Monitoring report form for CDM project activity
(Version 07.0)

Complete this form in accordance with the instructions attached at the end of this form.

MONITORING REPORT		
Title of the project activity	Omnia N_2O Abatement Project II	
UNFCCC reference number of the project activity	6083	
Version number of the PDD applicable to this monitoring report	03	
Version number of this monitoring report	01	
Completion date of this monitoring report	08/08/2019	
Monitoring period number	7	
Duration of this monitoring period	01/08/2018 – 31/07/2019; 365 days	
Monitoring report number for this monitoring period	Not applicable	
Project participants	Omnia Fertilizer, Division of Omnia Group (Pty) Ltd Nordic Environment Finance Corporation Belektron d.o.o	
Host Party	South Africa	
Applied methodologies and standardized baselines	Applied Methodology: ACM0019 v01.0.0.	
Sectoral scopes	5	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	0 t CO2e	188,474 t CO2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	323,097 t CO2e	

SECTION A. Description of project activity

A.1. General description of project activity

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a) The increasing demand for fertilizer in South Africa induces the development of new and additional facilities related to fertilizer manufacturing. Omnia Fertilizer, a division of Omnia Group (Pty) Ltd. (hereafter "Omnia") is a leading Nitrogen Fertilizer producer in South Africa. Omnia operates two nitric acid plants in Sasolburg, South Africa. The second nitric acid plant was commissioned second quarter 2012, designed by Uhde GmbH with a confirmed production capacity of 400,000 ton 100% concentrated nitric acid per year. The CDM project at this second plant was registered as "Omnia N_2O Abatement Project II".

Nitrous Oxide (N_2O) is an undesired by-product of the nitric acid (HNO_3) production process at the synthetic fertilizer production facility. However, N_2O emissions from nitric acid production are not regulated in South Africa. No N_2O abatement system was designed into the plant. Without the incentive of the proposed CDM project activity, approx. 800,000 tCO_2e per year[1] would be emitted at Omnia Nitric Acid Plant II. Therefore, the baseline scenario without the CDM project would be the operation of the nitric acid plant without N_2O reduction catalyst.

The aim of the project activity is to reduce N_2O emissions in the tail gas by installing a tertiary catalyst after the absorption unit. It is expected that the N_2O abatement catalyst reduces 98 % of the N_2O[2]. Against the standardized baseline emissions factor the project would generate an estimated 3,481,376 t CO_2e emission reductions during a 10 year crediting period.

b) The N_2O abatement system consists of a tertiary N_2O catalyst unit, which is installed downstream of the HNO_3 absorber and before the tail gas turbine. It was designed and constructed by Uhde (Germany) and is called the EnviNox™ system. The tertiary catalyst consists of an additional catalysts containment facility that was erected at the plant.

A.2. Location of project activity

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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.

[1] An estimated business-as-usual emissions factor of 6.45kgN_2O/tHNO_3 (Average Baseline Emission factor of the first 5 monitoring periods of the first N_2O abatement project at Omnia's existing nitric acid plant) and annual confirmed capacity of 400,000tHNO_3/year was taken into account.

[2] While the calculations are based on this conservative assumption it should be noted that from experience from Omnia´s first N_2O reduction project as well as from other similar projects with the same technology even higher abatement efficiencies of up to 99.9 % were observed.

