



## Approved consolidated baseline and monitoring methodology ACM0019

### “N<sub>2</sub>O abatement from nitric acid production”

## I. SOURCE, DEFINITIONS AND APPLICABILITY

### Sources

This consolidated baseline and monitoring methodology is based on elements from the following approved baseline and monitoring methodologies and proposed new methodologies:

- NM0339 “N<sub>2</sub>O abatement in New Capacity nitric acid plants” prepared by N.serve Environmental Services GmbH;
- NM0340 “N<sub>2</sub>O abatement in New Nitric Acid Plants” prepared by Carbon Climate Protection GmbH and Enaex S.A.;
- AM0028 “Catalytic N<sub>2</sub>O destruction in the tail gas of Nitric Acid or Caprolactam Production Plants”, Version 05;
- AM0034 “Catalytic reduction of N<sub>2</sub>O inside the ammonia burner of nitric acid plants”, Version 04.

This methodology also refers to the latest approved versions of the following tools:

“Tool to determine the mass flow of a greenhouse gas in a gaseous stream”;

“Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion”.

For more information regarding the proposed new methodologies and the tools as well as their consideration by the Executive Board please refer to <http://cdm.unfccc.int/goto/MPappmeth>.

### Selected approach from paragraph 48 of the CDM modalities and procedures

“Existing actual or historical emissions, as applicable”.

### Definitions

For the purpose of this methodology, the following definitions apply:

**Secondary N<sub>2</sub>O abatement.** Refers to the installation of a catalyst inside the ammonia burner unit with the sole purpose of removing N<sub>2</sub>O emissions from the stream.

**Tertiary N<sub>2</sub>O abatement.** Refers to the installation of an abatement system in the tail-gas leaving the absorption column of a nitric acid plant to destroy the N<sub>2</sub>O generated in the ammonia burner unit.



### Applicability

This methodology applies to project activities that introduce N<sub>2</sub>O abatement measures in nitric acid plants.

The methodology is applicable under the following conditions:

In the case that the nitric acid plant started commercial operation before the implementation of the CDM project activity, the project participants shall demonstrate that there was no secondary or tertiary abatement technology installed in the respective nitric acid plant;

Continuous real-time measurements of the N<sub>2</sub>O concentration and the total gas volume flow can be carried out in the tail gas stream after the abatement of N<sub>2</sub>O emissions throughout the crediting period of the project activity;

No law or regulation which mandates the complete or partial destruction of N<sub>2</sub>O from nitric acid plants exists in the host country where the CDM project activity is implemented.

In addition, the applicability conditions included in the tools referred to above apply.

## II. BASELINE METHODOLOGY PROCEDURE

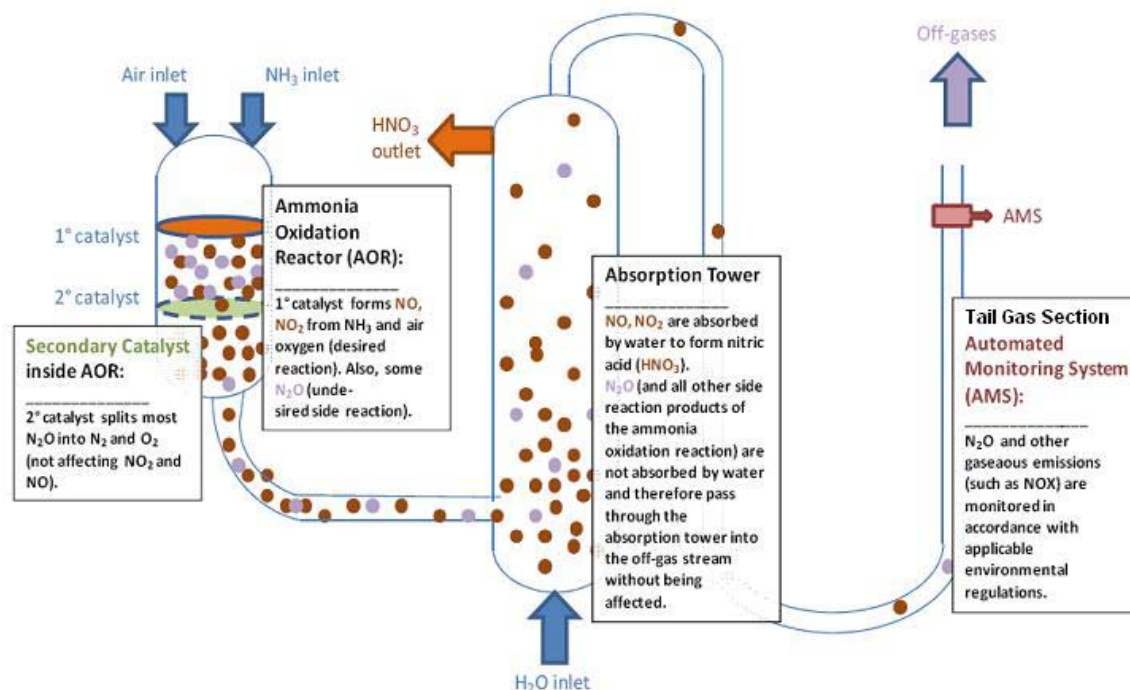
### Identification of the baseline scenario and demonstration of additionality

