



**CLEAN DEVELOPMENT MECHANISM
PROPOSED NEW METHODOLOGY: MONITORING (CDM-NMM)
Version 01 - in effect as of: 1 July 2004**

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**SECTION A. Identification of methodology****A.1. Title of the proposed methodology:**

“Monitoring Methodology for catalytic N₂O destruction in the Reactor gas of Nitric Acid Plants”

A.2. List of category(ies) of project activity to which the methodology may apply:

Abatement of Nitrous Oxide gas (N₂O) in the stack gas from Nitric acid plants; Chemical Industry

A.3. Conditions under which the methodology is applicable to CDM project activities:

This methodology is concerned with the abatement of Nitrous Oxide (N₂O) from the stack gas of a nitric acid plant. N₂O is an significant greenhouse gas with a global warming potential of 310 produced as a by product in the production of nitric acid. The result of the installation of a catalyst in the reactor (Secondary catalyst) is to destroy the N₂O by converting the N₂O to Nitrogen N₂ and Oxygen O₂. The methodology is applicable to the N₂O waste stream from a nitric acid production plant where:

1. The nitric acid plant has not installed any N₂O destruction or abatement technology that reduces the entire N₂O in the waste gas stream.
2. The nitric acid plant has not already installed a Non Selective Catalytic Reduction Unit (NSCR) for the destruction of NO_x.
3. The project activity does not cause a nitric acid production increase.
4. The project activity is specific to the reduction of N₂O only and will not lead to an increase in any other gases present in the waste gas stream.
5. The N₂O baseline emissions and N₂O emissions related to the project activity are measurable in real time upstream and downstream of the catalytic destruction facility.
6. Host country regulations do not restrict N₂O emissions.

A.4. What are the potential strengths and weaknesses of this proposed new methodology?

The methodology is applicable to a wide range of project activities for N₂O destruction. This monitoring methodology prescribes the use of international standard monitoring equipment and practices. Both, baseline and project emissions will be measured real time. The methodology and its use of measured and analysed data for determination of emission reductions, generated by using a reliable metering and monitoring system, has no tendency to overestimate the emission reductions. Another strength of the methodology is that the number of assumptions is very low and those considered are conservative. The weaknesses of the methodology are the high monitoring effort and the high demand on the measuring devices.

**SECTION B. Proposed new monitoring methodology****B.1. Brief description of the new methodology:**

The proposed monitoring methodology follows option 1, “monitoring of the emissions in the project scenario and the baseline scenario”.

The GHG emission reductions achieved by the project activity are directly related to the quantities of N₂O destroyed in the catalytic N₂O destruction facility. Project and baseline emissions depend on the total amount of nitric acid production, the production conditions and the efficiency of the catalytic N₂O destruction facility. Emissions from the downtime of the N₂O destruction facility are neither claimed for baseline emissions nor for project emissions (outside of the project boundary). Due to the project specific circumstances, baseline emissions are measured at the inlet of the catalytic N₂O destruction facility (DF). Real time measurement of baseline N₂O emissions upstream of the N₂O destruction facility represents a conservative approach for determination of baseline emission. Baseline parameters to be monitored are the quantity of N₂O at the inlet of the N₂O destruction facility (Q_N₂O_I_DF_m); calculated based on measurements of (a) the flow rate (Q_RG) and (b) the N₂O concentration (N₂O_co_RG_I) in the Reactor gas upstream of the N₂O destruction facility. Furthermore national regulations on N₂O emissions (Reg_1_N₂O_E; Reg_2_N₂O_E; Reg_3_N₂O_E) have to be observed. Limitations on N₂O emissions are taken into account for determination of the baseline emissions. This data will allow computation of the baseline emissions.

Project emissions to be monitored are the project N₂O emissions. Project N₂O emissions are monitored by measuring the tail/Stack gas flow rate and (2) the N₂O concentration at the outlet of the N₂O destruction facility (sample point located in the nitric acid plant stack)

Project parameters to be monitored are the N₂O emissions downstream of the N₂O destructions facility (P_N₂O_p), calculated based on the tail/Stack gas flow rate (Q_TG), the N₂O concentration (N₂O_co_TG_O) and the operating hours in period (M_h).

Other data required, such as emission factors are derived from public sources (e.g. IPCC).