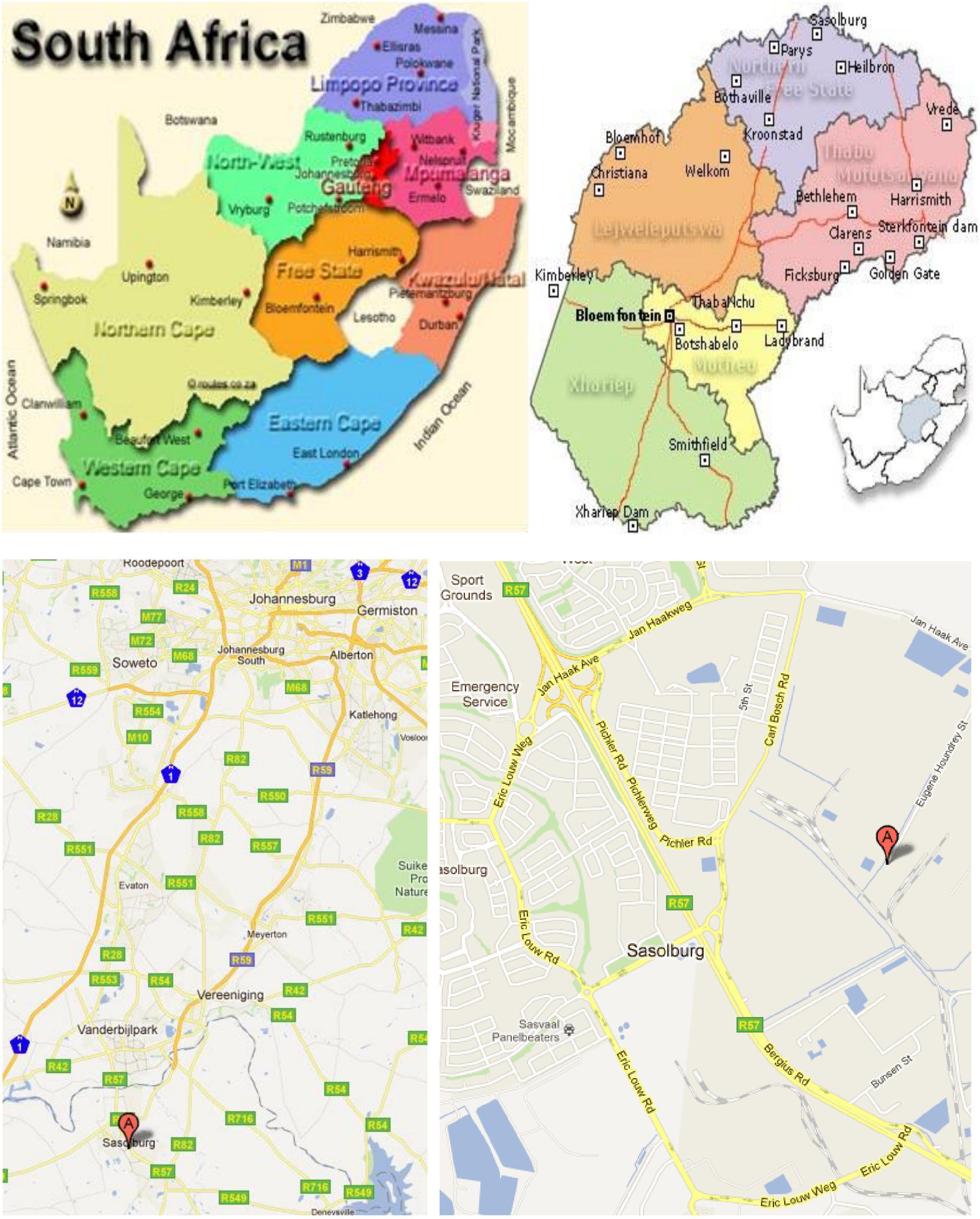

Figure 1: Physical location of the Omnia II nitric acid plant in Sasolburg, South Africa

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
South Africa (host party)	Omnia Fertilizer, Division of Omnia Group (Pty) Ltd	No

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Norway	Nordic Environment Finance Corporation	No
United Kingdom of Great Britain and Northern Ireland	Belektron d.o.o.	No

A.4. References to applied methodologies and standardized baselines

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1. (a) Applied methodology: ACM0019 Version 01.0.0: "N_2O abatement from nitric acid production"[3]
   (b) Applied tools:

i. "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (Version 02)"[4]
ii. "Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)"[5]

A.5. Crediting period type and duration

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(a) Type of Crediting Period: Non-renewable 10 years and 0 months
(b) Duration of the Crediting Period: 30/04/2012 – 29/04/2022

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

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a) The project activity entails the installation of:

- Tertiary N_2O abatement technology,
- Specialized monitoring equipment that is installed at the tail gas stream after the abatement of N_2O emissions.

