation catalyst manufacturer or for typical catalyst loadings; or,
- c. If information for (b) above is not available, based on a relevant technical literature source.

Once the permitted ranges for pressure, temperature, ammonia flow rate and ammonia to air ratio are determined, it must also be demonstrated that these ranges are within the specifications of the facility. If not, the baseline campaign must be reassessed.

2. Determination of baseline emission factor: measurement procedure for N₂O concentration and gas volume flow

N₂O concentration and gas volume flow are to be monitored throughout the baseline campaign. The monitoring system is to be installed using the European Norm 14181 (2004). This monitoring system provides separate readings for N₂O concentration and gas flow volume for a defined period of time (e.g. every hour of operation, it provides an average of the measured values for the previous 60 minutes). Error readings (e.g. downtime or malfunction) and extreme values are to be automatically eliminated from the output data series by the monitoring system.

¹ (e.g. from Ullmann's Encyclopedia of Industrial Chemistry, Fifth, completely revised edition, Volume A 17, VCH, 1991, P. 298, Table 3. or other standard reference work or literature source

Measurement results can be distorted before and after periods of downtime or malfunction of the monitoring system and can lead to mavericks. To eliminate such extremes and to ensure a conservative approach, the following statistical evaluation is to be applied to the complete data series of N₂O concentration as well as to the data series for gas volume flow. The statistical procedure will be applied to data obtained after eliminating data measured for periods where the plant operated outside the permitted ranges:

- a) Calculate the sample mean (\bar{x})
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values (volume of stack gas (VSG) and N₂O concentration of stack gas (NCSG))

The average mass of N₂O emissions per hour is estimated as product of the NCSG and VSG. The N₂O emissions per campaign are estimates product of N₂O emission per hour and the total number of complete hours of operation of the campaign using the following equation:

$$BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC} \quad (tN_2O) \quad (1)$$

The plant specific baseline emissions factor representing the average N₂O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N₂O emissions by the total output of 100% concentrated nitric acid for that period. The overall uncertainty of the monitoring system shall also be determined and the measurement error will be expressed as a percentage (*UNC*). The N₂O emission factor per tonne of nitric acid produced in the baseline period (EF_{BL}) shall then be reduced by the estimated percentage error as follows:

$$EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100) \quad (tN_2O/tHNO_3) \quad (2)$$

where:

Variable	Definition
EF_{BL}	Baseline N ₂ O emissions factor (tN ₂ O/tHNO ₃)
BE_{BC}	Total N ₂ O emissions during the baseline campaign (tN ₂ O)
$NCSG_{BC}$	Mean concentration of N ₂ O in the stack gas during the baseline campaign (mgN ₂ O/m ³)
OH_{BC}	Operating hours of the baseline campaign (h)
VSG_{BC}	Mean gas volume flow rate at the stack in the baseline measurement period (m ³ /h)
NAP_{BC}	Nitric acid production during the baseline campaign (tHNO ₃)
UNC	Overall uncertainty of the monitoring system (%), calculated as the Combined uncertainty of the applied monitoring equipment

In the absence of any national or regional regulations for N₂O emissions, the resulting EF_{BL} will be used as the baseline emission factor.

NOTE: Under certain circumstances, the operating conditions during the measurement period used to determine baseline N₂O emission factor may be outside the permitted range or limit corresponding to normal operating conditions. For instance, temperature, pressure, ammonia flow rate or ammonia to air ratio may be outside the permitted condition. Any N₂O baseline data that is measured during hours where the operating conditions are outside the permitted range must be eliminated from the calculation of the baseline emissions factor. If historical data and baseline data for each minute are available, values could be eliminated on a minute-by-minute basis.

The baseline campaign is not valid and must be repeated if the plant operates outside of the permitted range for more than 50% of the duration of the baseline campaign.

In order to further ensure that operating conditions during the baseline campaign are representative of normal operating conditions, statistical tests should be performed to compare the average values of the permitted operating conditions with the average values obtained during the baseline determination period.

If it can be concluded with 95% confidence level, in any of the tests, that the two values are different, then the baseline determination should be repeated

Impact of regulations:

Should N₂O emissions regulations that apply to nitric acid plants be introduced in the host country or jurisdiction covering the location of the project activity, such regulations shall be compared to the calculated baseline factor for the project (EF_{BL}), regardless of whether the regulatory level is expressed as:

- An absolute cap on the total volume of N₂O emissions for a set period;
- A relative limit on N₂O emissions expressed as a quantity per unit of output; or
- A threshold value for specific N₂O mass flow in the stack;
-

In this case, a corresponding plant-specific emissions factor cap (max. allowed tN₂O/tHNO₃) is to be derived from the regulatory level. If the regulatory limit is lower than the baseline factor determined for the project, the regulatory limit shall serve as the new baseline factor, that is:

if $EF_{BL} > EF_{reg}$,

then the baseline N₂O emission factor shall be EF_{reg} for all calculations.

where:

Variable Definition

EF _{BL}	Baseline emissions factor	(tN ₂ O/tHNO ₃)
EF _{reg}	Emissions level set by newly introduced policies or regulations	(tN ₂ O/tHNO ₃).

Such EF_{reg} shall be determined according to the nature of the regulation (e.g. in terms of absolute emission, by-product rate, concentration in stack gas), as described in the approved methodology AM0028.

The composition of the ammonia oxidation catalyst:

If the composition of the ammonia oxidation catalyst used for the baseline campaign and after the implementation of the project are identical to that used in the campaign for setting the operating conditions (previous five campaigns), then there shall be no limitations on N₂O baseline emissions. A change in the composition of the ammonia oxidation catalyst in the baseline campaign to a composition other than that used in the previous five campaigns, is permissible without any limitation on the N₂O baseline emissions if the following conditions are met

- (i) The baseline catalyst composition is considered as common practice in the industry, or

(ii) The change in catalyst composition is justified by its availability, performance, relevant literature etc.

Otherwise, the baseline emission factor shall be set to the conservative IPCC default emission factor for N₂O from nitric acid plants which have not installed N₂O destruction measures (4.5 kg-N₂O / t HNO₃).

If the nitric acid plant operator has changed the composition of the ammonia oxidation catalyst in a project campaign to a composition not used in the baseline campaign, the project proponent could:

- 1) Repeat the baseline campaign to determine a new baseline emissions factor (tN₂O/tHNO₃), compare it to the previous baseline emissions factor and adopt the lower figure as EF_{BL}, or
- 2) Set the baseline emissions factor to the conservative IPCC default emission factor for N₂O from nitric acid plants which have not installed N₂O destruction measures (4.5 kg-N₂O / t HNO₃).

Parameters to be monitored for composition of the catalyst are as follows:

GS _{normal}	Gauze supplier for the operation condition campaigns
GS _{BL}	Gauze supplier for baseline campaign
GS _{project}	Gauze supplier for the project campaign
G _{normal}	Gauze composition for the operation condition campaigns
GC _{BL}	Gauze composition for baseline campaign
GC _{project}	Gauze composition for the project campaign

Campaign Length

In order to take into account the variations in campaign length and its influence on N₂O emission levels, the historic campaign lengths and the baseline campaign length are to be determined and compared to the project campaign length. Campaign length is defined as the total number of metric tonnes of nitric acid at 100% concentration produced with one set of gauzes.

Historic Campaign Length

The average historic campaign length (CL_{normal}) defined as the average campaign length for the historic campaigns used to define operating condition (the previous five campaigns), will be used as a cap on the length of the baseline campaign.