**B.2. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario:**

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B.2.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:

ID number (Please use numbers to ease cross-referencing to table B.7)	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
<i>A1 TGF</i>	<i>Q_{TG} Volume flow tail/stack gas after N₂O destruction facility</i>	<i>Tail/Stack Gas Measuring device, data management system</i>	<i>Cubic metres / hour</i>	<i>Measured continuously</i>	<i>Hourly/daily/weekly/monthly</i>	<i>100%</i>	<i>electronic</i>	<i>Data records will be maintained for a period of 12 years. Flow metering system will automatically record flow adjusted to standard temperature and pressure</i>
<i>A2 N₂O (Tail/stack)</i>	<i>N₂O_{co}_TG_O N₂O concentration after destruction facility</i>	<i>Gas concentration, measuring device, data management system</i>	<i>tN₂O/m₃</i>	<i>Measured continuously</i>	<i>Hourly/daily/weekly/monthly</i>	<i>100%</i>	<i>electronic</i>	<i>Data records will be maintained for a period of 12 years.</i>
<i>A3 Time period</i>	<i>M_h Operation hours in period</i>	<i>Measuring device, data management system</i>	<i>h</i>	<i>Measured continuously</i>	<i>Hourly/daily/weekly/monthly</i>	<i>100%</i>	<i>electronic</i>	<i>Data records will be maintained for a period of 12 years.</i>

**B.2.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO₂ equ.):****Calculation of the project N₂O Emissions**

The direct emissions from the project activity are equivalent to the N₂O emissions not destroyed plus emissions related to the operation of the N₂O destruction facility (emissions from additional ammonia and hydrocarbon input).

Total project emissions in period P_E_p [tCO₂e] are given by:

$$P_E_p = P_N_2O_b_p + DF_O_E_p$$

where:

P_E_p	Total project emissions in period	[tCO ₂ e]
P_N ₂ O_b_p	N ₂ O based project emissions (N ₂ O not destroyed)	[tCO ₂ e]
DF_O_E_p	Emissions related to the operation DF	[tCO ₂ e]

The **first part** of the project emissions consists of the N₂O not destroyed by the project activity. The N₂O project emissions monitoring equipment will measure the tail/stack gas volume flow (flow rate, temperature and pressure automatically present the volume flow rate of the tail gas at standard temperature and pressure) and (2) the N₂O concentration at the outlet of the N₂O destruction facility (DF)(sample point in the stack). The amount of N₂O at the outlet of the N₂O destruction facility can then directly be calculated by multiplying the tail/stack gas volume flow and the N₂O concentration.

The emissions of non destroyed N₂O over a period are given by:

$$P_N_2O_b_p = P_N_2O_p * GWP_N_2O = (Q_TG * N_2O_co_TG_O * M_h) * GWP_N_2O$$

where:

P_N ₂ O_b_p	N ₂ O based project emissions (N ₂ O not destroyed)	[tCO ₂ e]
P_N ₂ O_p	Project N ₂ O emissions	[tN ₂ O]
GWP_N ₂ O	N ₂ O Global warming potential of N ₂ O	[-]
Q_TG	Volume flow rate of tail/stack gas in DF	[m ³ /h]
N ₂ O_co_TG_O	N ₂ O concentration outlet DF	[tN ₂ O/m ³]
M_h	Operating hours in period	[h]

The global warming potential of N₂O is set at 310 according to the Kyoto Protocol rules.



B.2.3. Relevant data necessary for determining the <u>baseline</u> of anthropogenic emissions by sources of greenhouse gases (GHG) within the project boundary and how such data will be collected and archived:								
ID number (Please use numbers to ease cross-referencing to table B.7)	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
B1 RGF	<i>Q_{RG}</i> Volume flow Reactor gas before N ₂ O destruction facility Flow	Reactor Gas Flow, data management system	Cubic metres/ hour	Calculated continuously	Hourly/daily/weekly/monthly	100%	electronic	Data records will be maintained for a period of 12 years. Flow metering system will automatically record flow adjusted to standard temperature and pressure.
B2 N ₂ O Reactor	<i>N₂O_{co}_RG_O</i> N ₂ O concentration before destruction facility	Gas concentration, measuring device, data management system	tN ₂ O/m ₃	Measured continuously	Hourly/daily/weekly/monthly	100%	electronic	Data records will be maintained for a period of 12 years.
B3 Nitric acid production	<i>P_{HNO₃}_p</i>	Annual reports	tonnes	measured	monthly	100%	electronic	Data records will be maintained for a period of 12 years.
B4 RAmGF	<i>Q_{RAmGF}</i> Volume flow Reactor ammonia gas flow before N ₂ O destruction facility	Reactor ammonia gas flow, Gas Measuring device, data management system	Cubic metres / hour	Measured continuously	Hourly/daily/weekly/monthly	100%	electronic	Data records will be maintained for a period of 12 years. Flow metering system will automatically record flow adjusted to standard temperature and pressure.

