



**Monitoring report form**  
**(Version 05.1)**

*Complete this form in accordance with the Attachment "Instructions for filling out the monitoring report form" at the end of this form.*

**MONITORING REPORT**

<b>Title of the project activity</b>	Omnia Fertilizer Limited Nitrous Oxide (N <sub>2</sub> O) Reduction Project	
<b>UNFCCC reference number of the project activity</b>	0752	
<b>Version number of the monitoring report</b>	01	
<b>Completion date of the monitoring report</b>	16/06/2016	
<b>Monitoring period number and duration of this monitoring period</b>	Monitoring Period 2 01/08/2015 – 31/05/2016 Duration (305 days)	
<b>Project participant(s)</b>	Omnia Fertilizer Limited	
<b>Host Party</b>	South Africa	
<b>Sectoral scope(s)</b>	Sectoral Scope: 05	
<b>Selected methodology(ies)</b>	Applied Methodology: ACM0019 Version 02.0.	
<b>Selected standardized baseline(s)</b>	Not applicable	
<b>Estimated amount of GHG emission reductions or net GHG removals by sinks for this monitoring period in the registered PDD</b>	352,557	
<b>Total amount of GHG emission reductions or net GHG removals by sinks achieved in this monitoring period</b>	GHG emission reductions or net GHG removals by sinks reported up to 31 December 2012	GHG emission reductions or net GHG removals by sinks reported from 1 January 2013 onwards
	0	137,864

## SECTION A. Description of project activity

### A.1. Purpose and general description of project activity

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a). Omnia Fertilizer Limited has implemented a project activity aimed at reducing the N<sub>2</sub>O emissions from its Nitric Acid plant in Sasolburg, South Africa. The project activity is under the category large scale, Sectoral scope 5 “Chemical Industry.

b). The project activity involves the installation of an N<sub>2</sub>O catalytic Destruction Facility, EnviNox in the tail gas section of the process downstream of the absorption column at Omnia Fertilizer nitric acid plant in Sasolburg, South Africa. Catalytic reduction of N<sub>2</sub>O occurs when the N<sub>2</sub>O in the tail gas reacts, in the presence of the iron zeolite catalyst, with the reducing agent in the Destruction Facility. The reaction removes the oxygen from the N<sub>2</sub>O molecules and forms one or more compounds. In this case the reducing agent is natural gas, comprised mostly of methane (CH<sub>4</sub>).

c).

Registration date: 03/05/2007

1<sup>st</sup> Crediting period: 26/02/2008 to 25/02/2015 (Renewable)

2<sup>nd</sup> Crediting period: 26/02/2015 to 25/02/2022 (Renewable)

The starting date of operation of the project activity is 26/02/2008.

The EnviNox installation was completed and commissioned in January 2008.

Omnia erected and commissioned the Nitric Acid Plant in 1983.

d). Total emission reductions achieved in this monitoring period 137,864 tCO<sub>2</sub>e

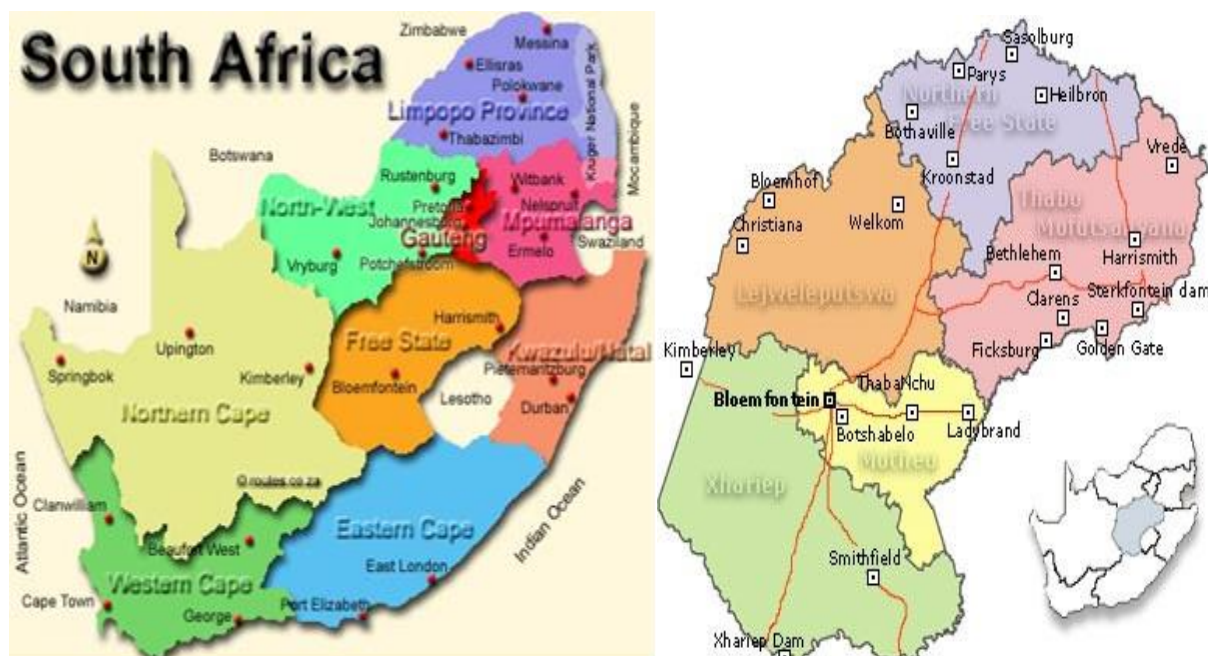
## A.2. Location of project activity

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a) Host Party: Republic of South Africa

b) Free State Province, Sasolburg, Metsimaholo Municipality

c) Omnia's plant is located at latitude of approximately 26°48'48" South and a longitude of 27°51'23" East.



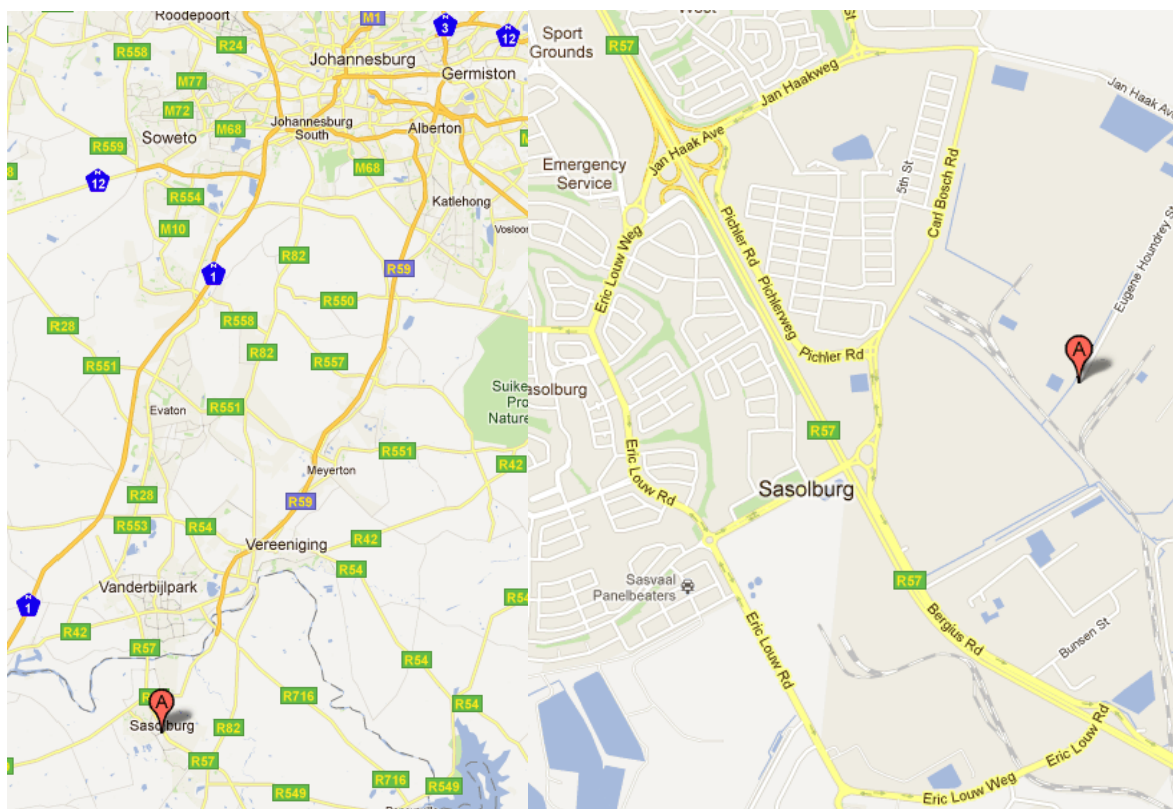


Figure 1: Physical location of the Omnia I nitric acid plant in Sasolburg, South Africa