Baseline Campaign Length (CL_{BL})

If CL_{BL} ≤ CL_{normal}

all N₂O values measured during the baseline campaign can be used for the calculation of EF_{BL} (subject to the elimination of data that was monitored during times where the plant was operating outside of the “permitted range”).

If CL_{BL} > CL_{normal}

N₂O values that were measured beyond the length of CL_{normal} during the production of the quantity of nitric acid (i.e. the final tonnes produced) are to be eliminated from the calculation of EF_{BL}.

Project Emissions

Over the duration of the project activity, N₂O concentration and gas volume flow in the stack of the nitric acid plant as well as the temperature and pressure of ammonia gas flow and ammonia-to-air ratio will be measured continuously.

Estimation of campaign-specific project emissions

The monitoring system is to be installed using the guidance document EN 14181 and will provide separate readings for N₂O concentration and gas flow volume for a defined period of time (e.g. every hour of operation, i.e. an average of the measuring values of the past 60 minutes). Error readings (e.g. downtime or malfunction) and extreme values are automatically eliminated from the output data series by the monitoring system. Next, the same statistical evaluation that was applied to the baseline data series is to be applied to the project data series:

- a) Calculate the sample mean (\bar{x})
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values

$$PE_n = VSG * NCSG * 10^{-9} * OH \quad (tN_2O) \quad (3)$$

where:

Variable	Definition
VSG	Mean stack gas volume flow rate for the project campaign (m ³ /h)
NCSG	Mean concentration of N ₂ O in the stack gas for the project campaign (mgN ₂ O/m ³)
PE _n	Total N ₂ O emissions of the nth project campaign (tN ₂ O)
OH	Is the number of hours of operation in the specific monitoring period (h)

Derivation of a moving average emission factor

In order to take into account possible long-term emissions trends over the duration of the project activity and to take a conservative approach a moving average emission factor shall be estimated as follows:

Step 1: estimate campaign specific emissions factor for each campaign during the project’s crediting period by dividing the total mass of N₂O emissions during that campaign by the total production of 100% concentrated nitric acid during that same campaign.

For example, for campaign n the campaign specific emission factor would be:

$$EF_n = PE_n / NAP_n \quad (tN_2O/tHNO_3) \quad (4)$$

Step 2: estimate a moving average emissions factor be calculated at the end of a campaign n as follows:

$$EF_{ma,n} = (EF_1 + EF_2 + \dots + EF_n) / n \quad (tN_2O/tHNO_3) \quad (5)$$

This process is repeated for each campaign such that a moving average, EF_{ma,n}, is established over time, becoming more representative and precise with each additional campaign.

To calculate the total emission reductions achieved in a campaign in formula (7) below, the higher of the two values EF_{ma,n} and EF_n shall be applied as the emission factor relevant for the particular campaign to be used to calculate emissions reductions (EF_p). Thus:

$$\begin{aligned} &\text{If } EF_{ma,n} > EF_n \text{ then } EF_p = EF_{ma,n} \\ &\text{If } EF_{ma,n} < EF_n \text{ then } EF_p = EF_n \end{aligned} \tag{6}$$

Where:

Variable	Definition
EF _n	Emission factor calculated for a specific project campaign (tN ₂ O/tHNO ₃)
EF _{ma,n}	Moving average (ma) emission factor of after n th campaigns, including the current campaign (tN ₂ O/tHNO ₃)
n	Number of campaigns to date
EF _p	Emissions factor that will be applied to calculate the emissions reductions from this specific campaign (i.e. the higher of EF _x and EF _n) (tN ₂ O/tHNO ₃)

Minimum project emission factor

A campaign-specific emissions factor shall be used to cap any potential long-term trend towards decreasing N₂O emissions that may result from a potential built up of platinum deposits. After the first ten campaigns of the crediting period of the project, the lowest EF_n observed during those campaigns will be adopted as a minimum (EF_{min}). If any of the later project campaigns results in a EF_n that is lower than EF_{min}, the calculation of the emission reductions for that particular campaign shall use EF_{min} and not EF_n.²

where:

Variable	Definition
EF _{min}	Is equal to the lowest EF _n observed during the first 10 campaigns of the project crediting period (N ₂ O/tHNO ₃)

Project Campaign Length

a. Longer Project Campaign

If the length of each individual project campaign CL_n is longer than or equal to the average historic campaign length CL_{normal}, then all N₂O values measured during the baseline campaign can be used for the calculation of EF (subject to the elimination of data from the Ammonia/Air analysis, see above).

b. Shorter Project Campaign

² In practice this will mean that, if the assumption that platinum deposits do have a reducing effect on N₂O emissions is correct, then an increasing adoption of EF_{min} instead of EF_n should be experienced as the project progresses through its crediting period.

If $CL_n < CL_{normal}$, recalculate EF_{BL} by eliminating those N₂O values that were obtained during the production of tonnes of nitric acid beyond the CL_n (i.e. the last tonnes produced) from the calculation of EF_n .

Leakage

No leakage calculation is required.

Emission Reductions

The emission reductions for the project activity over a specific campaign are determined by deducting the campaign-specific emission factor from the baseline emission factor and multiplying the result by the production output of 100% concentrated nitric acid over the campaign period and the GWP of N₂O:

$$ER = (EF_{BL} - EF_P) * NAP * GWP_{N_2O} \quad (tCO_2e) \quad (7)$$

Where:

Variable	Definition
ER	Emission reductions of the project for the specific campaign (tCO _{2e})
NAP	Nitric acid production for the project campaign (tHNO ₃). The maximum value of NAP shall not exceed the design capacity.
EF _{BL}	Baseline emissions factor (tN ₂ O/tHNO ₃)
EF _P	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of EF _{ma,n} and EF _n)

By nameplate (design) implies the total yearly capacity (considering 365 days of operation per year) as per the documentation of the plant technology provider (such as the Operation Manual). If the plant has been modified to increase production, and such de-bottleneck or expansion projects were completed before December 2005, then the new capacity is considered nameplate, provided proper documentation of the projects is available (such as, but not limited to: properly dated engineering plans or blueprints, engineering, materials and/or equipment expenses, or third party construction services, etc.).

Appendix C

Uncertainty Calculation Methodology

UNCERTAINTY CALCULATION USING EN14181

Introduction

This document describes the estimation of uncertainty for the measurement of the nitrous oxide (N₂O) emission rate from the Number 1 Nitric Acid Plant (NAP1) at Orica Canada's Carseland works.

This measurement will provide evidence of the level of N₂O emission before and after the installation of abatement technology. A methodology document, 'Catalytic Nitrous Oxide Abatement Project Orica – Carseland, Alberta'⁴, describes the data collection and retention requirements for this measurement. This document requires the calculation of the uncertainty of the N₂O emission rate for use in the calculation of the amount of carbon emission reduction credits awarded to the plant.

Measurement System

Overview of Measurement System

The measurement system provides a measure of the emission rate of N₂O from the stack (the measurand). The measurement system expresses the measurand in kg/h.

The measurement system consists of three independent instruments:

1. in-situ gas analyser (analyser);
2. ultrasonic flow meter (flowmeter); and
3. temperature probe;

Analyser

The analyser, by Procal (U.K.), measures the volume fraction of N₂O in the tail gas passing through its sample chamber. The result is expressed as N₂O in parts per million volume (ppmv) (or volume N₂O x 10⁶ per volume all components at standard temperature and pressure).

The sample chamber is located within the stack (in-situ). The sample is continuously heated to maintain a constant sample temperature. There is no other sample conditioning. The unit uses internal pressure and temperature probes to compensate for variations in these conditions in the sample gas.