In the absence of regulations requiring the abatement of N<sub>2</sub>O emissions, the operator of the nitric acid plant has no economic incentives to take any N<sub>2</sub>O abatement measures because this entails capital and operating costs but no financial benefits. Therefore, the CDM project activity is considered **additional** and the baseline scenario is that the N<sub>2</sub>O is emitted to the atmosphere with no N<sub>2</sub>O abatement measure being implemented.

### Project boundary

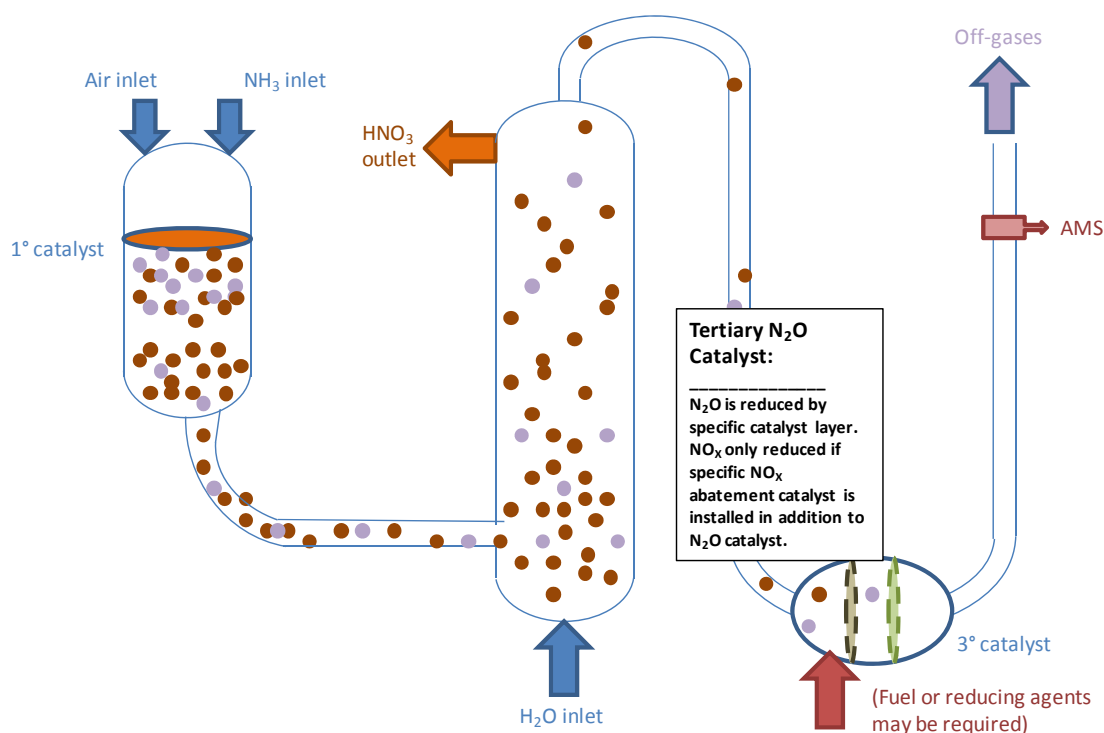
The **spatial extent** of the project boundary encompasses the facility and equipment for the nitric acid production process from the inlet of the ammonia burner to the outlet of the tail gas section.

If the project activity introduces only secondary and no tertiary N<sub>2</sub>O abatement, then the only gas to be included as project emissions is the N<sub>2</sub>O that is not destroyed and is still present in the tail gas stream of the plant. The situation using a secondary abatement technology is illustrated below in Figure 1.