### A.3. Parties and project participant(s)

Party involved (host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate whether the Party involved wishes to be considered as project participant (yes/no)
South Africa (host)	Omnia Fertilizer Limited	No
United Kingdom of Great Britain and Northern Ireland	Rabobank International (withdrawn)	No
Netherlands	International Finance Corporation (withdrawn)	No
Norway	Nordic Environment Finance Corporation	No

### A.4. Reference of applied methodology and standardized baseline

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1. (a) Applied methodology: ACM0019 Version 02.0: "N<sub>2</sub>O abatement from nitric acid production"
- (b) Applied tools:
  - i. "Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion" (Version 02)
  - ii. "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0.0)

### A.5. Crediting period of project activity

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- (a) Type of Crediting Period: Renewable: 7 years and 0 months
- (b) Start date of 1<sup>st</sup> Crediting Period: 26.02.2008 (End date: 25.02.2015)  
Start date of 2<sup>nd</sup> Crediting Period: 26.02.2015 (End date: 25.02.2022)
- (c) Start of this Monitoring Period: 01.08.2015

- (d) End date of this Monitoring Period: 31/05/2016  
 (e) Length of this Monitoring Period: 305 days

#### A.6. Contact information of responsible persons/entities

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See table in annex 1

## SECTION B. Implementation of project activity

### B.1. Description of implemented registered project activity

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- a) The project activity entails the installation of:
- Tertiary N<sub>2</sub>O abatement technology,
  - Specialized monitoring equipment that is installed at the tail gas stream after the abatement of N<sub>2</sub>O emissions.

#### Catalyst Technology

In the production process of nitric acid (HNO<sub>3</sub>), NO<sub>2</sub> is produced as an intermediate material from ammonia (NH<sub>3</sub>). The associated chemical reactions of oxidizing ammonia and simultaneous unwanted reactions are as follows:

- |   |   |   |  |
|---|---|---|--|
| 1. NH <sub>3</sub> + 2 O <sub>2</sub>   | → | HNO <sub>3</sub> + H <sub>2</sub> O     | (overall desirable reaction)                           |
| 2. 4 NH <sub>3</sub> + 5 O <sub>2</sub> | → | 4 NO + 6 H <sub>2</sub> O               | (desirable in the NH <sub>3</sub> oxidization process) |
| 3. 2NO + O <sub>2</sub>                 | → | 2 NO <sub>2</sub>                       | (desirable in the NO oxidization process)              |
| 4. 3 NO <sub>2</sub> + H <sub>2</sub> O | → | 2 HNO <sub>3</sub> + NO                 | (desirable in the NO <sub>2</sub> absorption process)  |
| 5. 4 NH <sub>3</sub> + 3 O <sub>2</sub> | → | 2 N <sub>2</sub> + 6 H <sub>2</sub> O   | (undesirable)  |
| 6. 4 NH <sub>3</sub> + 4 O <sub>2</sub> | → | 2 N <sub>2</sub> O + 6 H <sub>2</sub> O | (undesirable)  |
| 7. 2 NH <sub>3</sub> + 8 NO             | → | 5 N <sub>2</sub> O + 3 H <sub>2</sub> O | (undesirable)  |

Through the sixth and seventh reactions, some N<sub>2</sub>O is generated in the process.

The N<sub>2</sub>O abatement technology is installed in the tail gas downstream after the HNO<sub>3</sub> absorber and before the tail gas turbine. A tertiary catalyst reduces N<sub>2</sub>O that is formed in the primary ammonia oxidation reaction. A wide range of metals (e.g. Cu, Fe, Mn, Co and Ni) have been shown to be of varied efficiency in N<sub>2</sub>O abatement catalysts. The abatement efficiency of this pelleted catalyst has been shown to be up to 99.9% in the following reaction<sup>1</sup>:



In the tertiary abatement system N<sub>2</sub>O is removed by catalytic reduction with a hydrocarbon, such as methane from natural gas.

The applied technology is chosen because it has negligible risk of decreasing HNO<sub>3</sub> production and a high expected N<sub>2</sub>O reduction.

The expected remaining lifetime of the N<sub>2</sub>O reduction unit is at least 10 years. It is expected to be in the range of 25 years. However the installed catalyst itself may need to be replaced after a few years, depending on the achieved abatement performance.

In addition NO<sub>x</sub> is reduced in a separate catalyst bed by reduction with ammonia.

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<sup>1</sup> While the calculations of estimated emission reductions are based on the conservative estimation of an abatement efficiency of 98 %, it should be noted that from experience from the first crediting period of this project as well as from other similar projects with the same technology even higher abatement efficiencies of up to 99.9 % were observed.

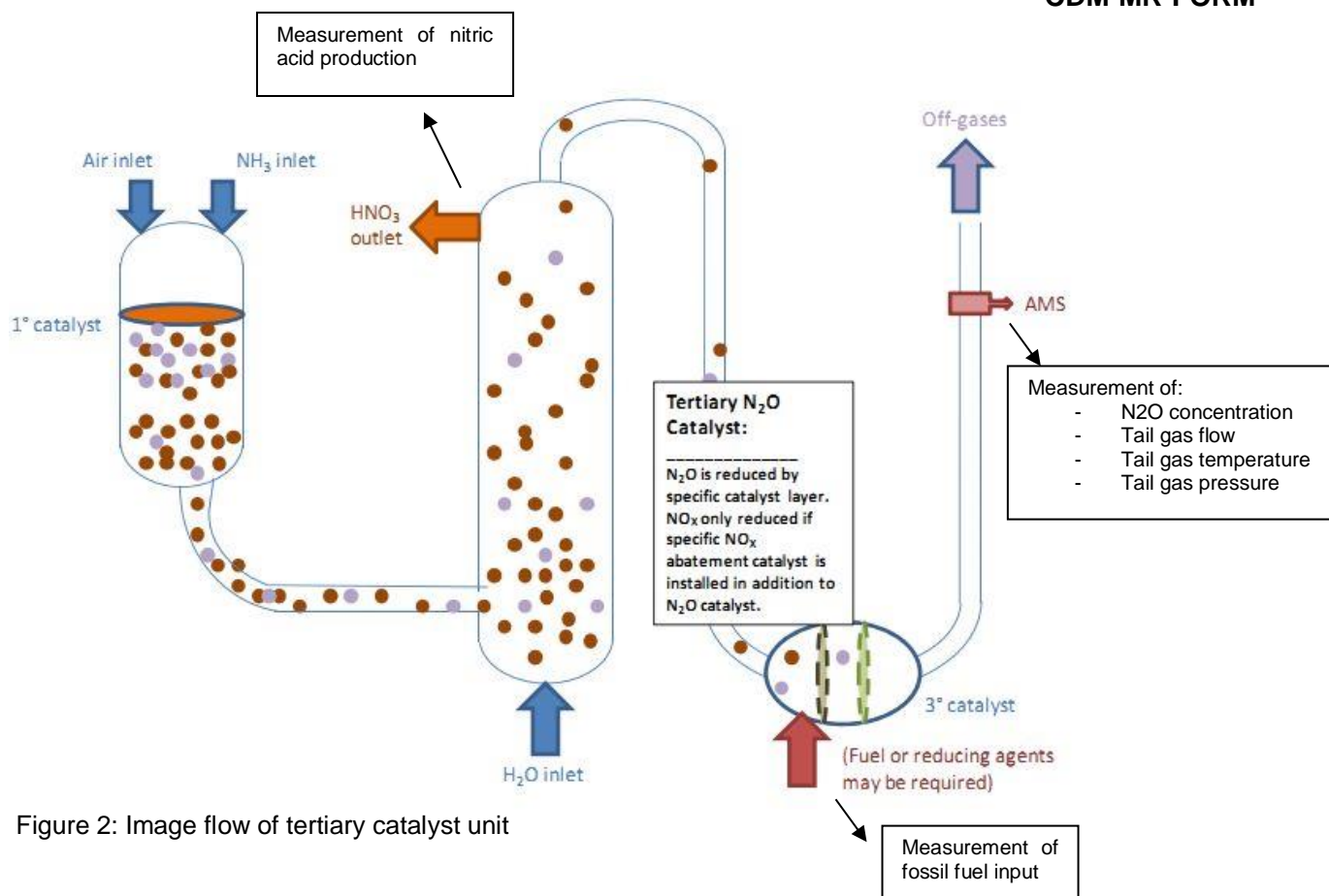


Figure 2: Image flow of tertiary catalyst unit

b) Events or situations of plant downtime during this monitoring period

Begin of downtime	End of downtime	Time duration (hours)	reason
09/08/2015 18:00	18/08/2015 23:00	222	Stop plant due to high levels, use opportunity to do some work
01/09/2015 10:00	01/09/2015 11:00	2	Ammonia bullets excess valves closed
26/09/2015 13:00	26/09/2015 17:00	5	Thermo couple gasket between TG 1 and CC2 failed, resulting in a plant trip
30/09/2015 12:00	06/10/2015 14:00	147	Steam drum manhole gasket failure, install new BFW pre-heaters
14/10/2015 19:00	17/10/2015 13:00	67	Stop plant due to PIC 24, steam inlet valve from Sasol isolation valve failed
17/10/2015 18:00	17/10/2015 19:00	2	Secondary air to bleaching tower valve failed, steam drum level low
19/10/2015 03:00	19/10/2015 07:00	5	Pressure transmitter on Nox compressor failed
21/10/2015 14:00	21/10/2015 19:00	6	Stop plant due to Nox leak on Nox compressor discharge line
28/10/2015 00:00	28/10/2015 05:00	6	Power outage ex Escom, low frequency

