# Quantification Protocol for Nitrous Oxide Abatement from Nitric Acid Production

## Technical Protocol Plan

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Submitted to:

Alberta Environment
Protocol Development

Submitted by:

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# PART B

***Description of Technical Protocol Plan Content***

**B.1. Description of the Project Type**

The abatement of nitrous oxide from the production of nitric acid is a project activity that results in emission reductions from the installation of a dedicated $N_2O$ abatement catalyst inside the ammonia burner of a nitric acid plant that catalytically reduces $N_2O$. The catalyst consists of precious metal coated ceramic substrate. The components are made of $Al_2O_3$ (ceramic substrate), and precious metal alloys (catalyst). No regulations currently exist in Alberta concerning abatement of $N_2O$ from nitric acid production.

**Description of how real reductions or removals will be achieved**

Nitric Acid is produced for use in fertilizer and explosives. A plant produces nitric acid through the oxidation of ammonia ($NH_3$) and air on a precious metal primary catalyst and absorbs nitrogen oxide gases in water. Waste nitrous oxide ($N_2O$) 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. The precious metal primary catalyst is typically replaced every 90-240 days, which is called a campaign.

The installation of a proprietary secondary catalyst will destroy $N_2O$ created during the production of nitric acid. As $N_2O$ is a greenhouse gas (GHG) with a global warming potential of 310, the $N_2O$ abatement achieved by use of a secondary catalyst leads to significant reductions in GHG emissions. The installation of the secondary catalyst doesn't affect production levels of nitric acid; therefore its installation wouldn't be necessary or advantageous for business as usual operation, if it wasn't for the Alberta Offset System.

**B.2. Description of Background Information/Best Practice Guidance Used**

Table 2.1 lists the sources of best practice guidance and best science used in preparing this technical protocol plan.

**TABLE 2.1: Good Practice Guidance**

| 1. Document Title | 2. Publishing Body/Date | 3. Description |
|---|---|---|
| CDM Methodology AM0034 v3.01, "Catalytic reduction of $N_2O$ inside the ammonia burner of nitric acid plants" (excluding the monitoring system) | Executive Board of the Clean Development Mechanism, August 2, 2008. | This methodology covers project activities involving the installation of a dedicated $N_2O$ abatement catalyst inside the ammonia burner of a nitric acid plant that catalytically reduces $N_2O$. |
| Alberta Continuous Emissions Monitoring System (CEMS) Code ($N_2O$ monitoring system ) | Alberta Environment, May 1998. | The code establishes requirements for the installation, operation, maintenance and certification of CEMS; updated to include $N_2O$ |

| | | |
|---|---|---|
| | | monitoring. |
| ISO 14064-2:2006 | International Organization for Standardization | Greenhouse gases -- Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements |

In addition to the above Good Practice Guidance, listed below are the technical experts consulted, and their roles:

<u>Orica Mining Services</u>

- Project Proponent

Orica Mining Services offers commercial explosives, initiating systems and Blast-Based Services to the mining, quarrying and construction industries. The business is run globally with a presence in Australia, Asia, Europe, the former Soviet Union, Africa, the Middle East, North America and Latin America.

Orica is the world's leading provider of commercial blasting solutions that are safety-focused, cost-effective, accurate and flexible. Its product range can be divided into broad segments including Initiating Systems, Ammonium Nitrate, Bulk Explosives and Packaged Explosives. Their manufacturing plants are world-scale, efficient and strategically located.

<u>W. C. Heraeus</u>

- Technology provider

W.C. Heraeus is the international precious metals operation of the Heraeus Group. One of their key areas of expertise is in the manufacturing of precious metal catalysts. The first Haraeus precious metal catalyst was developed in 1914. Today they offer a wide variety from standard chemical catalysts and supported catalysts specially developed to meet customer requirements, to the manufacture of a wide variety of exhaust catalysts. With a multiplicity of precious metal compounds that they have developed, various impregnation technologies and the many support media available, they manufacture an enormous diversity of catalyst varieties.