**Figure 1: Project boundary if the project activity consists of the introduction of a secondary N<sub>2</sub>O abatement measure (simplified standard nitric plant layout displaying the location of the N<sub>2</sub>O abatement catalyst, process sources of N<sub>2</sub>O and the sampling point location for the Automated Monitoring System (AMS))**

If the project activity introduces tertiary N<sub>2</sub>O abatement, then any remaining N<sub>2</sub>O emissions from the project plant and CO<sub>2</sub> emissions arising from the operation of the tertiary abatement system are included as project emissions in the project boundary. The situation using a tertiary abatement technology is illustrated below in Figure 2.



**Figure 2: Project boundary if the project activity consists of the introduction of a tertiary N<sub>2</sub>O abatement measure (simplified standard nitric plant layout displaying the location of the N<sub>2</sub>O abatement catalyst, process sources of N<sub>2</sub>O and the sampling point location for the Automated Monitoring System (AMS))**

The greenhouse gases included in or excluded from the project boundary are shown in Table 1.

**Table 1: Emissions sources included in or excluded from the project boundary**

Source		Gas	Included?	Justification / Explanation
Baseline	NH <sub>3</sub> oxidation at the primary catalyst gauze	CO <sub>2</sub>	No	The project activity has no influence on these types of emissions, if present
		CH <sub>4</sub>	No	
		N <sub>2</sub> O	Yes	Included, main emission source
Project activity	NH <sub>3</sub> oxidation at the primary catalyst gauze	CO <sub>2</sub>	No	The project activity has no influence on these types of emissions, if present
		CH <sub>4</sub>	No	
		N <sub>2</sub> O	Yes	Included, main emission source
	Operation of a tertiary N <sub>2</sub> O Abatement facility	CO <sub>2</sub>	Yes	In some cases, fossil fuels are used as reducing agent and/or for decomposing the tail gas as part of a tertiary N <sub>2</sub> O abatement



		CH <sub>4</sub>	No	facility. In this case the fossil fuels are mainly converted to CO <sub>2</sub> . CO <sub>2</sub> emissions arising from the production of ammonia are assumed to be small and <b>not</b> taken into account
		N <sub>2</sub> O	Yes	Included

### Baseline emissions

Baseline emissions are calculated as follows:

$$BE_n = P_{NA,n} \times EF_{BL,N_2O,n} \times GWP_{N_2O} \times 10^{-3} \quad (1)$$

Where:

- BE<sub>n</sub> = Baseline emissions in monitoring period *n* (t CO<sub>2</sub>e)
- P<sub>NA,n</sub> = Nitric acid produced in the monitoring period *n* (t HNO<sub>3</sub>)
- EF<sub>BL,N<sub>2</sub>O,n</sub> = Baseline N<sub>2</sub>O emission factor for nitric acid production in the monitoring period *n* (kg N<sub>2</sub>O / t HNO<sub>3</sub>)
- GWP<sub>N<sub>2</sub>O</sub> = Global Warming Potential of N<sub>2</sub>O valid for the commitment period

#### Determination of the baseline N<sub>2</sub>O emission factor (EF<sub>BL,N<sub>2</sub>O,n</sub>)

The baseline N<sub>2</sub>O emission factor in the monitoring period *n* (EF<sub>BL,N<sub>2</sub>O,n</sub>) shall be determined as a default emission factor EF<sub>default,y</sub> given for each calendar year *y* for which BE<sub>n</sub> is calculated (see monitoring tables for EF<sub>default,y</sub>), as follows:

$$EF_{BL,N_2O,n} = EF_{default,y} \quad (2)$$

Where:

- EF<sub>BL,N<sub>2</sub>O,n</sub> = Baseline N<sub>2</sub>O emission factor for nitric acid production in the monitoring period *n* (kg N<sub>2</sub>O / t HNO<sub>3</sub>)
- EF<sub>default,y</sub> = Default N<sub>2</sub>O baseline emissions factor in the calendar year *y* of the monitoring period *n* (kg N<sub>2</sub>O / t HNO<sub>3</sub>)

If the monitoring period *n* spans across two (or more) calendar years, the baseline emissions (BE<sub>n</sub>) shall be calculated separately for each calendar year, first establishing EF<sub>BL,N<sub>2</sub>O,n</sub> and then applying this to the nitric acid production of that calendar year.

### Project emissions

Project emissions include emissions of N<sub>2</sub>O which have not been destroyed by the project activity and, in case of the installation of a tertiary N<sub>2</sub>O abatement facility, CO<sub>2</sub> emissions resulting from the operation of the N<sub>2</sub>O abatement facility.