Analyser calibration involves passing N₂O gas of known concentration through the analyser sample chamber. Cylinder Gas Audits (CGA) regularly check that the calibration gas composition matches the stated concentration.

⁴ Orica, June 2007.

The analyser has certification to EN14181 standard for many gases (including NO_x). Procal (U.K.) are in the process of obtaining certification for N₂O.

Flowmeter

The ultrasonic flow meter, by SickMaihak (Germany) model Flowsic 107, measures the actual rate of gas flow in the stack. The result is expressed in m/h (meters per hour). This instrument completes a self zero and span every 24 hours.

Temperature

The temperature probe provides temperature information for the calculation of the flow rate at standard conditions. The temperature probe expresses results in °C.

Typical Readings

Table 4 provides typical readings for the instruments described in sections 0, 0, and 0. This document will use these typical readings as the test value for the uncertainty estimate.

Table 4: Typical readings for the instruments in the measurements system.

PPD Tag	Variable	Source	Expected/ Typical Reading	Units
ppmv	N2O Meter	Analyser	900	ppm
VEL	Flowrate	Flowmeter	127800	m/h
TEMP	Temperature	Temperature probe	117	°C
	Stack Area	Design Document	1.131	m ²

Conclusions of Measurement System

The measurement system consists of four independent instruments. The site's DCS (distributed control system) collects the measures from the four instruments. The DCS calculates the measurand using Equation 1.

$$\begin{aligned}
 BE &= \frac{VSG \times NCSG}{1000000} \\
 &= \frac{\left(\frac{(VEL)(stack\ area)(PRESS)(273.15)}{1000(273.15 + TEMP)} \right) \left(\frac{(ppmv)(MW_{N_2O})}{Std.V} \right)}{1000000}
 \end{aligned}$$

Equation 1

where:

BE = the measurand

ppmv = N₂O concentration (ppmv)

VEL = gas velocity (m/h)

stack area = stack area (m²)

PRESS = gas pressure (mbar) = 1000 mbar
 TEMP = gas temperature (°C)

Collecting the constants leaves:

$$BE = \frac{c_1(\text{VEL})(\text{stack area})(\text{PRESS})(\text{ppmv})}{(c_2 + \text{TEMP})}$$

Equation 2

where:

$$c_1 = \frac{\left(\frac{273.15}{1000}\right)\left(\frac{\text{MW}_{\text{N}_2\text{O}}}{\text{Std.V}}\right)}{1000000} = \frac{\left(\frac{273.15}{1000}\right)\left(\frac{44.0126}{22.4}\right)}{1000000}; \text{ and}$$

$$c_2 = 273.15$$

Using the typical readings in Table 4, gives a value of BE of 179 kg/h.

Calculation of Uncertainty

Basis for Calculation

The basis for the calculation of uncertainty for this project is the recommendation of the European Norm 14181 (EN14181) as this represents the highest standard available for the calculation of uncertainty. EN14181 states that QAL1 (of EN ISO 14956) is used to establish the uncertainty of the measurement system is within required bounds. Of the QAL1 process, EN14181 states⁵:

‘In QAL1 the total uncertainty required by the applicable regulation is calculated by summing in an appropriate manner all the relevant uncertainty components arising from the individual performance characteristics.’

For continuing monitoring of uncertainty, EN14181 states⁶:

‘The standard deviation, s_{AMS} shall be derived from the information obtained for the QAL1 calculations. s_{AMS} shall be calculated considering plant conditions and not the test conditions during QAL1’

Consequently, the basis of this calculation is Section 8 of ISO 14956⁷.

⁵ European Committee for Standardisation (2004), EN14181-Stationary Source Emissions-Quality Assurance of Automated Measuring Systems, European Committee for Standardisation, Section 5.1.

⁶ *ibid.* Section 7.2.

⁷ ISO (2002), ISO14956-Air Quality-Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty, ISO.

Uncertainty Equation

ISO 14956 provides the following equation to calculate uncertainty in a measurand (Equation 4, pg. 8).

$$u_c^2 = \sum_i w_i^2 u^2(y_i) + \sum_j b_j^2 u^2(\Delta x_j)$$

Equation 3

where:

c = the measurand = BE

u_c = the combined standard uncertainty of c

i = the index of an input quantity (to the equation of c) with an uncertainty

w_i = the weighting factor of y_i ; first derivative $w_i = \frac{\partial c(y_1, \dots, y_n)}{\partial y_i}$

$u(y_i)$ = the standard uncertainty (deviation) of y_i

y_i = an input quantity to the measurand

j = the index of a non-ideal influence during calibration (i.e. differences between the calibration temperature and the actual temperature attained during calibration)

b_j = the sensitivity of the measurand to Δx_j

$u(\Delta x_j)$ = the standard uncertainty (deviation) of Δx_j

Δx_j = non-ideal influence during calibration (i.e. differences between the calibration temperature and the actual temperature attained during calibration)

Uncertainty of BE

Equation 2 shows the calculation method for the measurand, BE.

Thus y_i for this measurand are:

$y_{\text{ppmv}} = \text{N}_2\text{O concentration (ppmv) (analyser)}$

$y_{\text{VEL}} = \text{gas velocity (m/h) (flowmeter)}$

$y_{\text{stack area}} = \text{stack area (m}^2\text{)}$

$y_{\text{TEMP}} = \text{gas temperature (}^\circ\text{C)}$

For ease of estimating the partial derivative, gas temperature is converted to absolute:

$\text{TEMPA} = (c_2 + \text{TEMP}) = \text{gas temperature (K)}$

The weighting factors, w_i , for these y_i are:

$$w_{\text{ppmv}} = \frac{\partial c}{\partial \text{ppmv}} = \frac{c_1(\text{stack area})(\text{PRESS})(\text{VEL})}{(c_2 + \text{TEMPA})} = 0.201$$

$$w_{\text{VEL}} = \frac{\partial c}{\partial \text{VEL}} = \frac{c_1(\text{stack area})(\text{PRESS})(\text{ppmv})}{(c_2 + \text{TEMPA})} = 0.00141$$

$$w_{\text{stack area}} = \frac{\partial c}{\partial \text{stack area}} = \frac{c_1(\text{VEL})(\text{PRESS})(\text{ppmv})}{(c_2 + \text{TEMPA})} = 160$$

$$w_{\text{TEMPA}} = \frac{\partial c}{\partial \text{TEMPA}} = - \frac{c_1 (\text{stack area})(\text{PRESS})(\text{VEL})(\text{ppmv})}{(c_2 + \text{TEMP})^2} = 0.463$$

$u(y_{\text{ppmv}})$ = uncertainty in N₂O concentration (ppmv) (analyser)

Basis: The basis for this uncertainty calculation should be the uncertainty calculation made to obtain QAL1 under EN14181 (e.g. ISO14956). Actual data from site would then be included to update the analysis. However, the vendor, Procal, is in the process of MCERTS testing (MCERTS is the equivalent certification to EN14181 for the UK). Consequently, none of the input and influence factors are known for this instrument. Orica should update this uncertainty calculation following the completion of the certification process and delivery by Procal of the certification report.

For the moment, the uncertainty calculation will assume that the two most significant sources of uncertainty are: reproducibility and the uncertainty in the calibration gas composition.