Catalyst Technology

In the production process of nitric acid (HNO_3), NO_2 is produced as an intermediate material from ammonia (NH_3). The associated chemical reactions of oxidizing ammonia and simultaneous unwanted reactions are as follows:

1.	$NH_3 + 2\,O_2$	$\rightarrow$	$HNO_3 + H_2O$	(overall desirable reaction)
2.	$4\,NH_3 + 5\,O_2$	$\rightarrow$	$4\,NO + 6\,H_2O$	(desirable in the NH_3 oxidization process)
3.	$2\,NO + O_2$	$\rightarrow$	$2\,NO_2$	(desirable in the NO oxidization process)
4.	$3\,NO_2 + H_2O$	$\rightarrow$	$2\,HNO_3 + NO$	(desirable in the NO_2 absorption process)
5.	$4\,NH_3 + 3\,O_2$	$\rightarrow$	$2\,N_2 + 6\,H_2O$	(undesirable)
6.	$4\,NH_3 + 4\,O_2$	$\rightarrow$	$2\,N_2O + 6\,H_2O$	(undesirable)
7.	$2\,NH_3 + 8\,NO$	$\rightarrow$	$5\,N_2O + 3\,H_2O$	(undesirable)

Through the sixth and seventh reactions, some N_2O is generated in the process.

The N_2O abatement technology is installed in the tail gas downstream after the HNO_3 absorber and before the tail gas turbine. A tertiary catalyst reduces N_2O 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_2O abatement catalysts. The abatement efficiency of this pelleted catalyst has been shown to be up to 99.9% in the following reaction:

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[3] https://cdm.unfccc.int/filestorage/C/D/M/CDM_ACMHXKPX0GBQMNS4MA745SZQ2NX6OE672/EB61_repan04_ACM0019_NM0339_NM0340.pdf?t=dVF8cHZ3cWVifDBN-6cjPD9H8hBS6HoSRysA

[4] https://cdm.unfccc.int/EB/041/eb41_repan11.pdf

[5] https://cdm.unfccc.int/filestorage/O/Y/W/OYWC4R3ELV2MSK1NJ9AZ7P0QH85DXB/eb61_repan11.pdf?t=bkJ8cHZ3cWpqfDAcz2OL7-hEOFL-5vv8Pd3A

$$4N_2O + CH_4 \rightarrow 4N_2 + 2H_2O + CO_2$$

In the tertiary abatement system N_2O 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_3 production and a high expected N_2O reduction.

The expected lifetime of the N_2O 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_x is reduced in a separate catalyst bed by reduction with ammonia.