Project emissions are calculated as follows:

$$PE_n = PE_{N_2O,n} + PE_{CO_2,tertiary,n} \quad (3)$$



Where:

- $PE_n$  = Project emissions in monitoring period  $n$  (t CO<sub>2</sub>e)  
 $PE_{N_2O,n}$  = Project emissions of N<sub>2</sub>O from the project plant in monitoring period  $n$  (t CO<sub>2</sub>e)  
 $PE_{CO_2,tertiary,n}$  = Project emissions of CO<sub>2</sub> from the operation of the tertiary N<sub>2</sub>O abatement facility in monitoring period  $n$  (t CO<sub>2</sub>)

Project emissions of N<sub>2</sub>O from the project plant ( $PE_{N_2O,n}$ )

The amount of N<sub>2</sub>O emissions from the project activity include two emission sources:

- The N<sub>2</sub>O contained in the tail gas stream of the plant which is released to the atmosphere; and
- In the case of a tertiary N<sub>2</sub>O abatement, the N<sub>2</sub>O contained in any by-pass streams to the tertiary N<sub>2</sub>O abatement facility.

Accordingly,  $PE_{N_2O,n}$  is determined as follows:

$$PE_{N_2O,n} = (Q_{N_2O,tail\ gas,n} + Q_{N_2O,by-pass,n}) \times GWP_{N_2O} \quad (4)$$

Where:

- $PE_{N_2O,n}$  = Project emissions of N<sub>2</sub>O from the project plant in monitoring period  $n$  (t CO<sub>2</sub>e)  
 $Q_{N_2O,tail\ gas,n}$  = Amount of N<sub>2</sub>O released through the tail gas of the project plant to the atmosphere in monitoring period  $n$  (t N<sub>2</sub>O)  
 $Q_{N_2O,by-pass,n}$  = Amount of N<sub>2</sub>O released through the by-pass to a tertiary N<sub>2</sub>O abatement system to the atmosphere in monitoring period  $n$  (t N<sub>2</sub>O)  
 $GWP_{N_2O}$  = Global warming potential of N<sub>2</sub>O valid for the commitment period

Determination of  $Q_{N_2O,tail\ gas,n}$

The amount of N<sub>2</sub>O emissions from the tail gas stream of the project plant shall be determined using the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”.

In applying the tool, the following provisions apply:

- Throughout the crediting periods of the project activity, the N<sub>2</sub>O concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is to be installed and maintained throughout the crediting period based on the European Norm 14181 (2004), or any more recent update of that standard;
- The monitoring system should provide separate hourly average values for the N<sub>2</sub>O concentration and the volume or mass flow of the tail gas based on 2 seconds (or shorter) interval readings that are recorded and stored electronically. These N<sub>2</sub>O data sets shall be identified by means of a unique time / date key indicating when exactly the values were observed;
- The correction factors derived from the calibration curve of the QAL2 audit for the monitoring components as determined during the QAL2-test in accordance with EN14181 must be applied to both the N<sub>2</sub>O concentration and the volume or mass flow of the tail gas. This can either be



applied automatically to the raw data recorded by the data storage system at the plant or it can be applied to the calculated hourly averages as part of the calculation of project emissions;

- If data for either the N<sub>2</sub>O concentration or the volume or mass flow of the tail gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour shall be replaced with the maximum value of N<sub>2</sub>O concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the N<sub>2</sub>O concentration nor the volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of N<sub>2</sub>O calculated during the monitoring period shall be applied to any such hour. Values observed during five operating hours before and after a plant start-up and shut-down shall not be used for the determination of the maximum values;

The hourly values are then aggregated for the duration of the monitoring period  $n$ , as follows:

$$Q_{N_2O, tail\ gas, n} = \sum_{h=1}^{h=h_n} F_{N_2O, tail\ gas, h} \cdot 10^{-3} \quad (5)$$

Where:

$Q_{N_2O, tail\ gas, n}$	=	Amount of N <sub>2</sub> O released through the tail gas of the project plant to the atmosphere in monitoring period $n$ (t N <sub>2</sub> O)
$F_{N_2O, tail\ gas, h}$	=	Mass flow of N <sub>2</sub> O in the gaseous stream of the tail gas in the hour $h$ (kg N <sub>2</sub> O/h)
$h_n$	=	Number of hours in monitoring period $n$ during which the plant was in operation

During any periods in which a tertiary abatement system is by-passed,  $F_{N_2O, tail\ gas, h}$  is set to zero in order to avoid double counting of project emissions.