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B5 RAGF	<i>Q_RAGF</i> Volume flow Reactor air gas flow before N ₂ O destruction facility	Reactor air gas flow, Gas Measuring device, data management system	Cubic metres / hour	Measured continuously	Hourly/daily/ weekly/monthly	100%	electronic	Data records will be maintained for a period of 12 years. Flow metering system will automatically record flow adjusted to standard temperature and pressure.
B6 Reg 1	<i>Reg_1_N₂O_E</i> Regulation 1 absolute quantity N ₂ O limited	National legislation	Tonnes N ₂ O	calculated	At date of introduction or change of regulation	100%	electronic	Data records will be maintained for a period of 12 years.
B7 Reg 2	<i>Reg_2N₂O_E</i> Regulation 2 N ₂ O emissions per unit of product limited	National legislation	Tonnes N ₂ O per tonne HNO ₃	calculated	At date of introduction or change of regulation	100%	electronic	Data records will be maintained for a period of 12 years.
B8 Reg3	<i>Reg_3_N₂O_E</i> Regulation III: N ₂ O concentration in tail gas limited	National legislation	Tonnes N ₂ O per M ₃	calculated	At date of introduction or change of regulation	100%	electronic	Data records will be maintained for a period of 12 years.

B.2.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO₂ equ.):

Baseline emissions are calculated based on the quantity of N₂O emitted in the baseline scenario taking national regulations into consideration. The quantity of N₂O is determined based on the measurement of the N₂O at the inlet of the N₂O destruction facility, which results in a conservative estimation of baseline emissions.

The N₂O baseline emissions monitoring equipment will

(1) calculate the Reactor gas flow being the sum of the measured Reactor air flow and Reactor ammonia gas flow (temperature and pressure are also measured and the volume flow rate automatically corrected to standard temperature and pressure) and

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(2) the N₂O concentration at the inlet of the N₂O destruction facility. The amount of N₂O baseline emissions can then directly be calculated by multiplying the Reactor gas volume flow and the N₂O concentration at the inlet to the destruction facility.

Total baseline emissions in period (p) BL_E_p [tCO₂e] are given by:

$$BL_E_p = BL_N_2O_E_p * GWP_N_2O$$

where:

BL_E_p	Total baseline emissions in period	[tCO ₂ e]
BL_N ₂ O_E_p	Quantity of baseline N ₂ O emissions in period	[tN ₂ O]
GWP_N ₂ O	Global warming potential of N ₂ O	[-]

The global warming potential of N₂O is set at 310 according to the Kyoto Protocol rules.

Depending on the implementation of regulations for N₂O emissions and the character of the regulation, baseline N₂O emissions (BL_N₂O_E_p) are calculated as shown below.

Case 1: No legal regulations for N₂O existing:

The quantity of baseline N₂O emissions in the period (BL_N₂O_E_p) are:

$$BL_N_2O_E_p = Q_N_2O_I_DF_m_p$$

where:

BL_N ₂ O_E_p	Quantity of baseline N ₂ O emissions in period	[tN ₂ O]
Q_N ₂ O_I_DF_m_p	Quantity of N ₂ O emissions at the inlet DF	[tN ₂ O]

The quantity of N₂O emissions at the inlet of the N₂O destruction facility (DF) is calculated based on Calculated Reactor gas volume flow rate and the N₂O concentration at the inlet of the N₂O destruction facility. Therefore the quantity of N₂O at the inlet is given by:

$$Q_N_2O_I_DF_m_p = Q_RG * N_2O_co_RG_I * M_h$$

where:

Q_N ₂ O_I_DF_m_p	Quantity of N ₂ O emissions at the inlet DF	[tN ₂ O]
Q_RG:	Volume flow rate Reactor gas	DF [m ³ /h]
N ₂ O_co_RG_I N ₂ O	concentration measured inlet DF	[tN ₂ O/m ³]
M_h	Operation hours in period	[h]

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Case 2: Legal regulations for N₂O are implemented:

In case national regulations concerning the N₂O emissions are implemented during the crediting period, the impact on baseline N₂O emissions is considered without any delay by adjusting the measured N₂O emissions, at the time regulation has to be implemented. Depending on the character of the regulation the adjustment is done as shown below:

Case 2.1: Regulation setting of a threshold of an absolute quantity of N₂O emissions per nitric acid plant and per time:

Baseline N₂O emissions are limited by the absolute quantity of N₂O emissions given by the regulation. If the measured baseline N₂O emissions are exceeding the regulative limit, then measured baseline N₂O emissions are substituted by the regulative limit.