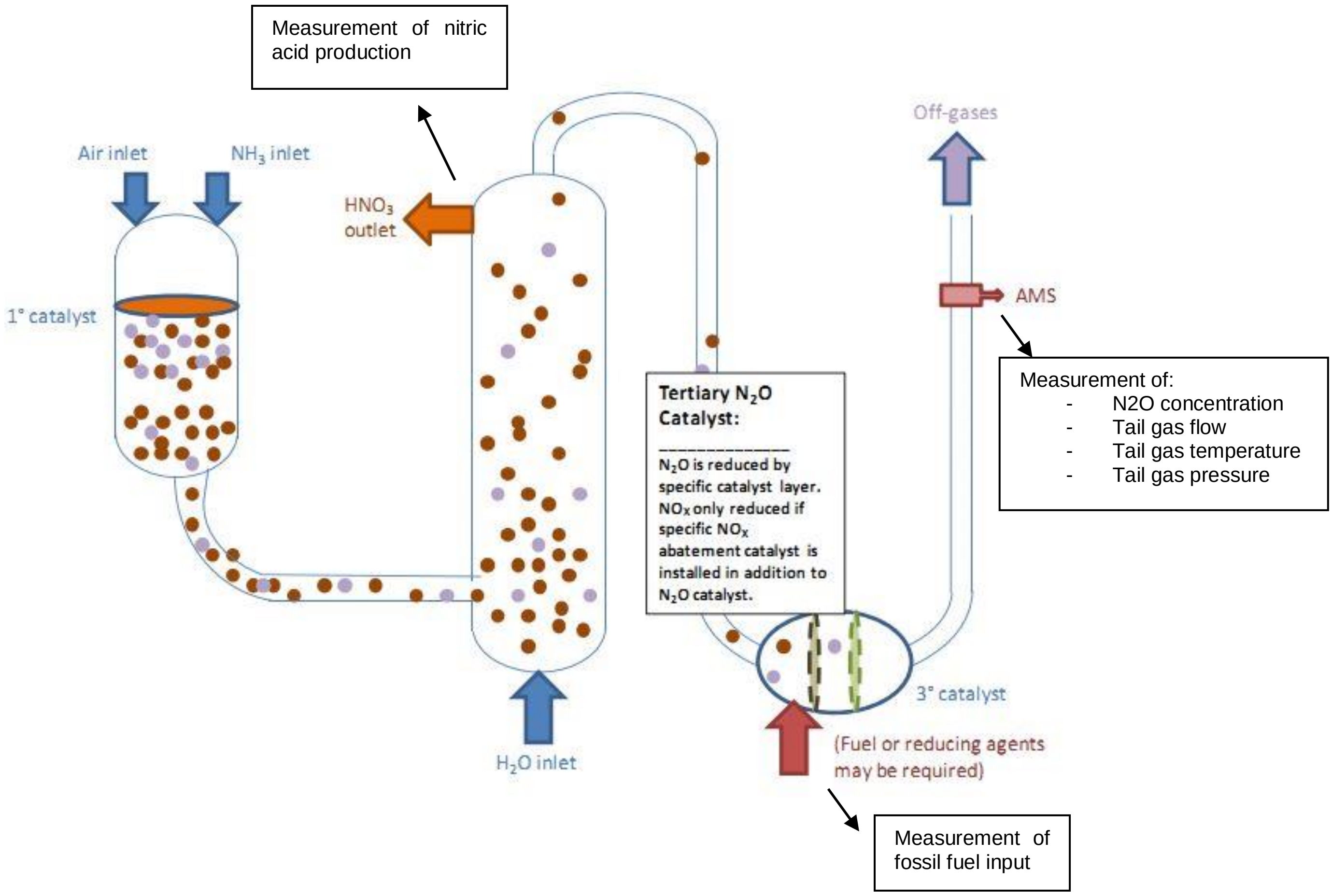

Figure 2: Image from CDM Methodology ACM0019: Flow of tertiary catalyst unit

b) Relevant Dates for the Project Activity

Date	Event
14/09/2009	Basic Engineering Nitric Acid Plant
09/03/2010	Detailed engineering Design Nitric Acid Plant
04/06/2011	Approval of ACM0019 by UNFCCC
18/07/2011	Change Order UHDE from De-NOx to EnviNox™
31/03/2012	Commission Nitric Acid Plant
31/032012	Commission Project
30/04/2012	Project registered at UNFCCC
30/04/2012	Start Crediting period
30/04/2012 – 30/11/2012	1st Monitoring period – status: issued

01/12/2012 – 31/05/2014	2nd Monitoring period – status: issued
01/06/2014 – 31/07/2015	3rd Monitoring period – status: issued
01/08/2015 – 31/05/2016	4th Monitoring period – status: issued
01/06/2016 – 30/06/2017	5th Monitoring period – status: issued
01/07/2017 – 31/07/2018	6th Monitoring period – status: issued
01/08/2018 – 31/07/2019	7th Monitoring period – status: this monitoring period

Table 1: Project activity dates

B.2. Post-registration changes

B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies, standardized baselines or other methodological regulatory documents

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No

B.2.2. Corrections

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The following corrections were approved on 03/03/2017 prior to this monitoring period (PRC-6083-001).

Corrections are as follows:

1. Project participants:

Update of the list of project participants on the cover page, Chapter A.4 and Appendix 1 from Omnia Fertilizer, Division of Omnia Group (Pty) Ltd.
to
Omnia Fertilizer, Division of Omnia Group (Pty) Ltd,
Nordic Environment Finance Corporation,
Belektron d.o.o

2. PDD, Section B.6.2 and Section B.7.1

Information for “Purpose of data” added as this is a new requirement of the new PDD template.

Parameter “$w_{C,i,y}$” removed from the section B.6.2 as this is a Parameter to be monitored and not fixed ex-ante

3. PDD, Section B.7.1

Information for “Monitoring frequency“ added as this is a new requirement of the new PDD template

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

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No

B.2.4. Inclusion of monitoring plan

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No

B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other methodological regulatory documents

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The following post registration changes were approved on 03/03/2017 prior to this monitoring period (PRC-6083-001).