#### Determination of $Q_{N_2O, by-pass, n}$

This emission source only needs to be estimated if a tertiary N<sub>2</sub>O abatement facility is installed under the project activity. In some situations, the gas stream from the nitric acid plant may not be sent to the tertiary N<sub>2</sub>O abatement facility but may be directly vented to the atmosphere through a by-pass.

In these situations, the project emissions are assumed to equal the baseline emissions and no emission reductions are claimed under the project activity. This means that during the time when the by pass is open the project emission factor will be equal to the baseline emission factor.

Accordingly,  $Q_{N_2O, by-pass, n}$  is determined as follows:

$$Q_{N_2O, by-pass, n} = EF_{BL, N_2O, n} \cdot P_{NA, n} \cdot T_{open, n} \cdot 10^{-3} \quad (6)$$

Where:

$Q_{N_2O, by-pass, n}$	=	Amount of N <sub>2</sub> O released through the by-pass to a tertiary N <sub>2</sub> O abatement system to the atmosphere in monitoring period $n$ (t N <sub>2</sub> O)
$EF_{BL, N_2O, n}$	=	Baseline N <sub>2</sub> O emission factor for nitric acid production in monitoring period $n$ (kg N <sub>2</sub> O / t HNO <sub>3</sub> )



$P_{NA,n}$  = Nitric acid produced in the monitoring period  $n$  (t HNO<sub>3</sub>)  
 $T_{open,n}$  = Fraction of time in monitoring period  $n$  during which the by-pass valve on the line feeding the tertiary N<sub>2</sub>O abatement facility was open to vent the gas directly to the atmosphere

Project emissions from the operation of the tertiary N<sub>2</sub>O abatement facility ( $PE_{CO_2,tertiary,n}$ )

This emission source only needs to be estimated if a tertiary N<sub>2</sub>O abatement facility is installed under the project activity and if fossil fuels are used to operate the facility or re-heat the gas after the facility.

The emissions related to the operation of the N<sub>2</sub>O destruction facility include only On-site emissions due to the fossil fuel use as input to the N<sub>2</sub>O destruction facility:

$$PE_{CO_2,tertiary,n} = PE_{FF,n} \quad (7)$$

Where:

$PE_{CO_2,tertiary,n}$  = Project emissions of CO<sub>2</sub> from the operation of the tertiary N<sub>2</sub>O abatement facility in monitoring period  $n$  (t CO<sub>2</sub>)  
 $PE_{FF,n}$  = Project emissions related to fossil fuel input to the destruction facility and/or re-heater in monitoring period  $n$  (t CO<sub>2</sub>)

Project proponents shall use the latest version of the “Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion” to calculate the project emissions related to fossil fuels used in monitoring period  $n$ .

Specific guidance on the use of the tool:

- The parameter  $PE_{FC,j,y}$  used in the “Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion” corresponds to the parameter  $PE_{FF,n}$  in this methodology, and
- The element process  $j$  in the tool corresponds to the consumption of fossil fuels for the operation of the tertiary N<sub>2</sub>O abatement facility and/or the re-heating of the tail gas.

## Leakage

Any leakage emissions sources are deemed to be negligible.

## Emission reductions

Emission reductions are calculated as follows:

$$ER_n = BE_n - PE_n \quad (8)$$

Where:

$ER_n$  = Emission reductions in monitoring period  $n$  (t CO<sub>2</sub>e)  
 $BE_n$  = Baseline emissions in monitoring period  $n$  (t CO<sub>2</sub>e)  
 $PE_n$  = Project emissions in monitoring period  $n$  (t CO<sub>2</sub>e)



**Data and parameters not monitored**

In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the tools referred to in this methodology apply.