Begin of downtime	End of downtime	Time duration (hours)	reason
21/11/2015 19:00	03/12/2015 01:00	271	Stop due to leak on Nox compressor split face
04/12/2015 01:00	04/12/2015 05:00	5	Plant trip due to low ammonia evaporator level, control valve stuck close
04/12/2015 07:00	04/12/2015 11:00	5	Thermo couple gasket between TG 1 and CC2 failed, resulting in a plant trip
11/01/2016 12:00	07/05/2016 21:00	2818	Stop plant due to low production demand, annual shutdown
10/05/2016 10:00	10/05/2016 12:00	3	Plant trip due to low oil level in governor
16/05/2016 09:00	17/05/2016 22:00	38	Power outage ex Escom, low frequency
20/05/2016 18:00	23/05/2016 08:00	63	Equalizing valve open un-expectably, lost BFW pumps
23/05/2016 21:00	24/05/2016 01:00	5	Plant trip due to low ratio
24/05/2016 23:00	25/05/2016 02:00	4	Plant trip due to low ratio
25/05/2016 10:00	25/05/2016 21:00	12	Plant trip due to low ratio

For the periods:

06/10/2015 15:00,  
 03/12/2015 20:00 - 03/12/2015 21:00,  
 07/05/2016 22:00 - 08/05/2016 05:00,  
 08/05/2016 16:00 - 09/05/2016 15:00,  
 17/05/2016 23:00,  
 23/05/2016 09:00

the results for HNO<sub>3</sub> production showed implausible results and were manually replaced by 0 t/h HNO<sub>3</sub> as the most conservative approach.

During 63 hours of the monitoring period the N<sub>2</sub>O analyser was out of operation or in maintenance for more than 1/3 of an hour. The results were replaced by the maximum value that was recorded during the monitoring period.

c) Description of:

i. Events or situations that may have impacted the applicability of the applied methodology:

None

ii. The following describes how these events or situations have been addressed:

N/A

## B.2. Post-registration changes

### B.2.1. Temporary deviations from registered monitoring plan, applied methodology or applied standardized baseline

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No

**B.2.2. Corrections**

>>  
No

**B.2.3. Changes to start date of crediting period**

>>  
No

**B.2.4. Inclusion of a monitoring plan to the registered PDD that was not included at registration**

>>  
No

**B.2.5. Permanent changes from registered monitoring plan, applied methodology or applied standardized baseline**

>>  
No

**B.2.6. Changes to project design of registered project activity**

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No

**B.2.7. Types of changes specific to afforestation or reforestation project activity**

>>  
Not Applicable

**SECTION C. Description of monitoring system**

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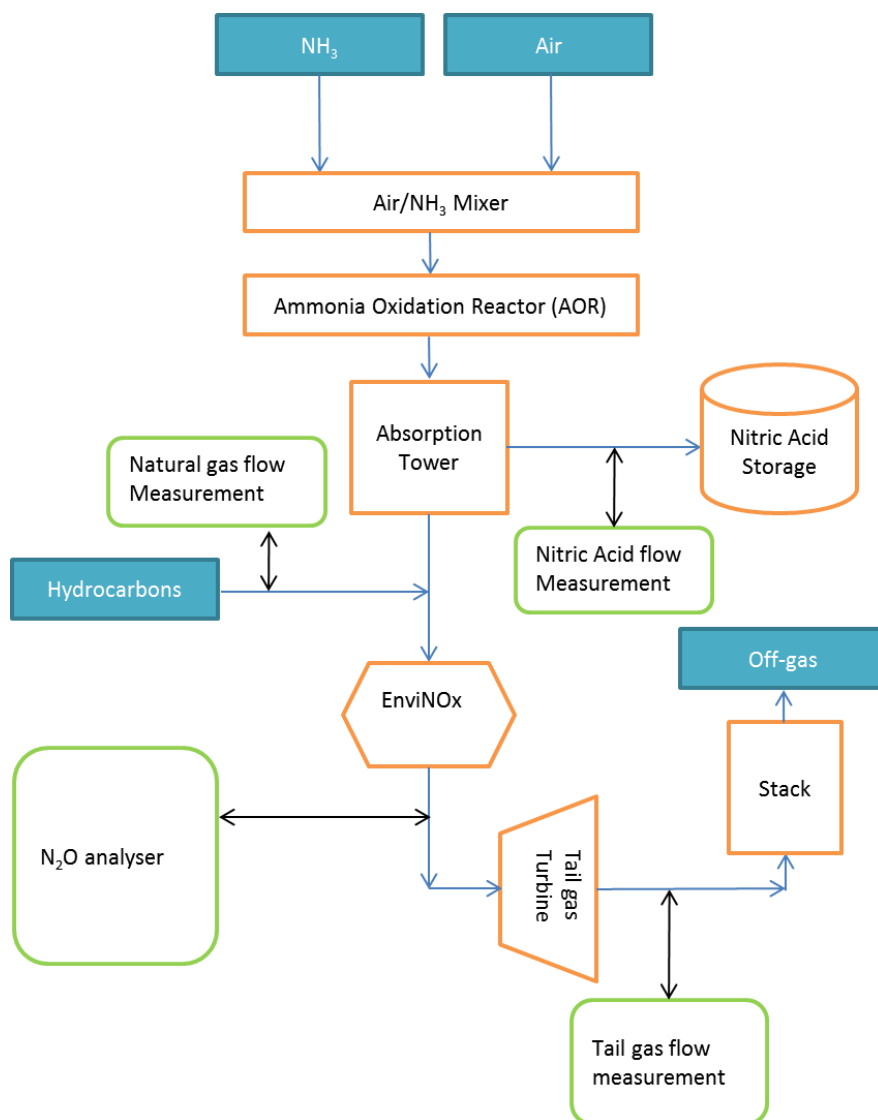


Figure 3: Schematic diagram of location of sample points

#### Sample points

The sample points were chosen in accordance with the AMS requirements, EN 14181:2004 requirements and the plant design specifications to allow an optimum of data collecting quality.

The location of the sample point was selected to provide ease of access and a location close to the analyser. The most suitable position is in the horizontal section of the exit stack. At this point, the gas is still hot and well mixed. The graph above shows the location of the sample point schematically.

#### Analyser

The Emerson NGA 2000 is capable of analysing N<sub>2</sub>O concentration in gas mixtures. The continuous NDIR industrial photometer can selectively measure concentrations of up to four sample components. In this case it is equipped for the measurement of N<sub>2</sub>O and NO. The analyser features gas-filled optopneumatic detectors. The detector provides optimum sensitivity and high selectivity compared with the other gas components in the sample. The Analyser is QAL1 tested according to EN 14181:2004 for the measurement of N<sub>2</sub>O.

#### Sample Conditioning System

The gas sample is extracted at the sampling point particles are removed with a heated filter unit and the clean sampling gas is delivered through a heated sampling line to the analyser cabinet. Before being fed to the analyser, traces of moisture are removed by a sample conditioning system that is installed in the analyser cabinet. The minimum flow rate to the analyser is controlled and connected to an alarm.

#### Stack gas flow meter



The Durag annubar measuring system D-FL 100 operates according to the differential pressure principle. The probe has two separate chambers, between which the flow builds up a differential pressure. Taking into account the other flow parameters absolute pressure and temperature, the volume flow is converted from operating to standard conditions. The D-FL 100 is QAL1 tested according to EN 14181:2004 and EN ISO 15267.

#### Accuracy and Calibration of Instruments

All meters are maintained to ensure a high level of accuracy. The exact specifications of each meter have been included in procedures to maintain those levels of accuracy.

All key monitoring instruments are calibrated in regular intervals. A record is being maintained showing the location and unique identification number of each meter, the calibration status of that meter (when last calibrated, when next due for calibration).