Post registration changes are as follows:

PDD, Section B.7.1.; Parameter Pt:
Permanent change of the QA/QC calibration procedure of the monitoring parameter Pt (part of the stack gas flow meter) described in the PDD as “Periodic calibration against a primary device must be performed periodically and records of calibration procedures must be kept available as well as the primary device and its calibration certificate. Pressure transducers (either capacitive or resistive) must be calibrated monthly”,
to
“Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. According to EN 14181, the flow meter (including the parameter Pt) is 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.”

B.2.6. Changes to project design

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No

B.2.7. Changes specific to afforestation or reforestation project activity

>>
Not applicable

SECTION C. Description of monitoring system

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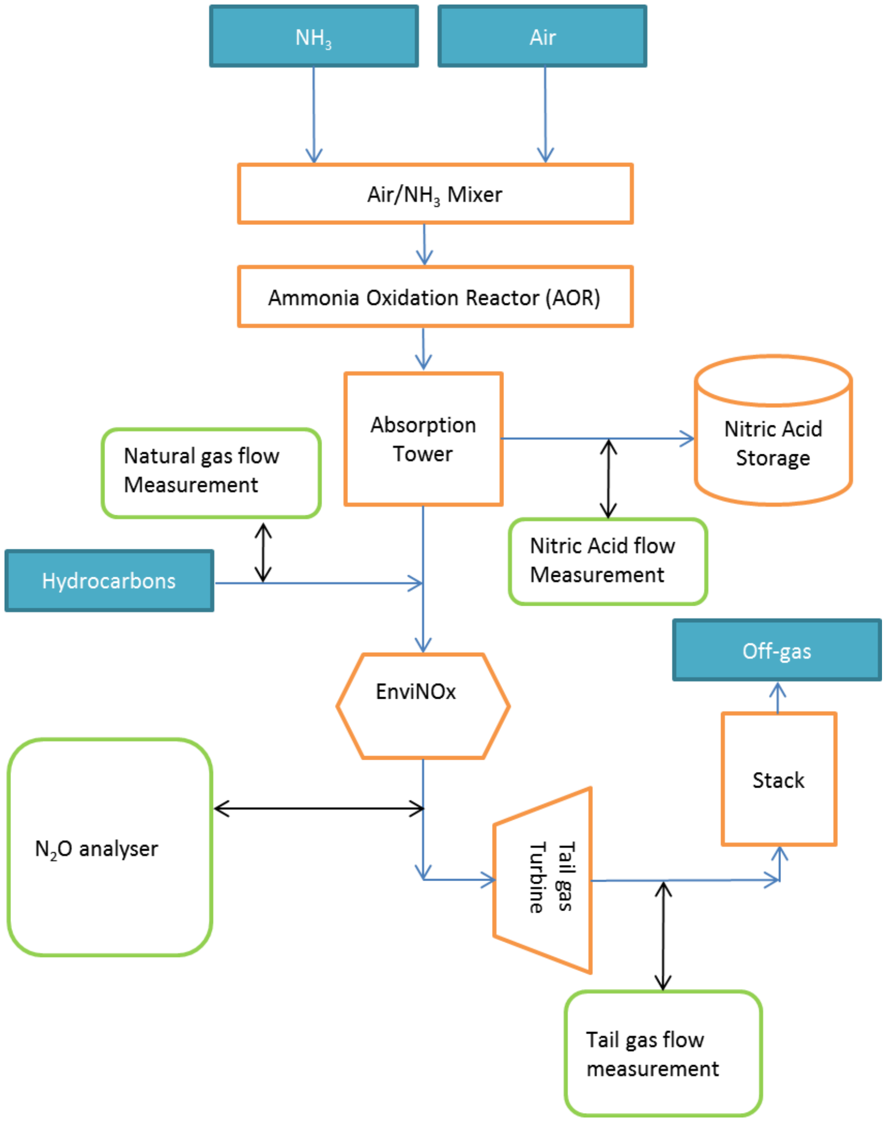

Figure 3: Schematic diagram of location of sample points

<u>Sample points</u>
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 graph above shows the location of the sample point schematically.