<b>Data / Parameter:</b>	$EF_{\text{default},y}$																																												
<b>Data unit:</b>	kg N <sub>2</sub> O / t HNO <sub>3</sub>																																												
<b>Description:</b>	Default N <sub>2</sub> O baseline emissions factor in the calendar year $y$ of the monitoring period $n$																																												
<b>Source of data:</b>	<p>The default N<sub>2</sub>O baseline emission factor will vary every year. In year 2005 the emission factor will be 5.1 and then it will decrease every year until it reaches a final value of 2.5 in the year 2020. The value of 2.5 will remain constant after 2020, as provided in the following table:</p> <table border="1"> <thead> <tr> <th>Year</th><th>Emission factor (kgN<sub>2</sub>O/tHNO<sub>3</sub>)</th></tr> </thead> <tbody> <tr><td>2005</td><td>5.10</td></tr> <tr><td>2006</td><td>4.90</td></tr> <tr><td>2007</td><td>4.70</td></tr> <tr><td>2008</td><td>4.60</td></tr> <tr><td>2009</td><td>4.40</td></tr> <tr><td>2010</td><td>4.20</td></tr> <tr><td>2011</td><td>4.10</td></tr> <tr><td>2012</td><td>3.90</td></tr> <tr><td>2013</td><td>3.70</td></tr> <tr><td>2014</td><td>3.50</td></tr> <tr><td>2015</td><td>3.40</td></tr> <tr><td>2016</td><td>3.20</td></tr> <tr><td>2017</td><td>3.00</td></tr> <tr><td>2018</td><td>2.80</td></tr> <tr><td>2019</td><td>2.70</td></tr> <tr><td>2020</td><td>2.50</td></tr> <tr><td>2021</td><td>2.50</td></tr> <tr><td>2022</td><td>2.50</td></tr> <tr><td>2023</td><td>2.50</td></tr> <tr><td>⋮</td><td>⋮</td></tr> <tr><td>Year <math>n</math></td><td>2.50</td></tr> </tbody> </table>	Year	Emission factor (kgN <sub>2</sub> O/tHNO <sub>3</sub> )	2005	5.10	2006	4.90	2007	4.70	2008	4.60	2009	4.40	2010	4.20	2011	4.10	2012	3.90	2013	3.70	2014	3.50	2015	3.40	2016	3.20	2017	3.00	2018	2.80	2019	2.70	2020	2.50	2021	2.50	2022	2.50	2023	2.50	⋮	⋮	Year $n$	2.50
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Year $n$	2.50																																												
<b>Measurement procedures (if any):</b>	None																																												
<b>Any comment:</b>	The decrease in the value for the baseline emission factor over time is to reflect the technological development																																												



<b>Data / Parameter:</b>	GWP <sub>N<sub>2</sub>O</sub>
Data unit:	t CO <sub>2</sub> e / t N <sub>2</sub> O
Description:	Global warming potential of N <sub>2</sub> O valid for the commitment period
Source of data:	Relevant decisions by the CMP
Measurement procedures (if any):	None
Any comment:	

### III. MONITORING METHODOLOGY

All data collected as part of monitoring should be archived electronically and be kept at least for 2 years after the end of the last crediting period. 100% of the data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards.

In addition, the monitoring provisions in the tools referred to in this methodology apply.

#### Data and parameters monitored

##### Baseline emissions

<b>Data / Parameter:</b>	P <sub>NA,n</sub>
Data unit:	t HNO <sub>3</sub>
Description:	Nitric acid produced in the monitoring period <i>n</i>
Source of data:	Measurements by project participants and production reports
Measurement procedures (if any):	
Monitoring frequency:	Every monitoring period
QA/QC procedures:	Measurement devices such as weight scales shall follow QA/QC supplier recommendations
Any comment:	

##### Project emissions

<b>Data / Parameter:</b>	h <sub>n</sub>
Data unit:	-
Description:	Number of hours of operation in a monitoring period <i>n</i>
Source of data:	Measured
Measurement procedures (if any):	
Monitoring frequency:	Every monitoring period
QA/QC procedures:	
Any comment:	Records to be maintained during project's lifetime



<b>Data / Parameter:</b>	T <sub>Open,n</sub>
Data unit:	%
Description:	Fraction of time in monitoring period <i>n</i> during which the by-pass valve on the line feeding the tertiary N <sub>2</sub> O abatement facility was open to vent the gas directly to the atmosphere
Source of data:	Measured
Measurement procedures (if any):	Measured as a fraction by monitoring the period of opened condition and the total operating hours of the production facility during the monitoring period <i>n</i>
Monitoring frequency:	Every monitoring period
QA/QC procedures:	Metering instruments shall be calibrated regularly to industry standards
Any comment:	Records to be maintained during project's lifetime.

#### IV. REFERENCES AND ANY OTHER INFORMATION

Methodology proposal “Standardized N<sub>2</sub>O baselines for new nitric acid plants” prepared by N.serve Environmental Services GmbH;

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#### History of the document

Version	Date	Nature of revision(s)
01.0.0	EB 61, Annex 4 3 June 2011	Initial adoption.
<b>Decision Class:</b> Regulatory <b>Document Type:</b> Standard <b>Business Function:</b> Methodology		