<u>ClimateCHECK</u>

- Protocol developer

ClimateCHECk is an innovative GHG management solutions company with expertise in the leading GHG standards and protocols such as WRI/WBCSD GHG Protocols, ISO 14064 GHG Standards, and UNFCCC Kyoto Protocol for CDM projects. One area of expertise is the focus on project validation, which includes assessing the technical correctness and consistency with GHG policies and criteria, of the underlying plans, procedures, and data with applicable standards and careful attention paid to the objectives of our clients.

Saskatchewan Research Council

- Stack Tester

Saskatchewan Research Council is the leading provider of applied R&D and technology commercialization. The Air Quality section specializes in collecting and analyzing various airborne elements and compounds. SRC offers a full range of air sampling and monitoring services including industrial stack emission testing and gaseous sampling. This includes in-stack sizing, full metal analysis, dioxin and furan sampling, volatile organic sampling (eg: CO, CO2, SO2, Cl2, NOx, NH3) PM-2.5 in-stack sizing.

Global Analyzer Systems Limited

- N2O Methodology Verifier

Global Analyzer Systems Limitied (GASL) is a provider of state of the art, multi-component Continuous Emissions Monitoring Systems (CEMS), Data Acquisition Systems, Quality Assurance Plans and a wide range of regulatory compliance support and documentation.

GASL has a proven track record for providing continuous monitoring under difficult circumstances and varied applications including sulphur recovery plant stacks, bitumen fueled steam generators, and power generation stacks. GASL knows the Alberta regulations and is committed to providing CEMS related services that meet or exceed the requirements and expectations.

**B.3. Regulatory, Legal Requirements and/or Government Incentive/Grant Programs**

List of potentially relevant regulations/legal requirements:

- At the Federal level, on March 10, 2008 Environment Canada released their *Turning the Corner: Regulatory Framework for Industrial Gas Emissions* document identifying reduction targets for each sector which are to take effect January 1, 2010. The Nitrogen fertilizer based sector has a de minimis threshold of 50kt of $CO_2$e. Environment Canada has not yet released the details regarding the specifics of how this sector may be regulated.

- In Alberta, Bill-3 *Climate Change and Emissions Management Act: Specified Gas Emitters Regulation* came into effect as of July 1, 2007 assigning emission intensity reduction targets to facilities that emit over 100,000 tonnes of GHG but excludes the industrial process emissions from the chemical reactions.

- The Alberta Regulation 33/2006 *Emissions Trading Regulation* establishes an Emissions Trading Registry and baseline emission rates for both nitrogen oxides and sulphur dioxides as the average emissions of these substances in kg/MWh in the earliest three years of normal operation after January 1, 2000.

- The National Pollutant Release Inventory (NPRI) is Canada's legislated inventory of pollutants released, disposed of and sent for recycling by facilities across the country. Those owners and operators of facilities that manufacture, process or otherwise use one or more of the NPRI-listed substances under prescribed conditions, this includes the production of nitric acid, are required to report under the *Canadian Environmental Protection Act, 1999 (CEPA 1999), subsection 46(1).*

- NPRI reporting, 15 sectors are required under the CEPA, 1999 Section 71, to report their air pollutants, GHG and other substances. This regulation applies to facilities with over 100,000 tonnes of GHG, and is submitted annually to Statistics Canada.

- In Alberta, facilities that emit over a threshold of 100,000 tonnes of direct GHG in a year are required to submit their air pollutant and GHG emissions to Alberta Environment under the Specified Gas Reporting Standard.

- Alberta Environment Protection Enhancement Act (AEPEA) requires facilities that have obtained an operating license in Alberta must report their facilities emissions to Alberta Environment.

List of potentially relevant climate change incentives:

- Neither Alberta nor the Canadian federal government has funding programs for this type of project.

**B.4. Barriers to Implementation**

*Financial Barriers*:

In addition to there being no regulatory requirement to reduce N2O process emissions resulting from a chemical reaction, the abatement of nitrous oxide from the production of nitric acid is a project activity that does not qualify for government funding. This means the capital and operating costs associated with this project type are incurred solely by the project proponent.

To successfully implement a nitrous oxide abatement project, the project proponent will have to install a $N_2O$ monitoring system, install the secondary catalyst, and maintain its operations.

Further to the capital and operating costs born by the project proponent, the installation of the technology does not yield any production benefits. The only benefit realized is the reduction of process related $N_2O$ emissions.