The instrument calibration by Procal shows the instrument measured 4932 ppm for N₂O gas of composition 4955 ppm⁸. Thus, the value of the partial uncertainty is:

$$u_{\text{rep}} = 1.(4955 - 4932) = 24 \text{ ppmv}$$

The calibration gas certificates show the uncertainty of calibration gas is 2 %. Thus, the value of the partial uncertainty is:

$$u_{\text{cal}} = 1. \frac{(0.02)(\text{ppmv})}{\sqrt{3}} = 1. \frac{(0.02)(900)}{\sqrt{3}} = 10.4 \text{ ppmv}$$

The combined uncertainty for the analyser is:

$$u(y_{\text{ppmv}}) = \sqrt{(u_{\text{rep}})^2 + (u_{\text{cal}})^2} = \sqrt{(23.0)^2 + (10.4)^2} = 25.2 \text{ ppmv}$$

$u(y_{\text{VEL}})$ = gas velocity (m/h) (flow meter)

Basis: Manufacture specification sheet for Flowsic 107⁹

Error is ±1% of full scale (30 m/s) = ±0.3 m/s = ±1080 m/hr

⁸ Procal (2007), 'Certificate of Calibration', attached.

⁹ Flowsic 107 'Technical Specifications', attached.

$$u(y_{VEL}) = 1. \frac{(1080)(m/h)}{\sqrt{3}} = 624m/h$$

$$u(y_{stack\ area}) = \text{stack area (m}^2\text{)}$$

Basis: Design Documents – Pipe Specifications

$$u(y_{stack\ area}) = 1. \frac{(0.00005)(\text{stack area})}{\sqrt{3}} = 1. \frac{(0.00005)(1.131)}{\sqrt{3}} = 0.000033\text{ m}^2$$

$$u(y_{TEMP}) = \text{gas temperature (}^\circ\text{C) (temperature probe)}$$

Basis: Relative accuracy test results (

Table 5)

Table 5: Summary of Previous Relative Accuracy Test Audit results

Rata Date	Temperature (+/- Deg C)
Oct-07	3.2
Apr-07	1.1
Aug-06	2.0
Apr-06	2.0
Oct-05	0.2
Average	1.7

$$u(y_{TEMP}) = 1 \cdot \frac{1.7}{\sqrt{3}} = 0.98 \text{ } ^\circ\text{C}$$

None of this information includes confidence limits for these uncertainties. It is assumed that the distribution is symmetric. Consequently, ISO14956 Equation 8 is used to convert the uncertainty range into a standard uncertainty.

Estimation of the combined uncertainty is through application of Equation 3:

$$u_c^2 = \sum_i w_i^2 u^2(y_i) + \sum_j b_j^2 u^2(\Delta x_j)$$

It is assumed that the input parameter uncertainties, $u^2(y_i)$, include all significant influence parameter uncertainties, $u^2(\Delta x_j)$.

$$u_c^2 = w_{ppmv}^2 u^2(y_{ppmv}) + w_{VEL}^2 u^2(y_{VEL}) + w_{stack\ area}^2 u^2(y_{stack\ area}) + w_{TEMP}^2 u^2(y_{TEMP})$$

$$u_c = \sqrt{(0.201)^2 (25.2)^2 + (0.00141)^2 (624)^2 + (160)^2 (0.000033)^2 + (0.463)^2 (0.98)^2}$$

$$= 5.2 \text{ kg/h}$$

Estimation of the expanded uncertainty uses Equation 17 of ISO 14956:

$$U_c = k \cdot u_c = 2.6 \cdot 5.2$$

$$= 10.4 \text{ kg/h}$$

Conclusions of Calculation of Uncertainty

Section 3 shows that the measurand at the typical readings shown in Table 4 was 179 kg/h. Thus, the uncertainty of the measurand is 179 ± 10.4 kg/h.

Conclusions and Recommendations

The uncertainty of the measurement system was found to be 179 ± 10.4 kg/h using the typical readings shown in Table 4.

The uncertainty estimation for the analyser was limited as the QAL1 results for the analyser are not yet available. The instrument vendor is in the process of obtaining this certification. It is recommended that Orca update this calculation following the completion of the QAL1 and the delivery by Procal of the certification report.

John May
4th June 2008

Appendix D
N₂O Meter (CEMS) Code
Draft

N₂O METER (CEMS) CODE

October 24, 2008: Draft

Background to this Document

The Alberta CEMS Code 1998 was used as the base document for creation of this Code for managing the N₂O meter to be installed as part of a project for catalytic nitrous oxide abatement from nitric acid production.

Canadian EPS 1/PG/7 was reviewed and some features were incorporated into this document.

The sections on NO_x, temperature, pressure and flow instrument have been retained in this document for completeness and reference only. The Alberta CEMS code will be used to manage these instruments since they are used in common for the NO_x analyzer and N₂O analyzer.

Section 4.5.8 is for reference only since N₂O does not have a standard reference method. SRC has designed a method for measuring N₂O based on FTIR unit.

1.0 INTRODUCTION

1.1 General

This code establishes requirements for the installation, operation, maintenance, and certification of a continuous emission monitoring system for nitrous oxide. These requirements will ensure effective measurement, recording, and standardized reporting of specified emissions and other parameters. In addition, the code establishes requirements for alternative monitoring systems and for the quality assurance and quality control of continuous emission monitoring data.

1.2 Purpose and Intent

The Alberta Continuous Emissions Monitoring System Code (CEMS Code) is largely based on methodology developed and used by both the U.S. Environmental Protection Agency and Environment Canada. This document uses the 1998 Alberta CEMS code as a basis for the development of a CEMS Code for N₂O to be used in the “*Quantification Protocol for Nitrous Oxide Abatement from Nitric Acid Production*” under Alberta’s Specified Gas Emitters Regulation. This CEMS Code for N₂O contains performance specifications for N₂O continuous emission monitoring system requirements.

1.3 CEMS Data Use

The CEMS data generated will be used for verification and validation of GHG offsets generated by abatement on a nitric acid plant.

1.4 Application of CEMS Code New and Existing CEMS Installations

1.4.1 Code Requirements for New Installations

All new CEMS required after the issuance of this Code must comply with all design, installation, performance, and quality control requirements of this Code. All new CEMS will be required to conduct the initial performance specification testing as contained in this CEMS Code and be certified in accordance with Section 4.0 of this code.

1.4.2 Code Requirements for Existing Installations

All existing CEMS required after the issuance of this Code must comply with all design, installation, performance, and quality control requirements of this Code. All existing CEMS will be required to conduct the initial performance specification testing as contained in this CEMS Code and be certified in accordance during or prior to the project baseline campaign, in accordance to Section 4.0 of this code.

1.5 CEMS Technology

In general, monitoring techniques are based on the direct measurement of both physical and chemical properties of the component of interest. The method selected for the gas analysis depends primarily upon the characteristics of the subject gas, but it can also be affected by other parameters such as regulatory requirements and stack conditions. Commonly used analytical techniques include those of spectroscopic absorption, luminescence, electroanalysis, electro-chemical analysis and paramagnetism.

The specifications of this Code address the use of independent certified gases for calibration and audit for CEMS that accept calibration gases.

1.6 CEMS Data Retention Requirements

Each facility shall maintain "raw" data for a period of at least 3 years and "summary" data for a period of at least 10 years. "Raw" data must be consistent with the definition of continuous as defined in Appendix A and should provide for "satisfactory demonstration" of quality control activities as defined in the CEMS Code and the facility Quality Assurance Plan (QAP). The media for storage of "raw" data shall be designated by the facility and documented in the facility QAP. Raw data shall be made available for inspection if requested.