Monitoring equipment (Tag-No./ Description)	Serial Number	Description; Related monitoring parameter as per applicable registered monitoring plan	Type	Accuracy or accuracy class	Calibration frequency	Calibrations
FT 7672	Transmitter: 3845068 Sensor: 14459566	Natural gas flow meter <b>FC<sub>i,j,n</sub></b>	Micro Motion Coriolis Massflow	+/- 0.5 % of the adjusted range	3 years	25/02/2015 13/08/2015
FT-76010	Transmitter: 3765698 Sensor: 14163265	Nitric acid flow meter <b>P<sub>production,y</sub></b>	Micro Motion Coriolis Massflow	+/- 0.2 % of the adjusted range	Annually	14/03/2015 13/08/2015 06/05/2016
TT 76009/6	02395244	Gauze Temperature (used to indicate plant operational status) <b>h<sub>y</sub></b>	Thermocouple/ Temperature Transmitter 248HA11N0NS	+/- 0.1%	Once per year or shorter, according to gauze change	15/02/2015 14/01/2016
FT/PT/TT 7681	1243953	Stack gas flow, pressure and temp <b>V<sub>t,db</sub>, P<sub>t</sub>, T<sub>t</sub></b>	Durag annubar measuring system D-FL 100	QAL1: +/- 2.23 % QAL 2: +/- 2,51 %.	AST done every year and QAL2 every 5 years	QAL2 (including AST): 01/06/2015 – 03/06/2015
AT 7639	9904717054 99	N <sub>2</sub> O Outlet Analyser <b>V<sub>i,t,db</sub></b>	Emerson NGA 2000	QAL1: +/- 1.6 % QAL 2: +/- 2.24 %.	QAL3 done automatically, zero every day, span every second day. AST done every year and QAL2 every 5 years.	QAL2 (including AST): 16/06/2014 – 20/06/2014  AST: 01/06/2015 – 03/06/2015

In the following, it is described how the procedures given in EN 14181:2004 and EN 14181:2014 for QAL1-3 have been applied at the plant.

#### QAL1

In accordance with EN14181:2004, the monitoring system for N<sub>2</sub>O concentration measurements has been proven suitable for its measuring task (parameter and composition of the flue gas) by use of the QAL1 procedure as specified by EN ISO 15267 or equivalent standards. Monitoring equipment for N<sub>2</sub>O concentration measurement and Stack gas flow measurement was installed at suitable sampling points in the tail gas of the nitric acid plant.

#### QAL2

QAL2 is a procedure for the determination of the calibration function and its variability. According to EN 14181:2004 and EN 14181:2014, the QAL2 test was conducted by an independent “testing house” or laboratory which is accredited according to EN ISO/IEC 17025. The QAL2 tests are performed on suitable

AMS that have been correctly installed and commissioned on-site (as opposed to QAL 1 which is conducted off-site).

A calibration function was established from the results of a number of parallel measurements performed with a Standard Reference Method (SRM). The variability of the measured values obtained with the AMS is then evaluated by the independent qualified "testing house". QAL2 tests are to be performed at least every 5 years according to EN 14181:2004 and EN 14181:2014.

### AST

In addition, Annual Surveillance Tests (AST) are conducted in accordance with EN 14181:2014; these are a series of measurements with independent measurement equipment in parallel to the existing AMS. The AST tests are performed annually. If a full QAL2 test is performed (at least every 5 years), an additional AST test is not necessary in that same year.

QAL2 and AST Test for N<sub>2</sub>O and volume flow combined with measurements of the moisture content of the tail gas. AST were done by TÜV SÜD Industrie Service GmbH.

### QAL3

QAL3 describes the on-going quality assurance and maintenance procedures and documentation for the AMS conducted by the plant operator. With this documentation it can be demonstrated that the AMS is in control during its operation so that it continues to function within the required specifications.

In essence, the instrumentation personnel performed QAL3 procedures through the established calibration procedures.

### N<sub>2</sub>O-Analyser Zero Calibration

Nitrogen gas was used as reference gas for zero calibration. The zero calibration was conducted automatically every 24 hours.

### N<sub>2</sub>O-Analyser Span calibration

Span calibrations were performed every second day by means of a certified calibration gas and were automatically triggered. Manual initiation of the span calibration can also be performed if required. The calibration results and subsequent actions were all documented as part of the CDM procedure. In addition, the analyser room and equipment was visually inspected on a regular basis.

### Flow meter calibration procedures

The flow meter itself does not need to be calibrated since it is a physical device which does not have drift. Therefore, it is sufficient to regularly inspect its physical condition by means of visual and electric checks of the probe. It was cleaned if deemed necessary. In addition the flow meter was checked during the QAL2 and AST tests by an independent laboratory by comparison to a standard reference method (SRM) as stated above.

### Organization Structure with Management & Operation Process

As an operator of nitric acid plants since many years, the plant's staff in general and its instrument department in particular have been accustomed to operating technical equipment adhering to high quality standards.

Omnia has trained the staff selected for the operation of the relevant monitoring systems and ensures that the operational standards required for the appropriate handling of the equipment is maintained throughout the crediting period. Measuring instruments are calibrated by the instrumentation engineer in accordance with the requirements of the instrument suppliers. The operations and equipment engineers of the nitric acid plant are responsible for the daily operation and maintenance of the systems.

The monitoring of the parameters for the determination of the mass flow of the N<sub>2</sub>O is the responsibility of the operational personal. All relevant data is recorded automatically and stored on electronic media.

### Data Processing

#### Archiving of data

In accordance with the PDD, all of the data collected for the project activity is stored in electronic format for the duration of the crediting period + 2 years. To meet these criteria, Omnia provides an extensive data storage system covering both the raw data received by the Delta V DCS as well as the output reports from the from the Delta V DCS as follows:

- All data collected by the Delta V DCS is stored on its internal hard drive for 1 month.
- The Envinox TM data on the server is also backed up to an external USB HDD which is kept at the instrumentation department and also retained there for the duration of the crediting period + 2 years.

- The monitoring team will periodically archive data to a secure and retrievable storage format. Calibration records may be archived by scanning and storage in an accessible electronic format. These data will be stored until 2 years after the end of the crediting period or the last issuance of CER's whichever occur later.

## SECTION D. Data and parameters

### D.1. Data and parameters fixed ex ante or at renewal of crediting period

(Copy this table for each piece of data and parameter)

<b>Data / Parameter:</b>	Operating pressure
Unit:	kPa
Description:	Operating pressure of the ammonia burner
Source of data:	Manufacturer specifications
Value(s) applied:	300
Choice of data or measurement methods and procedures	lowest design operation limit of the ammonia burner
Purpose of data:	Calculation of baseline emissions or baseline net GHG removals by sinks
<b>Additional comment:</b>	The design operational range is indicated by the manufacturer as 300 – 450 kPa

<b>Data / Parameter:</b>	EF <sub>historical</sub>
Unit:	kgN <sub>2</sub> O/tHNO <sub>3</sub>
Description:	Historical baseline emission factor of the nitric acid plant
Source of data:	Historical information from issuance reports of CDM-Project documents
Value(s) applied:	5.54
Choice of data or measurement methods and procedures	For plants that used AM0028 in the first crediting period: use the lowest baseline emission factor obtained in one calendar year, from 1 January to 31 December, obtained during the first crediting period;
Purpose of data:	Calculation of baseline emissions or baseline net GHG removals by sinks
<b>Additional comment:</b>	This value will remain constant over the second and third crediting period

<b>Data / Parameter:</b>	EF <sub>default,y</sub>
Unit:	kg N <sub>2</sub> O/t HNO <sub>3</sub>
Description:	Default emission factor according to the operating pressure of the ammonia burner in year y (related to 100 per cent pure acid)