*Technology Barriers*

This type of technology is the first in North America to be implemented, and therefore has not been operationally tested by any project proponent in the Canadian context.

**B.5. Review of Technology/Scientific Knowledge**

The production of nitric acid results in significant volumes of $N_2O$ as a byproduct. 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 $N_2O$ in the waste steam to the stack. The project does not lead to any change in any other GHG emissions, and therefore these are not included.

The technology employed for this type of project activity includes the installation of a state-of-the-art $N_2O$ abatement technology, specialized monitoring equipment, and training of staff for installation, operation, and maintenance of the secondary catalyst.

The project will install an $N_2O$ abatement catalyst which enables significant $N_2O$ emission reduction. The catalyst consists of precious metal coated ceramic substrate. The components are made of $Al_2O_3$ (ceramic substrate), and precious metal alloys (catalyst). This catalyst does not contain any dangerous materials. It also does not consist of foreign substances; the materials used for the processing of this product already exist in nitric acid reactors (e.g. precious metals consistent with materials of the primary catalyst).

The life of the catalyst is estimated at around 3 campaigns of 240 days each. At the end-life of the $N_2O$ abatement catalyst, the used catalyst will be refined, recycled and properly disposed of according to prevailing standards.

**B.6. Review of Existing Projects**

There are two types of commonly used technologies for the production of nitric acid in Canada and all of North America, mono pressure and dual pressure designs. Within these two types of plant designs, there is a variety of NOx abatement technologies available, “selective” catalytic reduction being the most common. SCR using ammonia does not reduce $N_2O$, which means, should a plant choose to reduce its $N_2O$ emissions, additional abatement technologies must be implemented. Extended absorption is also frequently used technology to abate NOx, but does not reduce $N_2O$ emissions

In addition to SCR technology and extended absorption technologies, “non-selective” catalytic reduction (NSCR) in a denox system is also used in North America. According to the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, NSCR makes up only 20% of the plants. NSCR technology which is installed for NOx destruction also destroys $N_2O$. Adding NSCR technology is not a viable alternative for a plant with extended absorption or SCR technology for $N_2O$ abatement due to plant design, high operating costs for carbon fuel and high equipment costs.

For the 80% of the existing mono and dual pressure plants with NOx abatement technology that does not destroy $N_2O$, technology options to abate $N_2O$, include primary, secondary, tertiary or ‘end of pipe’ measures. The selection of $N_2O$ abatement technology is dependent upon nitric acid plant design and operational pressure.

This project activity is applicable to nitric acid plants that do not use NSCR technology, and there are no projects of its kind in North America today, which precludes comparison within the Canadian context.

**B.7. Summary of Quantification Approaches**

On a global scale, the CDM has developed a methodology for the quantification of emission reductions due to catalytic reduction of $N_2O$ inside the ammonia burner of nitric acid plants, CDM Methodology AM0034 v3.1. This methodology was referenced in determining the quantification approaches.

The following three equations serve to complete the calculations of the emission reductions from the comparison of the baseline and project conditions.

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

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions Factor}_{\text{Baseline}} * \text{NAP} * \text{GWP}_{\text{N2O}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions Factor}_{\text{Project}} * \text{NAP} * \text{GWP}_{\text{N2O}}$$

Where:

$\text{Emissions}_{\text{Baseline}}$ = the sum of the emissions under the baseline condition

$\text{Emissions Factor}_{\text{Baseline}}$ = calculated emissions factor under the baseline conditions

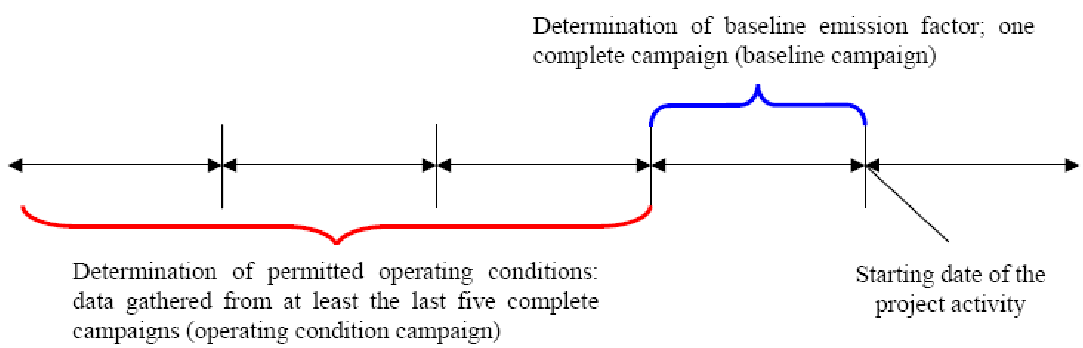
NAP = Nitric acid production for the project campaign ($tHNO_3$).