2.0 DESIGN SPECIFICATIONS

Continuous Emission Monitoring Systems for monitoring gases consists of the following four subsystems:

- ❑ Sample Interface/Conditioning;
- ❑ Gas Analyzers;
- ❑ Data Acquisition;
- ❑ Flow monitor (where applicable).

The acceptability of emission monitoring systems is in general, performance based; however minimal design specifications are specified for gas analyzers, and flow monitoring systems. These specifications have been established either to ensure the overall stability of the CEMS once the analyzers are incorporated into the system, or to ensure that accurate readings will be obtained for the parameter being measured. Procedures for the verification of design specifications are given in Section 4.0.

The chosen range for the N₂O monitor is specified in Table 1. If the average monthly parameter of any analyzer should fall outside these limits, the analyzer span should be adjusted so that the average is brought back within these limits. Data that fall outside the range of an analyzer are considered to be missing.

2.1 Design Specifications for Gas Analyzers

Design specifications for gas analyzers for monitoring nitrous oxide is given in Table 1;

Table 1 Design Specifications for CEM system gas analyzers

Design Specifications	N ₂ O Analyzers
Lower detection limit	≤ 2% of span
Interference rejection (sum total)	≤ ± 4% of span
Response time (95%)	200 s (Max.)
Temperature-responsive zero drift ^a	≤ ± 2% of span
Temperature-responsive span drift ^a	≤ ± 4% of span
Analyzer Range	≥ 1.5 times the maximum of the

^a for every 10°C change in analyzer operating temperature.

2.1.1 Interference Rejection

Each analyzer shall exhibit a response of less than that specified in Tables 1 for the sum of all interferences due to other gas constituents as measured by the

procedures given in Section 4.0.

2.1.2 Temperature-Responsive Drifts

Each pollutant gas analyzer used in the system must exhibit a zero drift less than 2% of the full-scale setting for any 10°C change over the temperature range of 5° to 35°C. Additionally, each analyzer must exhibit a span drift of less than 4% of the full-scale setting for any 10°C change in temperature from 5° to 35°C. Both the zero and span drift tests are to be carried out within the acceptable temperature operating range of the analyzer, as specified by the manufacturer. Follow the procedures outlined in Section 4.4.2 of the 1998 Alberta CEMS Code or alternatively confirm that Section 4.4.3 1998 Alberta CEMS Codes has been complied with to determine the temperature-responsive drift.

2.1.3 Cycle-time/Response Time

The cycle-time/response-time specification applies to systems, as opposed to analyzers. One complete measurement or cycle of measurements of all effluent streams must be completed in 15 minutes or less.

2.2 Design Specifications for Flow Monitors

Refer to the 1998 Alberta CEMS Code Section 2.3

2.3 Design Specifications for Temperature Sensors

Refer to the 1998 Alberta CEMS Code Section 2.4

2.4 Specifications for the Data Acquisition System

Refer to the 1998 Alberta CEMS Code Section 2.5

2.4.4 Backfilling and Substitution for Missing Data

Emission data that are missing due to a malfunction of the CEMS may be substituted for a period up to 120 hours for any single episode by averaging the previous 120 hours of data. Reference Method test data or data obtained from a monitor previously certified for the application may also be used for substituting data.

The technique used to obtain substitute data must be fully described in the QAP developed for each CEMS.

When a CEMS malfunction extends beyond 120 hours for any single episode, data must be generated by another authorized CEMS or valid Reference Method.

Quantification Protocol for N₂O Abatement Projects - Draft

Other CEMS used for this purpose must meet all design and performance specifications given in this Code. When using another system, the effluent stream sample shall be extracted from the sample port used for the Reference method during certification of the installed CEMS.

Data substitution shall be limited to a maximum of 120 hours per calendar month. .

3.0 INSTALLATION SPECIFICATIONS

This Section contains guidelines for selecting a suitable sampling site on the flue, duct, or stack and determining the representativeness of the desired location with respect to the homogeneity of the effluent stream.

3.1 Location of the Sampling Site

Refer to the 1998 Alberta CEMS Code Section 3.1.

3.2 Representativeness

The sampling probe or in-situ analyzer must be installed in a location where effluent gases are completely mixed or at a location authorized by the Project. Flowing gases are generally well mixed, but stratification can occur when there are differing temperatures or when dissimilar gas streams intersect or where the duct/flue geometry changes. The degree of stratification in a duct or stack can be quantified. One method of quantification has been proposed (U.S. EPA 1979) that involves traversing the stack or duct and obtaining gas concentrations and comparing those concentrations to the target gas at a fixed concentration.

Gas stratification testing may be conducted on another gas species, O₂ or NO_x; if the degree of stratification is acceptable, then the entire gas stream degree of stratification is also acceptable.

3.2.1 Stratification Test Procedure

A minimum of nine (9) traverse points are required for this test. Locate the points in a balanced matrix of equal area on the stack or duct, using the procedures of Method 1 of the Alberta Stack Sampling Code.

For determining flow stratification, a pitot tube may be used (instead of automated gas monitoring systems) following the procedures of Method 2 of the Alberta Stack Sampling Code.

If the concentration of the gas measured or the velocity of the effluent stream at the fixed location varies by more than +/-10% of the average concentration for longer than one minute during this test, retest for stratification when more stable conditions prevail.

Alternately, if the stability of the emission source has been demonstrated at a chosen load, using the output of a chosen automated analyzer withdrawing a sample from a fixed point, the single automated analyzer may be used to measure the degree of stratification.

The concentration of a target gas or the velocity of the effluent stream shall be measured at each of the sampling points in the matrix. At the conclusion of the traverses, repeat the measurement of the concentration at the initial

measurement point. If the concentrations differ by more than +/-10% for the pre- and post-test values at this point, retest for stratification when more stable conditions prevail.

The degree of stratification at each sampling point can be calculated as:

$$\% \text{ of stratification at point } i = \frac{(C_i - C_{ave})}{C_{ave}} \times 100$$

where:

C_i = concentration of target gas at point i

C_{ave} = average of target gas concentration

The sampling plane across the stack or duct is considered stratified if any of the calculated values are greater than +/- 10%.

4.0 PERFORMANCE SPECIFICATIONS and TEST PROCEDURES

4.1 General

This section addresses how to evaluate the acceptability of a CEMS at the time of installation and whenever specified in the CEMS Code. The specifications are not designed to evaluate CEMS performance over an extended period of time, nor do they identify detailed calibration procedures to assess CEMS performance. It is the responsibility of the source owner or operator to properly calibrate, maintain, and operate the CEMS.

Performance specifications and test procedure requirements for each specific CEMS are detailed in this section.

4.1.1 Initial Certification Requirements and Test Procedures

Subject to Section 1.5.1, the owner or operator of the facility shall demonstrate that the CEMS meets all the applicable system performance specifications within six (6) months of the installation of a new CEMS, upon recertification, or as specified otherwise by the Director. The satisfactory demonstration by the approval holder of meeting all of these performance specifications, along with notice of such to the Director, shall constitute certification of the CEMS.

4.2 Performance Specifications

Performance specifications for continuous emission monitoring systems are given in Table 2 and referenced 1998 Alberta CEMS Code Sections. .

4.2.1 Performance Specifications for Nitrous Oxide Emission Monitoring Systems.

Any owner or operator, shall install, calibrate, maintain, and operate N₂O

monitoring systems and record the output of the systems.

Table 2 provides a summary of the general performance specifications of N₂O emission monitoring systems. These specifications are not meant to limit the types of technologies that can be used or prevent the use of equivalent methods.