Source of data:	<p>This default N<sub>2</sub>O baseline emission factor will vary every year. In the year 2013 the emission factors will be 5.5; 8.4; and 12.6 kg N<sub>2</sub>O/t HNO<sub>3</sub> for low, medium and high pressure ammonia burners. For each subsequent year, the emission factors will decrease by 0.2 kg N<sub>2</sub>O/t HNO<sub>3</sub> until they reach a value of 2.5 or 2.4. After reaching the values of 2.5 or 2.4 the emission factor will remain constant over time:</p> <table border="1"> <thead> <tr> <th>Year</th><th>Low pressure (0 – 200 kPa)</th><th>Medium pressure (200 – 600kPa)</th><th>High pressure (Over 600 kPa)</th></tr> </thead> <tbody> <tr><td>2013</td><td>5.5</td><td>8.4</td><td>12.6</td></tr> <tr><td>2014</td><td>5.3</td><td>8.2</td><td>12.4</td></tr> <tr><td>2015</td><td>5.1</td><td>8.0</td><td>12.2</td></tr> <tr><td>2016</td><td>4.9</td><td>7.8</td><td>12</td></tr> <tr><td>2017</td><td>4.7</td><td>7.6</td><td>11.8</td></tr> <tr><td>2018</td><td>4.5</td><td>7.4</td><td>11.6</td></tr> <tr><td>2019</td><td>4.3</td><td>7.2</td><td>11.4</td></tr> <tr><td>2020</td><td>4.1</td><td>7</td><td>11.2</td></tr> <tr><td>2021</td><td>3.9</td><td>6.8</td><td>11</td></tr> <tr><td>2022</td><td>3.7</td><td>6.6</td><td>10.8</td></tr> <tr><td>2023</td><td>3.5</td><td>6.4</td><td>10.6</td></tr> <tr><td>2024</td><td>3.3</td><td>6.2</td><td>10.4</td></tr> <tr><td>2025</td><td>3.1</td><td>6</td><td>10.2</td></tr> <tr><td>2026</td><td>2.9</td><td>5.8</td><td>10</td></tr> <tr><td>2027</td><td>2.7</td><td>5.6</td><td>9.8</td></tr> <tr><td>2028</td><td>2.5</td><td>5.4</td><td>9.6</td></tr> <tr><td>2029</td><td>2.5</td><td>5.2</td><td>9.4</td></tr> <tr><td>2030</td><td>2.5</td><td>5.0</td><td>9.2</td></tr> </tbody> </table>	Year	Low pressure (0 – 200 kPa)	Medium pressure (200 – 600kPa)	High pressure (Over 600 kPa)	2013	5.5	8.4	12.6	2014	5.3	8.2	12.4	2015	5.1	8.0	12.2	2016	4.9	7.8	12	2017	4.7	7.6	11.8	2018	4.5	7.4	11.6	2019	4.3	7.2	11.4	2020	4.1	7	11.2	2021	3.9	6.8	11	2022	3.7	6.6	10.8	2023	3.5	6.4	10.6	2024	3.3	6.2	10.4	2025	3.1	6	10.2	2026	2.9	5.8	10	2027	2.7	5.6	9.8	2028	2.5	5.4	9.6	2029	2.5	5.2	9.4	2030	2.5	5.0	9.2
Year	Low pressure (0 – 200 kPa)	Medium pressure (200 – 600kPa)	High pressure (Over 600 kPa)																																																																										
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2029	2.5	5.2	9.4																																																																										
2030	2.5	5.0	9.2																																																																										
Value(s) applied):	2015: 8.0 2016: 7.8																																																																												
Choice of data or measurement methods and procedures	-																																																																												
Purpose of data:	Calculation of baseline emissions or baseline net GHG removals by sinks																																																																												
<b>Additional comment:</b>	The decrease in the value for the baseline emission factor over time is to reflect the technological development																																																																												

<b>Data / Parameter:</b>	EF <sub>new,y</sub>
Unit:	kg N <sub>2</sub> O/t HNO <sub>3</sub>
Description:	Baseline N <sub>2</sub> O emission factor for nitric acid production in year y (related to 100 per cent pure acid)

Source of data:	<p>The baseline N<sub>2</sub>O emission factor for nitric acid production 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/t HNO<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 n</td><td>2.50</td></tr> </tbody> </table>	Year	Emission factor (kgN <sub>2</sub> O/t HNO <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
Year	Emission factor (kgN <sub>2</sub> O/t HNO <sub>3</sub> )																																												
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Year n	2.50																																												
Value(s) applied:	2015: 3.40 2016: 3.20																																												
Choice of data or measurement methods and procedures	-																																												
Purpose of data:	Calculation of baseline emissions or baseline net GHG removals by sinks																																												
<b>Additional comment:</b>	The decrease in the value for the baseline emission factor over time is to reflect the technological development																																												

Data / Parameter	P <sub>product,max</sub>
Unit	t Product
Description	Design capacity of nitric acid production during the first crediting period
Source of data	Project operator and/or technology provider
Value(s) applied	273,020 t HNO <sub>3</sub> /year
Choice of data or Measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comment	This parameter is only for project activities applying case 1

<b>Data / Parameter:</b>	$GWP_{N_2O}$
Unit:	tCO <sub>2</sub> e/tN <sub>2</sub> O
Description:	Global warming potential of the nitrous oxide
Source of data:	Relevant decisions by the CMP
Value(s) applied):	298
Choice of data or measurement methods and procedures	Default value
Purpose of data:	Calculation of Baseline emissions or baseline net GHG removal by sinks, Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	-

Parameters from the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0.0):

<b>Data / Parameter:</b>	$R_u$
Unit:	Pa*m <sup>3</sup> /kmol*K
Description:	Universal ideal gas constant
Source of data:	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0.0)
Value(s) applied):	8,314
Choice of data or measurement methods and procedures	Default value
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	-

<b>Data / Parameter:</b>	$MM_i$
Unit:	kg/mol
Description:	Molecular mass of greenhouse gas $i$ (N <sub>2</sub> O)
Source of data:	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0.0)
Value(s) applied):	44.02
Choice of data or measurement methods and procedures	Default value
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	-

<b>Data / Parameter:</b>	$P_n$
Unit:	Pa
Description:	Total pressure at normal conditions
Source of data:	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0.0)
Value(s) applied):	101,325



Choice of data or measurement methods and procedures	Default value
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	-

<b>Data / Parameter:</b>	$T_n$
Unit:	K
Description:	Temperature at normal conditions
Source of data:	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0.0)
Value(s) applied:	273.15
Choice of data or measurement methods and procedures	Default value
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	-

## D.2. Data and parameters monitored

(Copy this table for each piece of data and parameter)

<b>Data / Parameter:</b>	$P_{\text{production},y}$
Unit:	t HNO <sub>3</sub>
Description:	Nitric acid produced in year y
Measured/ Calculated / Default:	Measured and Calculated
Source of data:	Measurements by project participants and production reports
Value(s) of monitored parameter:	2015: 75,650 2016: 18,195
Monitoring equipment:	Coriolis Meter Transmitter SN 3765698 Sensor SN 14163265 Accuracy: 0.5% Calibration frequency: 1 year Density & acid concentration are crosschecked by laboratory analysis.
Measuring/ Reading/ Recording frequency:	1 h average based on two seconds (or shorter) interval readings
Calculation method (if applicable):	Mass flow measurements (kg/h) are multiplied with acid concentration determined on the DCS to calculate $P_{\text{production},y}$ mass flow in tHNO <sub>3</sub> /h.
QA/QC procedures:	Periodic calibration
Purpose of data:	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comment:	-

<b>Data / Parameter:</b>	$h_y$
Unit:	h
Description:	Number of hours of operation in year y

Measured/ Calculated / Default:	Measured
Source of data:	Omnia production log and continuous monitoring according to operational parameter (operational temperature of the ammonia oxidation reactor)
Value(s) of monitored parameter:	2015: 2,929 2016: 705
Monitoring equipment:	The total operating hours are logged continuously in the production log
Measuring/ Reading/ Recording frequency:	1 h average based on two seconds (or shorter) interval readings
Calculation method (if applicable):	-
QA/QC procedures:	Operating hours are cross checked against other operational parameters of the plant according to internal QA/QC procedures.
Purpose of data:	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comment:	-

<b>Data / Parameter:</b>	$h_{r,y}$
Unit:	h
Description:	Number of hours (h) in year y where the abatement system is by-passed, underperforming or failed
Measured/ Calculated / Default:	Measured
Source of data:	Omnia production log and continuous monitoring according to AMS results
Value(s) of monitored parameter:	2015: 13 2016: 46
Monitoring equipment:	Omnia production log and continuous monitoring according to AMS results
Measuring/ Reading/ Recording frequency:	1 h average based on two seconds (or shorter) interval readings
Calculation method (if applicable):	Periods where the abatement system is by-passed are logged in the production log. Periods where the abatement system is underperforming or failed are calculated continuously based on AMS results
QA/QC procedures:	-
Purpose of data:	Calculation of baseline emissions or baseline net GHG removals by sinks, Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	-

<b>Data / Parameter:</b>	$F_{N_2O, Tailgas, h}$
Unit:	kgN <sub>2</sub> O/h
Description:	Mass Flow of N <sub>2</sub> O in the gaseous stream of the tail gas in hours h
Measured/ Calculated / Default:	Measured and Calculated
Source of data:	N <sub>2</sub> O concentration: Emerson N <sub>2</sub> O Analyzer Stack gas volume flow: Durag Annubar D-FL 100 flow meter

Value(s) of monitored parameter:	<p>Average value for this monitoring period: 13.14</p> <p>Applied for the determination of Project Emissions. See calculation sheet and sample calculation of section E.2.</p>
Monitoring equipment:	<p>N<sub>2</sub>O concentration: Emerson N<sub>2</sub>O Analyzer</p> <p>Stack gas volume flow: Durag Annubar D-FL 100 flow meter</p>
Measuring/ Reading/ Recording frequency:	1 h average based on two seconds (or shorter) interval readings
Calculation method (if applicable):	<p>(a) 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;</p> <p>(b) 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 two 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;</p> <p>(c) 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;</p> <p>(d) 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;</p> <p>(e) In the case that the N<sub>2</sub>O concentration and the volume or mass flow of the tail gas and by-pass are automatically converted to normal conditions by the AMS during the monitoring process, the parameters Pt and Tt do not need to be monitored except, if applicable, for the purpose of determining the moisture content in the gaseous stream.</p>
QA/QC procedures:	According to EN 14181:2004 and EN 14181:2014, the flow meter and the analyzer was tested and calibrated by an external laboratory with EN ISO IEC 17025 Accreditation. The QAL2 test is conducted once every 5 years; the AST test is conducted once per year. Every 5 years the AST test is part of the QAL2 test.
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks

Additional comment:	
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<b>Data / Parameter:</b>	PE <sub>FF,y</sub> (corresponding to PE <sub>CO2,tertiary,y</sub> )
Unit:	tCO <sub>2</sub> e
Description:	Project emissions related to fossil fuel input to the destruction facility and/or re-heater in monitoring period <i>n</i> (tCO <sub>2</sub> )
Measured/ Calculated / Default:	Calculated
Source of data:	The emissions related to the operation of the N <sub>2</sub> O destruction facility include only on-site emissions due to fossil fuel use as input to the N <sub>2</sub> O destruction facility. Natural gas consumption is measured by a mass-flow meter
Value(s) of monitored parameter:	2015: 1,538.64 2016: 453,99
Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	1 h average based on two seconds (or shorter) interval readings
Calculation method (if applicable):	Calculated based on measurement of natural gas consumption and w <sub>C,i,y</sub>
QA/QC procedures:	Maintenance and calibration of the mass flow meter is applied under the internal QA/QC procedures.
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	

<b>Data / Parameter:</b>	w <sub>C,i,y</sub>						
Unit:	tC/mass unit of fuel type natural gas						
Description:	Weighted average mass fraction of carbon in fuel type <i>i</i> in year <i>y</i>						
Measured/ Calculated / Default:	Measured						
Source of data:	<p>The following data source may be used if the relevant conditions apply:</p> <table border="1"> <thead> <tr> <th>Data Source</th><th>Conditions for using the data source</th></tr> </thead> <tbody> <tr> <td>a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source</td></tr> <tr> <td>b) Measurements by the project participants</td><td>If a) is not available</td></tr> </tbody> </table> <p><b>Option a)</b> Not received from Invoices but by request from supplier.</p>	Data Source	Conditions for using the data source	a) Values provided by the fuel supplier in invoices	This is the preferred source	b) Measurements by the project participants	If a) is not available
Data Source	Conditions for using the data source						
a) Values provided by the fuel supplier in invoices	This is the preferred source						
b) Measurements by the project participants	If a) is not available						
Value(s) of monitored parameter:	2015: 0.731 2016: 0.731						

Monitoring equipment:	-
Measuring/ Reading/ Recording frequency:	The mass fraction of carbon is obtained by request from supplier.
Calculation method (if applicable):	The mass fraction is calculated by using the composition obtained from the supplier.
QA/QC procedures:	Verify if the values under a) and b) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in b) should have ISO17025 accreditation or justify that they can comply with similar quality standards.
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	None

<b>Data / Parameter:</b>	$FC_{i,j,y}$
Unit:	Mass unit per monitoring period (ton)
Description:	Quantity of fuel type i combusted in process j during the monitoring period n
Measured/ Calculated / Default:	Measured
Source of data:	Measured by mass flow meter
Value(s) of monitored parameter:	2015: 573.76 2016: 169.29
Monitoring equipment:	Coriolis mass flow meter Transmitter SN: 3845068 Sensor SN: 14459566 Accuracy: 0.5% Calibration frequency: 3 years
Measuring/ Reading/ Recording frequency:	1 h average based on two seconds (or shorter) interval readings
Calculation method (if applicable):	-
QA/QC procedures:	Periodic calibrations
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	

<b>Data / Parameter:</b>	$V_{t,db}$
Unit:	Nm <sup>3</sup> dry gas/h
Description:	Volumetric flow of the gaseous stream in time interval t on a dry basis
Measured/ Calculated / Default:	Measured
Source of data:	Tail gas volume flow meter
Value(s) of monitored parameter:	Average Value: 77,437

Monitoring equipment:	Durag Annubar Flow meter
Measuring/ Reading/ Recording frequency:	1 h average based on two seconds (or shorter) interval readings
Calculation method (if applicable):	Calculation of normalized flow with measurement of temperature ( $T_i$ ) and pressure ( $P_i$ )
QA/QC procedures:	According to EN 14181:2014, the flow meter was tested and calibrated by an external laboratory with EN ISO IEC 17025 Accreditation. The QAL2 test is conducted once every 5 years; the AST test is conducted once per year. Every 5 years the AST test is part of the QAL2 test.
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	

<b>Data / Parameter:</b>	$V_{i,t,db}$
Unit:	$m^3$ gas / $m^3$ dry gas
Description:	Volumetric fraction of greenhouse gas $i$ in a time interval $t$ on a dry basis
Measured/ Calculated / Default:	measured
Source of data:	$N_2O$ gas analyzer
Value(s) of monitored parameter:	Average value: 0.00008905
Monitoring equipment:	Emerson $N_2O$ Analyser Serial No: 990471705499
Measuring/ Reading/ Recording frequency:	1 h average based on two seconds (or shorter) interval readings
Calculation method (if applicable):	-
QA/QC procedures:	According to EN 14181:2004, the analyzer was tested and calibrated by an external laboratory with EN ISO IEC 17025 Accreditation. The QAL2 test is conducted once every 5 years; the AST test is conducted once per year. Every 5 years the AST test is part of the QAL2 test. Additional QAL3 procedures are performed regularly
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	

<b>Data / Parameter:</b>	$C_{H_2O,t,db,n}$
Unit:	$kg H_2O/m^3$ drygas
Description:	Moisture content of the gaseous stream at normal conditions, in time interval $t$
Measured/ Calculated / Default:	Measured
Source of data:	Measurements according to the USEPA CF42 method 4 – Gravimetric determination of water content
Value(s) of monitored parameter:	2015: 0.0078 2016: 0.0078
Monitoring equipment:	Manual sampling by external laboratory or testing house.
Measuring/ Reading/ Recording frequency:	Annually, Measurements should coincide with the Annual Surveillance Test (associated with requirements of the EN 14181:2014 standard) or the calibration of the flow meter for the gaseous stream.

Calculation method (if applicable):	-
QA/QC procedures:	According to the USEPA CF42 method 4
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	Required for proving that the gaseous stream is dry.

<b>Data / Parameter:</b>	$T_t$
Unit:	°C
Description:	Temperature in the gaseous stream in time interval t
Measured/ Calculated / Default:	Measured
Source of data:	Tail Gas temperature measurement
Value(s) of monitored parameter:	Average value: 124
Monitoring equipment:	Thermocouples
Measuring/ Reading/ Recording frequency:	1 h average based on two seconds (or shorter) interval readings
Calculation method (if applicable):	-
QA/QC procedures:	According to EN 14181:2014, the instrument was tested together with the flowmeter by an external laboratory with EN ISO IEC 17025 Accreditation. The QAL2 test is conducted once every 5 years; the AST test is conducted once per year. Every 5 years the AST test is part of the QAL2 test.
Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	As parameters are converted to normal conditions during the monitoring process, this parameter is not needed. Calibration schedules are performed according to plant internal procedures

<b>Data / Parameter:</b>	$P_t$
Unit:	Pa
Description:	Pressure of the gaseous stream in time interval t
Measured/ Calculated / Default:	Measured
Source of data:	Pressure probe
Value(s) of monitored parameter:	Average value 85,634
Monitoring equipment:	Pressure probe
Measuring/ Reading/ Recording frequency:	1 h average based on two seconds (or shorter) interval readings
Calculation method (if applicable):	-
QA/QC procedures:	According to EN 14181:2014, the instrument was tested together with the flowmeter by an external laboratory with EN ISO IEC 17025 Accreditation. The QAL2 test is conducted once every 5 years; the AST test is conducted once per year. Every 5 years the AST test is part of the QAL2 test.



Purpose of data:	Calculation of project emissions or actual net GHG removals by sinks
Additional comment:	As parameters are converted to normal conditions during the monitoring process, this parameter is not needed. Calibration schedules are performed according to plant internal procedures.

**D.3. Implementation of sampling plan**

&gt;&gt;

Not applicable

## SECTION E. Calculation of emission reductions or GHG removals by sinks

### E.1. Calculation of baseline emissions or baseline net GHG removals by sinks

&gt;&gt;

Baseline emissions:

ACM0019, Version 02.0, is the methodology chosen for the implementation of this project activity.

In the following, the explanation of the calculation of baseline and project emissions, as required under the ACM0019, Version 02.0, is presented.

In this case the nitric acid plant used AM0028 during the first crediting period therefore 5.3.1 – Case 1 of the methodology applies.