$\text{GWP}_{\text{N2O}}$ = Global Warming Potential of $N_2O$ (310)

$\text{Emissions}_{\text{Project}}$ = the sum of the emissions under the project condition

$\text{Emissions Factor}_{\text{Project}}$ = calculated emissions factor under the project conditions

The baseline shall be established through continuous monitoring of both $N_2O$ 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:



These measurements are used to determine a plant-specific baseline emissions factor ($tN_2O/t\ HNO_3$). A permitted plant-specific range for parameters that influence the level of $N_2O$ 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.

During the project activity, the measurements of $N_2O$ and other parameters are carried out on a continuous basis and a new emission factor is established for each project campaign ($tN_2O/t\ HNO_3$).

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 a particular campaign.

A complete $N_2O$ monitoring system is installed as part of the project, which includes an infrared monitor to determine the concentration of $N_2O$ and an ultrasonic flow monitor to measure velocity. The total mass of $N_2O$ emissions is determined by multiplying the total volume flow by the concentration of $N_2O$.

Statistical analysis is applied to both the baseline emissions factor and each campaign-specific project emissions factor. Only those $N_2O$ 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 $N_2O$ monitoring equipment will be deducted from the baseline emissions factor.

**B.8. Other Impacts**

The production of nitric acid is a $N_2O$ intensive process. 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 $N_2O$ in the waste steam to the stack. The project does not lead to any change in any other GHG emissions, and therefore these are not included.

The risk of the project being unable to produce emission reductions directly lay on the proper and accurate installation of the abatement catalyst. If the catalyst is installed in an improper manner, then it will affect the function of the burner and production of nitric acid. The facility will continue to function or run, but cannot abate $N_2O$ if the catalyst is not installed accurately. The necessary safety checks and installation checks are in place to prevent the improper installation of the technology.

The continuous monitoring performed by the in-line $N_2O$ analyzer, which samples and collects gas flow volume and $N_2O$ concentration data throughout the life of each campaign ensures the accuracy of the calculated emission reductions.

An additional risk that has been considered is the additional leakage of emissions from the daily span and calibration of the analyzer which may release additional $N_2O$ into the atmosphere. An emission estimate for the 2 cylinders per year is 5000 ppm gas and is classified as an insignificant source of emissions.

There are no environmental consequences associated with this project. The project does not require additional construction or development to the facility. The project is located on an existing industrial site; site impact will only involve alterations to the existing technology. This technology does not generate waste liquids, solids, or gases; and the spent catalyst will be removed and recycled by the technology provider in an appropriate manner. No significant negative environmental impacts are expected from the implementation of the project.

**B.9. Assessment of Baseline Scenarios**

The baseline methodology application first involves identification of possible baseline scenarios, and then eliminating those that are not appropriate for the protocol. Table 2.2 identifies all the potential baseline scenarios and explains their acceptance or rejection.

**TABLE 2.2: Assessment of Possible Baseline Scenarios**

| 1. Baseline Options | 2. Description | 3. Static/Dynamic Baseline | 4. Accept or Reject and Justify |
|---|---|---|---|
| **Historic Benchmark:** | *Quantification of the plants$N_2O$ emissions for one campaign prior to the installation of a secondary catalyst.* | Static | Accepted - Meets current regulations and requires neither additional investments nor additional running costs. This is the most accurate approach to determine the GHG emission reductions for this project type. Data is available and continuously monitored. Quantification methodology (AM0034) already exist and is approved in CDM. |
| **Performance Standard:** | *Identification of the $N_2O$ emissions from Nitric Acid plants in Alberta or Canada based on a government standard or regulation.* | Static | Rejected – currently no $N_2O$ standard or regulations for process emissions in Alberta or Canada for Nitric Acid Plants. No performance standards have been developed to date for this type of project. |
| **Comparison-based:** | *Quantification of $N_2O$ emissions from a control group of Nitric Acid Plants* | Static | Rejected – minimal number of Nitric Acid Plants in Alberta and Canada. No access to information required to |