Table 2. Performance specifications for N₂O emission monitoring systems.

Performance Specifications	N₂O Systems
Analyzer linearity	$\leq \pm 2\%$ of span from cal. curve
Relative accuracy ^(a)	$\leq \pm 10\%$ of RM
Zero drift - 24 hr	$\leq \pm 2\%$ of span
Span drift - 24 hr	$\leq \pm 4\%$ of span

If the reference method value is less than 50% of the analyzer full scale, then use 2% of full scale for relative accuracy for N₂O.

4.2.2 Performance Specifications for Volumetric Flow/Velocity Monitoring Systems.

Refer to the 1998 Alberta CEMS Code Section 4.2.5

4.2.3 Performance Specifications for Temperature Sensors

Refer to the 1998 Alberta CEMS Code Section 4.2.6

4.3 Test Procedures – Administrative

Refer to the 1998 Alberta CEMS Code Section 4.3.

4.4 Test Procedures for Verifying Design Specifications

4.4.1 Manufacturer's Certificate of Conformance

It may be considered that specifications for both interference rejection and temperature responsive drift have been met if the analyzer meets the international performance standard, MCERTS Performance Standards for Continuous Emissions Monitoring Systems, Version 2 Revision 1 (April 2003).

TEST	MCERTS Specification
Cross Sensitivity to: H ₂ O (5%) and CO ₂	<+4%
Response Time	<200s
Detection Limit	<+2%
Availability	>95%
Maintenance Interval	To Be Reported

Refer to the 1998 Alberta CEMS code Section 4.4 for alternative certification methods.

4.5 Performance Specification Test Procedures

4.5.1 Conditioning Test Period

Refer to the 1998 Alberta CEMS Code section 4.5.1

4.5.2 Operational Test Period

When the Conditioning Test Period has been successfully completed, the CEMS must be operated for an additional 168-hour period during which the emission source is operating under typical conditions. The Operational Test Period need not immediately follow the Conditioning Test Period.

During the Operational Test Period, the CEMS must continue to analyze the gases without interruption and produce a permanent record, using the data acquisition system, of the emission data. Sampling may be interrupted during this test period only to carry out system calibration checks and specified procedures as contained in the QAP.

During this period, no unscheduled maintenance, repairs, or adjustments should be carried out. Calibration adjustments may be performed at 24-hour intervals or more frequently, if specified by the manufacturer and stated in the QAP. Automatic zero and calibration adjustments made without operator intervention may be carried out at any time, but these adjustments must be documented by the data acquisition system.

If the test period is interrupted because of process shutdown, the times and dates of this period should be recorded, and the test period continued when the process continues operation. If the test period is interrupted as a result of CEMS failure, the entire test period must be restarted after the problem has been rectified.

The Performance Specifications tests outlined in Section 4.5 are carried out during the Operational Test Period, with the exception of the relative accuracy tests, which may be conducted during the Operational Test Period or during the 168-hour period immediately following the Operational Test Period. These tests are to be carried under conditions that typify the day-to-day operation of the CEMS and should be described in the QAP.

4.5.3 Calibration Drift Test Protocol for Gas and Flow Monitoring Systems

Refer to the 1998 Alberta CEMS Code section 4.5.3

4.5.4 Linearity

Refer to the 1998 Alberta CEMS Code section 4.5.4

4.5.5 Flow Monitor Calibration Drift

Refer to the 1998 Alberta CEMS Code section 4.5.5

4.5.6 Flow Monitor Orientation Sensitivity

Refer to the 1998 Alberta CEMS Code section 4.5.6.

4.5.7 System Cycle Time/Response Time Test

Refer to the 1998 Alberta CEMS Code section 4.5.7.

4.5.8 Relative Accuracy and Bias Tests for Gas Monitoring Systems

Perform a Relative Accuracy Test audit (RATA) for each CEMS. Record the CEMS output from the data acquisition system. For each CEMS, calculate bias as well as relative accuracy for each test.

Plant Operating Conditions - For new CEMS installations, complete the RATA test. Perform the test for each CEMS at a normal rate for the unit.

CEMS Operating Conditions - Do not perform corrective maintenance, repairs, replacements or adjustments on the CEMS during the RATA other than as required in the operation and maintenance portion of the QAP.

Note: Since a specific Standard Reference Method (SRM) for N₂O does not exist, EPA Method 320 and 40 CFR, Part 60, Appendix B Performance Specification 15 will be used for measurement of N₂O. The two paragraphs below are for reference only.

Reference Method Sampling Points - When the absence of stratified flow has not been verified, or if the gas flow has been found to be stratified, the Reference Method samples must be collected at a number of points in the effluent stream. Establish a "measurement line" that passes through the centroidal area of the flue or duct. This line should be located within 30 cm of the CEM sampling system cross section. Locate three (3) sampling points at 16.7, 50, and 83.3% along the length of the measurement line. Other sample points may be selected if it can be demonstrated that they will provide a representative sample of the effluent flow over the period of the test. A tip of the Reference Method probe must be within 3 cm of each indicated traverse point, but no closer than 7.5 cm to the wall of the stack or duct.

Where two or more probes are in the same proximity, care should be taken to prevent probes from interfering with each other's sampling.

Reference Method Sampling Conditions - Conduct the Reference Method tests in accordance with the Alberta Stack Sampling Code, and in such a manner that they will yield results representative of the pollutant concentration, emission rate, moisture content, temperature, and effluent flow rate from the unit and can be correlated with the CEMS measurements. Conduct the diluent (O₂ or CO₂) measurements and any moisture measurements that may be needed simultaneously with the pollutant concentration measurements. To properly correlate individual CEMS data, with the Reference Method data, mark the beginning and end of each Reference Method test run (including the exact time of day) on the data acquisition system, individual chart recorder(s) or other permanent recording device(s).

(e) Consistency - Confirm that the CEMS and Reference Method test results are based on consistent moisture, pressure, temperature, and diluent concentration and in the same units. In addition, consider the response times of the CEMS to ensure comparison of simultaneous measurements.

For each RATA conducted, compare the measurements obtained from the monitor via the data acquisition system (in ppm, % CO₂, lb./M Btu, or other units as appropriate) against the corresponding Reference Method values. Display the paired data in a table.

Sampling Strategy - Perform a minimum of nine sets of paired monitor (or monitoring system) and Reference Method test data for every required (i.e., certification, semiannual, or annual) relative accuracy or Bias Test audit. Each test shall take a minimum duration of thirty (30) minutes, sampling for equal periods at the three (3) sampling points for stratified flow testing, or at the single point for nonstratified flow.

NOTE: the tester may choose to perform more than nine sets of Reference Method tests up to a total of 12 tests. If this option is chosen, the tester may reject a maximum of three sets of the test results, if an appropriate statistical test applied to the data demonstrates that these results are outliers, and as long as the total number of test results used to determine the relative accuracy or bias is greater than or equal to nine. All data must be reported, including the outliers, along with all calculations.

Calculations - Analyze the test data from the Reference Method and CEMS tests for the applicable CEMS.

Summarize the results on a data sheet. Calculate the mean of the monitor or monitoring system measurement values. Calculate the mean of the Reference Method values. Using data from the automated data acquisition system, calculate the arithmetic differences between the Reference Method and monitor measurement data sets. Then calculate the arithmetic mean of the difference, the standard deviation, the % confidence coefficient, and the monitor or monitoring system relative accuracy using the following procedures and equations.