#### Case 1: For nitric acid plants that have used AM0028 or AM0034 in the first crediting period

For nitric acid plants that have used AM0028 or AM0034 in the first crediting period and apply this methodology in their second or third crediting period, the baseline emissions are calculated as follows:

$$BE_y = \left( \frac{\min\{P_{production,y}; P_{product,max}\} \times EF_{existing,y}}{\max\{P_{production,y} - P_{product,max}; 0\} \times EF_{new,y}} \right) \times \frac{(h_y - h_{r,y})}{h_y} \times GWP_{N_2O} \times 10^{-3} \quad \text{Equation (1)}$$

Where:

$BE_y$	=	Baseline emissions in year $y$ (t CO <sub>2</sub> e)
$P_{product,max}$	=	Design capacity (t HNO <sub>3</sub> )
$P_{production,y}$	=	Production of nitric acid in year $y$ (t HNO <sub>3</sub> )
$EF_{existing,y}$	=	N <sub>2</sub> O emission factor for nitric acid plants that have used AM0028 or AM0034 in the first crediting period in year $y$ (kg N <sub>2</sub> O/t HNO <sub>3</sub> )
$EF_{new,y}$	=	Baseline N <sub>2</sub> O emission factor for nitric acid production in year $y$ (kg N <sub>2</sub> O/t HNO <sub>3</sub> )
$GWP_{N_2O}$	=	Global Warming Potential of N <sub>2</sub> O valid for the commitment period
$h_y$	=	Number of hours in year $y$ during which the plant was in operation ( $h$ )
$h_{r,y}$	=	Number of hours ( $h$ ) in year $y$ where: (a) For secondary N <sub>2</sub> O abatement: the abatement system was not installed, underperforming or failed; (b) For tertiary N <sub>2</sub> O abatement: the abatement system is by-passed, underperforming or failed

Sample calculation applying summed-up values of the whole monitoring period

• Year	BE <sub>n</sub>	P <sub>production,y</sub>	P <sub>product,max</sub>	EF <sub>existing,y</sub>	EF <sub>new,y</sub>
2015	• 124,279.4	• 75,650.4	• 114,444.0	• 5.537	• 3.4
• 2016	• 28,065.9	• 18,195.5	• 113,696.0	• 5.537	• 3.2

The N<sub>2</sub>O emission factor for nitric acid plants that have used AM0028 and AM0034 in the first crediting period ( $EF_{existing,y}$ ) will be calculated as follows:

$$EF_{existing,y} = \min\{EF_{historical}; EF_{default,y}\} \quad \text{Equation (2)}$$

Where:

- $EF_{existing,y}$  = N<sub>2</sub>O emission factor for nitric acid plants that have used AM0028 or AM0034 in the first crediting period in year  $y$  (kg N<sub>2</sub>O/t HNO<sub>3</sub>)
- $EF_{historical}$  = Historical baseline emission factor of the nitric acid plant (kg N<sub>2</sub>O/t HNO<sub>3</sub>)
- $EF_{default,y}$  = Default emission factor according to the operating pressure of the ammonia burner in year  $y$  (kg N<sub>2</sub>O/t HNO<sub>3</sub>)

Sample calculation applying summed-up values of the whole monitoring period

Year	$EF_{existing,y}$	$EF_{historical}$	$EF_{default}$
2015	5.537	5.537	8.000
2016	5.537	5.537	7.800

### Calculation of $h_{r,y}$

An abatement system is deemed to be bypassed, not working, underperform or failed in the hour  $h$  in year  $y$  if:

**Case 1: For nitric acid plants that have used AM0028 or AM0034 in the first crediting period**

$$F_{N2O,tail\ gas,h} > EF_{existing\ y} \times P_{NA,h} \quad \text{Equation (3)}$$

Where:

- $P_{NA,h}$  = Nitric acid produced in the hour  $h$  (t HNO<sub>3</sub>)
- $EF_{existing\ y}$  = Default N<sub>2</sub>O emission factor for nitric acid plants that have used AM0028 or AM0034 in the first crediting period in year  $y$  (kg N<sub>2</sub>O/t HNO<sub>3</sub>)
- $F_{N2O,tail\ gas,h}$  = 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)

## E.2. Calculation of project emissions or actual net GHG removals by sinks

>>

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:

$$PE_y = PE_{N_2O,y} + PE_{CO_2,tertiary,y} \quad \text{Equation (4)}$$

Where:

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

Sample calculation applying summed-up values of the whole monitoring period:

Year	PE <sub>y</sub>	PE <sub>N<sub>2</sub>O,y</sub>	PE <sub>CO<sub>2</sub>,tertiary,y</sub>
2015	10,304.4	8,765.7	1,538.6
2016	4,176.6	3,722.6	454.0

### Project emissions of N<sub>2</sub>O from the project plant (PE<sub>N<sub>2</sub>O,y</sub>)

The amount of N<sub>2</sub>O emissions from the project activity are the emissions from the N<sub>2</sub>O contained in the tail gas stream of the plant which is released to the atmosphere.

Accordingly, PE<sub>N<sub>2</sub>O,y</sub> is determined as follows:

$$PE_{N_2O,y} = \sum_{h=1}^{h_y-h_{r,y}} F_{N_2O,tail\ gas,h} \times GWP_{N_2O} \times 10^{-3} \quad \text{Equation (5)}$$

Where:

- $PE_{N_2O,y}$  = Project emissions of N<sub>2</sub>O from the project plant in year  $y$  (t CO<sub>2</sub>e)  
 $GWP_{N_2O}$  = Global warming potential of N<sub>2</sub>O valid for the commitment period  
 $F_{N_2O,tail\ gas,h}$  = 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)  
 $h_y$  = Number of hours in year  $y$  during which the plant was in operation ( $h$ )  
 $h_{r,y}$  = Number of hours ( $h$ ) in year  $y$  where: For tertiary N<sub>2</sub>O abatement. The abatement system is by-passed, underperforming or failed

Sample calculation applying summed-up values of the whole monitoring period:

Year	PE <sub>N<sub>2</sub>O,y</sub>	F <sub>N<sub>2</sub>O,tailgas,h</sub>	GWP
2015	8,765.7	29,415.2	298
2016	3,722.6	12,491.9	298

**Determination of  $F_{N_2O, tail\ gas, h}$** 

The amount of  $N_2O$  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:

- (f) Throughout the crediting periods of the project activity, the  $N_2O$  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;
- (g) The monitoring system should provide separate hourly average values for the  $N_2O$  concentration and the volume or mass flow of the tail gas based on two seconds (or shorter) interval readings that are recorded and stored electronically. These  $N_2O$  data sets shall be identified by means of a unique time/date key indicating when exactly the values were observed;
- (h) 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  $N_2O$  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;
- (i) If data for either the  $N_2O$  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  $N_2O$  concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the  $N_2O$  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  $N_2O$  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;
- (j) In the case that the  $N_2O$  concentration and the volume or mass flow of the tail gas and by-pass are automatically converted to normal conditions by the AMS during the monitoring process, the parameters  $P_t$  and  $T_t$  do not need to be monitored except, if applicable, for the purpose of determining the moisture content in the gaseous stream.

According to the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Version 02.0.0) the mass flow of greenhouse gas  $i$  in the gaseous stream in time interval  $t$  ( $F_{i,t}$ ) is calculated based on measurements of

- (a) the total volume flow or mass flow of the gas stream and
- (b) the volumetric fraction of the gas in the gaseous stream and
- (c) the water content and gas composition.

The tool covers possible measurement options, providing six different calculation options to determine the volume or mass flow of a particular greenhouse gas (A-F).

Furthermore, the tool provides several options for the determination of the moisture content of the gaseous stream. As the gaseous stream is assumed to be dry, Option A is applied. In order to apply this option, it shall be demonstrated that the gaseous stream is dry. As described in part (a) of Option A, the moisture content of the gaseous stream ( $C_{H_2O, t, db, n}$ ) will be measured and it shall be demonstrated that it is less or equal to 0.05 kg  $H_2O/m^3$  dry gas.

The moisture measurement shall coincide with the Annual Surveillance Test or the calibration of the flow meter for the gaseous stream.