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| | | | perform this baseline approach. |
| **Projection-Based:** | *Identification of future $N_2O$ emissions based on a projection of future Nitric Acid plants to be built in Alberta or Canada; or$N_2O$ emissions based on future regulations.* | Dynamic | Rejected – no future nitric acid plants expected to be built in Alberta; |
| **Adjusted Baseline:** | *Identification of a baseline using the average $N_2O$ emissions from Nitric Acid plants based on current industry practices. (Plants using NSCR vs. SCR technologies.)* | Dynamic | Rejected – currently no regulations or standards on $N_2O$ process emissions; EPA identifies 20% of plants use NSCR technology and future plants will install SCR technology |

If new or modified $N_2O$ emission regulations are introduced after the acceptance of the protocol, determination of the baseline scenario will be re-assessed.

For the determination of the adjusted baseline scenario the project participant should re-assess the baseline scenario and shall apply baseline determination process. After the baseline scenario is re-assessed, the baseline emissions shall be adjusted at the time the legislation has been legally implemented.

**B.10. Selection of Baseline Scenario**

After assessing the potential baseline scenarios it is concluded that the most appropriate baseline is the use of a projects historical benchmark. This baseline approach is the most accurate for this type of project since it uses site specific data monitored continuously. In addition, an approved methodology by the Clean Development Mechanism Program (AM0034) prescribes the use of historical baseline to quantify GHG emissions reductions from these types of project. Other potential baseline scenarios are rejected based on the rational provided in section B9, primarily due to lack of available data, current regulations, and the high costs associated to gathering accurate data on the limited number of Nitric Acid plants in Alberta and Canada.

This baseline is identified as static as the emission factor determined in the baseline scenario will be used for the lifetime of the project. If this project was not implemented, the GHG emissions associated with producing each unit of nitric acid would remain constant; therefore a static baseline is presented. The baseline campaign will be used to determine the baseline emissions and to ensure that the campaign is representative of typical plant operations; a comparison with data from the previous 5 years of operation is required. If the baseline campaign is not representative, then it must be rejected and a new baseline campaign reflecting typical plant operation must be started and used for quantification purpose.

**B.11. Definition of the Project Condition**

Installation of an $N_2O$ abatement catalyst inside the ammonia burner of a nitric acid plant. In the absence of the installation of the catalyst, nitrous oxide would have been released

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| into the atmosphere during the production of nitric acid. Nitrous oxide does not have any economic value or toxicity at emissions levels typical of nitric acid manufacture. The installation of the catalyst, under the project condition, results in significant $N_2O$ emission reductions.<br><br>This type of project activity is approved and has been creating Certified Emission Reductions under the Clean Development Mechanism methodology AM0034v3.1 "Catalytic reduction of $N_2O$ inside the ammonia burner of nitric acid plants". |
| **B.12. Functional Equivalence** |
| Production units of nitric acid are not expected to differ from baseline to project conditions, and are therefore the project and baseline are expected to be functionally equivalent.<br><br>The relevant project and baseline sources and sinks include only the nitric acid plant (burner inlet to stack). All other sources, which include leakage emissions from production, fuel extraction/processing, fuel delivery, electricity usage, site development, building equipment, construction on site, testing of equipment, and site decommissioning, are excluded in the quantification as they are considered to be immaterial. The disposal recycling of the secondary catalyst materials are also identified as a part of the project sources and sinks; however minimal emissions are expected to occur and are excluded from quantification. |
| **B.13. Flexibility Mechanisms** |
| Flexibility in applying the quantification protocol is provided to project developers in the following way (s):<br><br>1. Project developers may use alternative monitoring methodologies and/or equipment rather than the methodologies and/or equipment described in the protocol. The proponent must justify that the chosen methodology and/or equipment provides equivalent or more accurate and/or conservative data than the specified equipment;<br><br>If applicable, the proponent must indicate and justify why the flexibility provision was used. |