Quantification Protocol for N₂O Abatement Projects - Draft

The absolute value of the average difference, | \bar{d} |, is calculated using the equation:

$$|\bar{d}| = \frac{1}{n} \sum_{i=1}^n (X_i - Y_i)$$

Where: n = number of data points

X_i = concentration from the Reference Method

Y_i = concentration from the CEMS

The standard deviation, S_d, is calculated using the equation:

$$S_d = \sqrt{\frac{\sum_{i=1}^n d_i^2 - \frac{1}{n} \left(\sum_{i=1}^n d_i \right)^2}{n - 1}}$$

Where: d_i = difference between individual pairs

The 2.5% error confidence coefficient, |t_{cc}|, is calculated using the equation:

$$|t_{cc}| = t_{0.025} \frac{S_d}{\sqrt{n}}$$

Where: t_{0.025} = t - table value from Table 3.

Table 3. Range of t-values applicable for calculating confidence coefficients in Relative Accuracy Tests of CEMS.

<u>t-VALUES</u>			
n	$t_{0.025}$	n	$t_{0.025}$
2	12.706	10	2.262
3	4.303	11	2.228
4	3.182	12	2.201
5	2.776	13	2.179
6	2.571	14	2.160
7	2.447	15	2.145
8	2.365	16	2.131
9	2.306		

The Relative Accuracy (RA) is calculated using the equation:

$$RA = \frac{| \bar{d} | + | cc |}{\overline{RM}} \times 100$$

Where:

|d| = Absolute value of the mean difference

|cc| = Absolute value of the confidence coefficient RM =

Average Reference Method value

(h) The Bias Test

A bias, or systematic error is considered to be present if:

$$| d | \geq | cc |$$

(i) Acceptance Criteria for Analyzer Bias-

For each pollutant and diluent gas analyzer in the CEMS, calculate |d| and |cc|, in the units of the analyzer. If

$$| d | - | cc | \leq 2\% \text{ of FS}$$

the analyzer has significant bias. The cause of the bias must be determined and rectified. After corrections have been made, the Relative Accuracy Tests must be repeated to determine if the systematic error has been eliminated or reduced to an acceptable level.

4.5.9 Relative Accuracy Test for Flow Monitors

Refer to the 1998 Alberta CEMS Code section 4.5.9

4.5.10 Relative Accuracy Test for Temperature Sensors

Refer to the 1998 Alberta CEMS Code section 4.5.10

5.0 QUALITY ASSURANCE AND QUALITY CONTROL

The Quality Assurance (QA) procedures consist of two distinct and equally important functions. One function is the assessment of the quality of the CEMS data by estimating accuracy. The other function is the control and improvement of the quality of the CEMS data by implementing Quality Control (QC) policies and corrective actions. These two functions form a control loop. When the assessment function indicates that the data quality is inadequate, the control effort must be increased until the data quality is acceptable.

To provide high-quality data on a continuing basis a good QA program is necessary. The approval holder shall develop a QAP for each installed CEMS to ensure the quality of the CEMS measurements.

A "Quality Assurance" program is defined as a management program to ensure that the necessary quality control activities are being adequately performed, whereas "Quality Control" activities are those that detail the day-to-day operation of the system. The program shall be fully described in a Quality Assurance Plan (QAP) that is specific to the CEMS for N₂O.

5.1 Quality Assurance Plan (QAP) for CEMS

The QAP must include and describe a complete program of activities to be implemented to ensure that the data generated by the CEMS will be complete, accurate, and precise. As a minimum, the manual must include QA/QC procedures specified in this code. The recommended Table of Contents for a QAP is shown in Table 4.

5.1.1 Section 1 - Quality Assurance Activities

This section of the manual describes the CEM system QAP, and describes how the QA program is managed, provide personnel qualifications, and describe the QA reporting system. It must describe the CEMS, how it operates, and the procedures for calibration and inspection. It must also include preventative maintenance and performance evaluation procedures.

5.1.2 Section 2 - Quality Control Activities

This section of the manual provides the detailed descriptions of the step-by-step procedures, the standard operating procedures required to operate and evaluate the system, including details about daily calibration procedures, CGAs, Relative Accuracy Tests, and tests for system bias. Minimum criteria and procedures for these activities are provided in Section 4.2, Section 4.4, and Section 4.5 of this document.

Table 4. Example Table of Contents for facility CEMS QAP for N₂O.

SECTION	SUBSECTION	CONTENTS
I		The Quality Assurance Plan
	1	Assurance Policy and Objectives
	2	QAP Distribution
	3	Quality Requirement of CEM System
	4	Document Revision and Control
	5	CEMs Description
	6	Organization and Responsibilities
	7	Equipment and Spare Parts
	8	Data Handling: Methods and Procedures
	9	System Calibrations and Quality Control Checks
	10	Preventative Maintenance and System Evaluations
	11	Performance Evaluations
	12	Corrective Maintenance
	13	Reports
14	Data Back Filling Procedures	
II		Quality Control Procedures
	1	Installation and Start-up
	2	Daily CEMS Operation
	3	Calibration Procedures
	4	Preventative Maintenance Procedures
	5	Corrective Maintenance Procedures
	6	Evaluation Procedures - Cylinder Gas Audits
	7	Evaluation Procedures - Relative Accuracy Tests
	8	System and Subsystem Evaluation Procedures
	9	Data Backup Procedures
	10	Training
	11	CEMS Security
12	Data Reporting Procedures	
III		Appendices
	1	Facility Approval
	2	CEMS Specifications
	3	Reference Method Procedures
	4	Blank Forms

5.1.3 Inspection, Verification, and Calibration

Inspection, verification and calibration (when required) of the CEMS performance are among the most important aspects of the QA/QC program. The following summarizes the requirements for inspection, verification and calibration, all of which must appear in the QAP.

The method of verifying the accuracy of a CEMS component is to compare the value of the reference standard (e.g., reference gas or dead weight tester output) to the value displayed by the data acquisition system.

Frequency - All CEMS components shall be inspected periodically (approval holder shall identify frequency in the QAP) to verify that individual components have not failed and are operating within prescribed guidelines (e.g., sample system flow rates are appropriate). The use of system components with integral fault detection diagnostics is highly desirable.

The minimum verification frequency for individual CEMS components (e.g., analyzers and temperature transmitters) performance shall be as specified in Table 6. The minimum frequency may be reduced provided the operator can demonstrate (using historical data) that a lower verification frequency will not affect system performance at the 95% confidence level.

(a) Accuracy of Verification/Calibration Equipment and Materials - The minimum accuracy requirement for verification/calibration equipment and materials shall be a factor of two or better than the performance requirement specified for that system component in Section 4.2 of this document. (For example, if a performance specification requires an accuracy of $\pm 2\%$ then the verification/calibration equipment shall be accurate to within $\pm 1\%$.)

For analyzers, the use of certified reference gases is acceptable for routine analyzer system performance verifications. Protocol 1 gases are required for a CGA. All other calibration equipment such as test pressure gauges, dead weight testers and multi-meters must be calibrated at least every 2 years in a manner that is traceable either through the Canadian Standards Association (CSA) or the U.S. National Institute of Standards and Technology (NIST).

For parameters for which cylinder gases are not available at reasonable cost, are unstable, or are unavailable, alternative calibration techniques are acceptable.

Calibration Adjustment - A CEMS component must be calibrated (i.e., output adjusted) whenever the observed inaccuracy exceeds the limits for that system component accuracy as specified in the Performance Specifications. A CEMS component need not be calibrated after each verification, only when it exceeds the specified tolerance.