In accordance with Option A of the tool, the mass flow of greenhouse gas  $i$  ( $F_{i,t}$ ) is calculated as follows:

$$F_{i,t} = V_{t,db} * v_{i,t,db} * \rho_{i,t}$$

Equation (6)

With:

$$\rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t}$$

Equation (7)

Where:

- $F_{i,t}$  = mass flow of greenhouse gas  $N_2O$  in the gaseous stream in time interval  $t$  (kg gas /h)  
 $V_{t,db}$  = Volumetric flow of the gaseous stream in time interval  $t$  on dry basis ( $m^3$  dry gas/h)  
 $v_{i,t,db}$  = Volumetric fraction of greenhouse gas  $i$  in the gaseous stream in a time interval  $t$  on a dry basis ( $m^3$  gas  $i$  /  $m^3$  dry gas)  
 $\rho_{i,t}$  = Density of greenhouse gas  $i$  in the gaseous stream in a time interval  $t$  (kg gas  $i$  /  $m^3$  gas  $i$ )  
 $P_t$  = Absolute pressure of the gaseous stream in time interval  $t$  (Pa)  
 $MM_i$  = Molecular mass of greenhouse gas  $i$  (kg/kmol)  
 $R_u$  = Universal ideal gases constant (Pa\*m<sup>3</sup>/kmol\*K)  
 $T_t$  = Temperature of the gaseous stream in time interval  $t$  (K)

Sample calculation for equation (6) applying average values for the monitoring period:

$F_{i,t}$	$V_{t,db}$	$v_{i,t,db}$	$\rho_{i,t}$
13.544	77,437	0.0000891	1.964

Calculation for equation (7) applying standard condition values:

$\rho_{i,t}$	$P_t$	$MM_{N_2O}$	$R_u$	$T_t$
1.96	101.33	44.02	8.31	273.150

### Project emissions from the operation of the tertiary $N_2O$ abatement facility ( $PE_{CO_2,tertiary,y}$ )

This emission source only needs to be estimated if a tertiary  $N_2O$  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. Therefore it needs only to be estimated for this nitric acid plant as fossil fuel is used for operation of the tertiary  $N_2O$  abatement facility.

The emissions related to the operation of the  $N_2O$  destruction facility include only on-site emissions due to the fossil fuel use as input to the  $N_2O$  destruction facility:

$$PE_{CO_2,tertiary,y} = PE_{FF,y}$$

Equation (8)

Where:

$PE_{CO_2,tertiary,y}$  = Project emissions of CO<sub>2</sub> from the operation of the tertiary N<sub>2</sub>O abatement facility in year  $y$  (t CO<sub>2</sub>)

$PE_{FF,y}$  = Project emissions related to fossil fuel input to the destruction facility and/or re-heater in year  $y$  (t CO<sub>2</sub>)

The 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 year  $y$ .

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  $PE_{FF,y}$  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.

CO<sub>2</sub> emissions from fossil fuel combustion in process  $j$  are calculated based on the quantity of fuels combusted and the CO<sub>2</sub> emission coefficient of those fuels, as follows:

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y} \quad \text{Equation (9)}$$

Where:

$PE_{FC,j,y}$  = CO<sub>2</sub> emissions from fossil fuel combustion in process  $j$  in year  $y$  (tCO<sub>2</sub>/yr)

$FC_{i,j,y}$  = Quantity of fuel type  $i$  combusted in the process  $j$  during year  $y$  (mass or volume unit/yr)

$COEF_{i,y}$  = CO<sub>2</sub> emission coefficient of fuel type  $i$  in year  $y$  (tCO<sub>2</sub>/mass or volume unit)

$i$  = fuel types combusted in process  $j$  during year  $y$

Sample calculation applying summed-up values of the whole monitoring period:

Year	$PE_{CO_2,tertiary,n}$	$PE_{FF,y}$
2015	<b>1,538.6</b>	1,538.6
2016	<b>454.0</b>	454.0

Year	$PE_{FC,j,y}$	$\sum FC_{i,j,y}$	$COEF_{i,y}$
2015	<b>1,538.6</b>	573.8	2.682
2016	<b>454.0</b>	169.3	2.682

As data about the chemical composition of the fuel type  $i$  is available  $COEF_{i,y}$  is calculated based on its chemical composition of the fossil fuel type  $i$  using Option A of the “Tool to calculate project



or leakage CO<sub>2</sub> emissions from fossil fuel combustion" (Version 02). As  $FC_{i,j,y}$  is measured in a mass unit, the following equation applies:

$$COEF_{i,y} = w_{C,i,y} \times 44/12 \quad \text{Equation (10)}$$

Where:

$COEF_{i,y}$  = CO<sub>2</sub> emission coefficient of fuel type  $i$  in year  $y$  (tCO<sub>2</sub>/volume unit)

$w_{C,i,y}$  = weighted average mass fraction of carbon in fuel type  $i$  in year  $y$  (tC/mass unit of the fuel)

$i$  = fuel types combusted in process  $j$  during the year  $y$

Sample calculation applying summed-up values of the whole monitoring period:

Year	COEF <sub>i,y</sub>	w <sub>C,i,y</sub>	
2015	2.682	0.731	44/12
2016	2.682	0.731	44/12

$w_{C,i,y}$  is calculated according to a mass fraction calculation of carbon in the fuel type applied

2015:

Component	Atoms Carbon per molecule	Molar weight	mol Fraction	Molar weight - weighted	Carbon contend Molar weight - weighted	mass fraction of carbon in fuel = w <sub>C,i,y</sub>
		g/mol	%	g/mol	g/mol	
Carbon		12.011				
Nitrogen	0	28.013	2.012	0.564	0.000	
Carbon dioxide	1	44.010	0.000	0.000	0.000	
Methane	1	16.043	93.890	15.063	11.277	
Ethane	2	30.070	2.221	0.668	0.534	
Propane	3	44.096	0.978	0.431	0.352	
i Butane	4	58.120	0.252	0.146	0.121	
n Butane	4	58.120	0.291	0.169	0.140	
i pentane	5	72.150	0.086	0.062	0.052	
n pentane	5	72.150	0.054	0.039	0.032	
neo Pentane	5	72.150	0.006	0.004	0.004	
Hexane	7	86.180	0.058	0.050	0.049	
Heptane	7	100.210	0.097	0.097	0.082	
Octane	8	114.230	0.023	0.026	0.022	
Nonane	9	128.260	0.022	0.028	0.024	
			Total	17.348	12.688	0.731

2016:

Component	Atoms Carbon per molecule	Molar weight	mol Fraction	Molar weight - weighted	Carbon contend Molar weight - weighted	mass fraction of carbon in fuel = wc,i,y
		g/mol	%	g/mol	g/mol	
<b>Carbon</b>		12.011				
Nitrogen	0	28.013	2.012	0.564	0.000	
Carbon dioxide	1	44.010	0.000	0.000	0.000	
Methane	1	16.043	93.890	15.063	11.277	
Ethane	2	30.070	2.221	0.668	0.534	
Propane	3	44.096	0.978	0.431	0.352	
i Butane	4	58.120	0.252	0.146	0.121	
n Butane	4	58.120	0.291	0.169	0.140	
i pentane	5	72.150	0.086	0.062	0.052	
n pentane	5	72.150	0.054	0.039	0.032	
neo Pentane	5	72.150	0.006	0.004	0.004	
Hexane	7	86.180	0.058	0.050	0.049	
Heptane	7	100.210	0.097	0.097	0.082	
Octane	8	114.230	0.023	0.026	0.022	
Nonane	9	128.260	0.022	0.028	0.024	
			Total	17.348	12.688	<b>0.731</b>

### E.3. Calculation of leakage

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Any leakage emissions sources are deemed to be negligible.

**E.4. Summary of calculation of emission reductions or net GHG removals by sinks**

Item	Baseline emissions or baseline net GHG removals by sinks (t CO <sub>2</sub> e)	Project emissions or actual net GHG removals by sinks (t CO <sub>2</sub> e)	Leakage (t CO <sub>2</sub> e)	GHG emission reductions or net GHG removals by sinks (t CO <sub>2</sub> e) achieved in the monitoring period		
				Up to 31/12/2012	From 01/01/2013	Total amount
2015	124,279.4	10,304.4	0	0	113,975.1	113,975.1
2016	28,065.9	4,176.6	0	0	23,889.3	23,889.3
<b>Total</b>	<b>152,345.4</b>	<b>14,480.9</b>	<b>0</b>	<b>0</b>	<b>137,864</b>	<b>137,864</b>

**E.5. Comparison of actual emission reductions or net GHG removals by sinks with estimates in registered PDD**

Item	Values estimated in ex ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO <sub>2</sub> e)	352,557	137,864

**E.6. Remarks on difference from estimated value in registered PDD**

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Due to the lower nitric acid production during the monitoring period, the achieved emission reductions were below the expected value.

## Appendix 1. Contact information of project participants and responsible persons/entities

<b>Project participant and/or responsible person/ entity</b>	<input checked="" type="checkbox"/> Project participant <input type="checkbox"/> Responsible person/ entity for completing the CDM-MR-FORM
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**Document information**

<i>Version</i>	<i>Date</i>	<i>Description</i>
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: <ul style="list-style-type: none"> <li>• Include provisions related to delayed submission of a monitoring plan;</li> <li>• Provisions related to the Host Party;</li> <li>• Remove reference to programme of activities;</li> <li>• Overall editorial improvement.</li> </ul>
04.0	25 June 2014	Revisions to: <ul style="list-style-type: none"> <li>• Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0));</li> <li>• Include provisions related to standardized baselines;</li> <li>• Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1;</li> <li>• Change the reference number from <i>F-CDM-MR</i> to <i>CDM-MR-FORM</i>;</li> <li>• Editorial improvement.</li> </ul>
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
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