This leads to the following condition:

If,

$$Q_{N_2O_I_DF_m_p} > Reg_1_N_2O_E$$

then,

$$BL_N_2O_E_p = Reg_1_N_2O_E$$

else,

$$BL_N_2O_E_p = Q_{N_2O_I_DF_m_p}$$

where:

$Q_{N_2O_I_DF_m_p}$	Quantity of N ₂ O emissions at the inlet DF	[tN ₂ O]
$Reg_1_N_2O_E$	Regulative limit 1 of N ₂ O emissions in period	[tN ₂ O]
$BL_N_2O_E_p$	Quantity of baseline N ₂ O emissions in period	[tN ₂ O]

The quantity of N₂O emissions at the inlet of the N₂O destruction facility (DF) is calculated based on measurement of the Calculated Reactor gas volume flow and the N₂O concentration at the inlet of the N₂O destruction facility. Therefore the quantity of N₂O at the inlet of the N₂O destruction facility ($Q_{N_2O_I_DF_m_p}$) is given by: $Q_{N_2O_I_DF_m_p} = Q_{RG} * N_2O_co_RG_I * M_h$

where:

$Q_{N_2O_I_DF_m_p}$	Quantity of N ₂ O emissions inlet DF	[tN ₂ O]
Q_{RG}	Volume flow rate Reactor gas DF	[m ³ /h]
$N_2O_co_RG_I$	concentration measured inlet DF	[tN ₂ O/m ³]
M_h	Operation hours in period	[h]

Case 2.2: Regulation setting of a threshold for specific N₂O emissions per unit of product:

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This leads to the following condition:

If,

$N_2O_spec_m_output > Reg_2_N_2O_E_p$

then,

$BL_N_2O_E_p = Reg_2_N_2O_E_p * P_HNO_3_p$

else,

$BL_N_2O_E_p = Q_N_2O_I_DF_m_p$

where:

$N_2O_spec_m_output$	Specific N_2O emissions per output nitric acid	$[tN_2O/tHNO_3]$
$Reg_2_N_2O_E_p$	Regulative limit 2 of N_2O emissions per product	$[tN_2O/tHNO_3]$
$BL_N_2O_E_p$	Quantity of baseline N_2O emissions in period	$[tN_2O]$
$Q_N_2O_I_DF_m_p$	Quantity of N_2O emissions at inlet DF	$[tN_2O]$

The specific N_2O emissions per unit of output nitric acid defined as:

$N_2O_spec_m_output = Q_N_2O_I_DF_m_p / P_HNO_3_p$

where:

$N_2O_spec_m_output$	Specific N_2O emissions per output nitric acid	$[tN_2O/tHNO_3]$
$P_HNO_3_p$	Nitric acid production in period	$[tHNO_3]$
$Q_N_2O_I_DF_m_p$	Quantity of N_2O emissions at inlet DF	$[tN_2O]$

The quantity of N_2O emissions at the inlet of the N_2O destruction facility ($Q_N_2O_I_DF_m_p$) is calculated based on the measurement of calculated Reactor tail gas volume flow rate and the N_2O concentration at the inlet of the N_2O destruction facility. Therefore the quantity of N_2O at the inlet is given by:

$Q_N_2O_I_DF_m_p = Q_RG * N_2O_co_RG_I * M_h$

where:

$Q_N_2O_I_DF_m_p$	Quantity of N_2O emissions inlet DF	$[tN_2O]$
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Q_RG	Volume flow rate Reactor gas DF	[m ³ /h]
N ₂ O_co_TG_I	N ₂ O concentration measured inlet DF	[tN ₂ O/m ³]
M_h	Operation hours in period	[h]

Case 2.3: Regulation setting of a threshold for specific N₂O concentration flow in the tail/stack gas
This leads to the following condition:

If,
N₂O_co_TG_I > Reg_3_N₂O_E_p

then
BL_N₂O_E_p = Reg_3_N₂O_E_p * Q_RG * M_h
else,
BL_N₂O_E_p = Q_N₂O_I_DF_m_p

where:

N ₂ O_co_RG_I	N ₂ O concentration measured inlet DF	[tN ₂ O/m ³]
Reg_3_N ₂ O_E_p	Regulative limit 3 of specific N ₂ O concentration	[tN ₂ O/m ³]
BL_N ₂ O_E_p	Quantity of baseline N ₂ O emissions in period	[tN ₂ O]
Q_N ₂ O_I_DF_m_p	Quantity of N ₂ O emissions at inlet DF	[tN ₂ O]

The quantity of N₂O emissions at the inlet of the N₂O destruction facility (Q_N₂O_I_DF_m_p) is calculated based on measurement of the Reactor gas volume flow rate and the N₂O concentration at the inlet of the N₂O destruction facility. Therefore the quantity of N₂O at the inlet is given by:

$$Q_{N_2O_I_DF_m_p} = Q_RG * N_2O_co_RG_I * M_h$$

where:

Q_N ₂ O_I_DF_m_p	Quantity of N ₂ O emissions inlet DF	[tN ₂ O]
Q_RG	Volume flow rate Reactor gas	DF [m ³ /h]
N ₂ O_co_RG_I	N ₂ O concentration measured inlet DF	[tN ₂ O/m ³]
M_h	Operation hours in period	[h]

**B.3. Option 2: Direct monitoring of emission reductions from the project activity:**

Not applicable

B.3.1. Data to be collected or used in order to monitor emissions from the project activity, and how this data will be archived:

ID number (Please use numbers to ease cross-referencing to table B.7)	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	Comment

Not applicable

B.3.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO₂ equ.):

Not applicable

B.4. Treatment of leakage in the monitoring plan:

There will be no leakage of Nitrous Oxide outside the project boundary associated with the project activity.

**B.4.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity:**

ID number (Please use numbers to ease cross-referencing to table B.7)	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	Comment

B.4.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO₂ equ.):

In case of the proposed project activity no significant change in anthropogenic emissions by sources of GHG outside the project boundary is identified. Therefore no monitoring mechanism is being suggested.

B.5. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO₂ equ.):

The greenhouse gas emission reduction (ER_p) achieved by the project activity over a period is the difference between the total baseline emissions over the period (BL_{E_p}), the total project emissions over the period (P_{E_p}) and the leakage (L_{E_p}) which in this case is zero.

$$\begin{aligned}
 ER_p &= BL_{E_p} - P_{E_p} - L_{E_p} = \\
 &= (BL_{N_2O_{E_p}} * GWP_{N_2O}) - (P_{N_2O_p} * GWP_{N_2O}) - (L_{N_2O_p} * GWP_{N_2O}) \\
 &[tCO_2e]
 \end{aligned}$$

B.6. Assumptions used in elaborating the new methodology:

CO₂ emission factors could either be obtained from certificated supplier information or from IPCC default value information. All other information used in the calculation of emissions are measured or calculated.

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**B.7. Please indicate whether quality control (QC) and quality assurance (QA) procedures are being undertaken for the items monitored:**

Data (Indicate table and ID number e.g. 3.-1.; 3.2.)	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
A1 TGF	low	Calibration procedure to be developed for routine calibration of gas flow meter to internationally recognised standards and in compliance with manufacturer's specification.
A2 N ₂ O	low	Calibration procedure to be developed for routine calibration of Nitrous Oxide monitor to internationally recognised standards and in compliance with manufacturer's specification.
A3 Time Period	low	Meters for measuring operations hours will be subject to regular calibration, maintenance and testing regime to ensure accuracy is maintained
B1 RGF (Calculated)	low	Calibration procedure to be developed for routine calibration of Reactor Ammonia gas flow meter and Reactor Air flow meter to internationally recognised standards and in compliance with manufacturer's specification.
B2 N ₂ O	low	Calibration procedure to be developed for routine calibration of Nitrous Oxide monitor to internationally recognised standards and in compliance with manufacturer's specification.
B4 RAmGF	low	Calibration procedure to be developed for routine calibration of gas flow meter to internationally recognised standards and in compliance with manufacturer's specification.
B5 RAGF	low	Calibration procedure to be developed for routine calibration of gas flow meter to internationally recognised standards and in compliance with manufacturer's specification.

B.8. Has the methodology been applied successfully elsewhere and, if so, in which circumstances?

Yes, a similar methodology was validated by a Designated Operational Entity for a JI project submitted to Senter Erupt 4 tender in 2004. The JI projects were in the United Kingdom.