(b) Out-of-Control Conditions - Only quality assured data may be used to determine CEMS availability. When an analyzer or system is out-of-control, the data generated by the specific analyzer or system are considered missing and does not qualify for meeting the requirement for system availability.

An out-of-control period occurs if either the low level (zero) or high level calibration results exceed twice the applicable Performance Specification. The criteria that pertain to out-of-control periods for specific CEMS are illustrated in Table 5.

Table 5. Criteria for out-of-control periods^e.

Instrument	Acceptable		2X ^(a,b)		4X ^(c)	
	Zero drift	Span drift	Zero drift	Span drift	Zero drift	Span drift
N ₂ O ^g	±2%	±4%	±4%	±8%	±8%	±16%

- a) Corrective action must be taken, at a minimum, whenever the daily zero calibration drift or daily span calibration drift exceeds two times the limits stated above.
- b) If either the zero or span calibration drift results exceeds twice the above stated calibration drift for five consecutive daily periods, the CEMS is out-of-control beginning on the fifth day of error.
- c) If either the zero or span calibration drift results exceeds four times the applicable calibration drift, the CEMS is out-of-control back to the previous calibration drift found to be within tolerance unless a decisive point error occurrence can be defined.
- d) If the CO₂/O₂ CEMS is defined as being out-of-control, the TRS/SO₂/NO_x will also be out-of-control, until the CO₂/O₂ CEMS is defined as being within acceptable limits.
- e) If the CEMS is out-of-control, assess and identify the cause of the excessive drift and correct accordingly. Once the appropriate corrective action has been implemented, repeat the calibration drift test in order to demonstrate the CEMS is back within acceptable limits.
- f) Values are given as a % of gas concentration.
- g) Values are given as a % of full scale reading.

In addition, an out-of-control period also occurs if any of the quarterly, semiannual, or annual performance evaluations exceed the applicable performance specification criteria (i.e., Relative Accuracy, Bias, etc.). In this case, the out-of-control period begins with the hour when this condition occurred and ends with the hour after this condition ends.

(c) Verification/Calibration—Data Logging, and Tabulation - The "as found" values for each verification point shall be recorded before any calibration occurs. The "as left" values for each verification point shall also be recorded after any component is calibrated (i.e., adjustment). For systems capable of automated calibrations, the data system shall record the "as found" and "as left" values including a time stamp (date and time). If strip chart recorder data are reported, any automatic calibration adjustments must be noted on the strip chart recorder.

All verification data must be time-stamped and tabulated on a daily (where applicable) and monthly basis. The use of quality control charts is recommended.

The approval holder must retain the results of all performance evaluations including raw test data as well as all maintenance logs, corrective action logs and the QAP (including sample calculations) for a period of at least 3 years.

(d) Gas Analyzer/ System Verification - For all CEMS, the system is calibrated rather than the analyzer.

System performance shall be verified in accordance with the procedures specified in the facility QAP.

For systems amenable to verification through the use of standard reference gases, the standard reference gas must be introduced at the probe inlet or in the vicinity of the probe inlet. A calibration filter may be used for daily system zero and span verification for path in-situ CEMS only.

Ensure enough time passes to allow the system to attain a steady output, as shown by the data acquisition system, before recording.

For CGAs, the process and analyzer system must be operating at normal conditions (e.g., pressure, temperature, flow rate, pollutant concentration). The analyzer system must be challenged three times with each gas, but not in succession. To do this, alternate the gases presented to the system. Calculate the average response of the system as indicated by the data acquisition system or chart recorder to the three challenges of each concentration of reference gas.

For analyzers not amenable to verification/calibration through the use of reference gases, the operator shall detail verification/calibration procedures in the facility's QAP.

(e) Flow Element Subsystem Verification - For pitot tube or similar systems visual inspection at turnaround (or at least once per year) and as opportunities present themselves for visible signs of plugging or damage. Wind tunnel calibration of pitot tubes should be carried out before initial installation, when visible damage has occurred, or when flow system inaccuracy exceeds acceptable tolerances and inaccuracy cannot be attributed to any component other than the flow element. For pitot tube systems, if, when compared to the stack survey data, $d > \pm 15\%$, then pitot tubes must be pulled and recalibrated unless the source of the error is found to be in the transmitter. (d refers to absolute difference.)

Backpurging (as necessary) of the primary flow measuring elements at an appropriate frequency is acceptable to ensure accurate data (and remove any build up of materials) but should be done when analyzer is being calibrated (or zeroed) so that actual complete sampling time of both flow and pollutant concentration is maximized.

For other flow methods such as ultrasonic meters, anemometers, etc., the QA/QC procedures and frequency shall be specified in the facility QAP and be followed accordingly.

Table 6. Minimum frequency for CEM system component Quality Assurance/Quality Control (QA/QC) requirements.

CEMS COMPONENT	Frequency of Performance Verification Parameter				
	Inspection	Zero Drift	Span Drift	Cylinder Gas Audit ^a	Relative Accuracy Test Audit ^a
Analyzers					
N ₂ O	Daily	Daily	Daily	1/campaign	1/campaign
Rate Measurement Components					
Temperature	Daily	1/year	1/year	NA	1/campaign
Diff. Pressure	Daily	1/year	1/year	NA	
Static Pressure	Daily	1/year	1/year	NA	
Flow Element	1/yr.	NA		NA	1/campaign
Data Acquisition Components					
Recorder	Daily	See Note b	See Note b		
PLC/DCS	Daily	See Note b	See Note b		

^a Frequency is subject to requirements in Section 5.2.

^b The inputs to a PLC/SCADA or DCS must be checked as part of the trouble shooting procedures, only if the analyzer or flow system is found to be out-of-control.

(f) Data Receiver Subsystem Verification

The inputs to the digital data acquisition system (e.g., PLC, DCS, Scada) or chart recorder must be verified at the frequency specified in Table 6 using an appropriate calibrator as identified in the QAP.

5.2 Relative Accuracy Test Audits and Cylinder Gas Audits

5.2.1 General Requirements (applicability)

The approval holder shall conduct Relative Accuracy Tests and Cylinder Gas Audits on each CEMS. A minimum of one Relative Accuracy Tests and a minimum of one CGAs must be conducted on each CEMS.

5.2.2 Relative Accuracy Test Procedures

The procedure for carrying out the relative accuracy and bias tests is given in Subsections 4.5.9 of this Code.

5.2.3 Cylinder Gas Audits

The Cylinder Gas Audit procedure and acceptance criteria are the same as the Linearity Procedure of 4.5.4.

5.2.4 Test Procedure Requirements

The associated QA/QC test procedures applicable to each CEMS and a description of the actual test procedures shall be contained in the facility QAP and adhered to by the facility operator.

During periods of scheduled CEMS quality control procedures, such as Relative Accuracy Test, the facility should be operated at a rate of at least 90 % of "normal" production. Normal production is defined as the average production or throughput for the facility over the previous month.

At least one month must elapse between conducting either a CGA or a RATA.

6.0 REPORTING REQUIREMENTS

6.1 General

All reporting will be as required in Section 2.3.6 of the Specified Gas Emitters Regulation Offset Credit Project Guidance Document (February 2008).

APPENDIX D.1 - DEFINITIONS

Refer to the 1998 Alberta CEMS Code Appendix A

APPENDIX D.2 - RELATIVE ACCURACY SAMPLE CALCULATIONS

Refer to the 1998 Alberta CEMS Code Appendix B

APPENDIX D.3 - BIBLIOGRAPHY

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