<u>Analyser</u>
The Emerson NGA 2000 is capable of analysing N_2O 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_2O and NO. The analyser features gas-filled opto-pneumatic 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_2O.

<u>Sample Conditioning System</u>
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.

<u>Stack gas flow meter</u>

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 such as, e.g. absolute pressure and temperature, the volume flow is converted from operating to standard conditions. This calculation is performed in the DURAG data system D-EMS 2000. The D-FL 100 is QAL1 tested according to EN 14181:2004.

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.

ACM0019 requires all key meters to be subject to a quality control regime that will include regular maintenance and calibration. For the N_2O and stack gas flow analyser this includes the application of the European Norm EN 14181. 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 relevant for this monitoring period
FT-95060	Transmitter: 3816752 Sensor:14257727	Natural gas flow meter $FC_{i,j,y}$	Micro Motion Coriolis Massflow	+/- 0.5 % of the adjusted range	Annually	08/03/2018 03/06/2019
FT-95023	Transmitter: 3811087 Sensor:14206070	Nitric acid flow meter $P_{NA,n}$	Micro Motion Coriolis Massflow	+/- 0.2 % of the adjusted range	Annually	09/03/2018 03/06/2019
AI-95005	9910103055428	N_2O Outlet Analyser $v_{i,t,db}$	Emerson NGA 2000	QAL1: +/- 2.71 % QAL2: +/- 2.70 % QAL2 (Range 2): 2.85 % AST: +/- 2.85 %.	QAL3 done automatically, zero every day, span every second day. AST done every year and QAL2 every 5 years.	QAL2/AST: 26/05/2015 - 29/05/2015 QAL2 for Range 2[6] 10/10/2018 – 12/10/2018 AST: 14/09/2017 – 15/09/2017 10/10/2018 – 12/10/2018
FT-95015	1223797	Stackgas volume flow meter $V_{t,db}$	Durag Annubar measuring system D-FL 100	QAL1: +/- 2.37 % QAL2: +/- 2.42 % AST +/- 2,94 %	AST done every year and QAL2 every 5 years	QAL2/AST: 31/10/2016 – 02/11/2016 AST 14/09/2017 – 15/09/2017 10/10/2018 – 12/10/2018
PT 95043	1220831	Stackgas pressure measurement P_t	Durag Annubar measuring system D-FL 100	QAL1: not specified QAL2: not specified	AST done every year and QAL2 every 5 years	QAL2/AST: 31/10/2016 – 02/11/2016 AST 14/09/2017 – 15/09/2017 10/10/2018 – 12/10/2018
TT 95075	02389948/49490828	Stackgas temperature measurement T_t	Durag Annubar measuring system D-FL 100	QAL1: not specified QAL2: not specified	AST done every year and QAL2 every 5 years	QAL2/AST: 31/10/2016 – 02/11/2016 AST 14/09/2017 – 15/09/2017 10/10/2018 – 12/10/2018

Table 2: Calibration dates

[6] Due to the decreasing efficiency of the N2O abatement catalyst the analyser switches periodically to the high measuring range. Therefore, a QAL2 for the high measuring range was performed in 2018

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

QAL1

In accordance with EN 14181:2004, the monitoring system for N_2O concentration measurements are suitable for the measuring task (parameter and composition of the flue gas) by use of the QAL1 procedure as specified by EN ISO 15267 or equivalent standards. This standard's objective proves that the total uncertainty of the results obtained from the AMS meets the specification for uncertainty stated in the applicable regulations. Such suitability testing was carried out under specific conditions by an independent third-party on a specific testing site.

QAL2

QAL2 is a procedure for the determination of the calibration function and its variability. According to EN 14181:2014, the QAL2 test including the SRM is conducted by an independent testing house which is accredited to EN ISO/IEC 17025. The QAL2 tests are performed on suitable AMS that is correctly installed and commissioned on-site (as opposed to QAL1 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 was then evaluated by the independent qualified "testing house". Initially, due to the high abatement efficiency of the N2O abatement catalyst the analyser operated in the low measuring range (0 – 100 ppm). Accordingly, the QAL2 was performed for this range only. Due to the decreasing efficiency of the N2O abatement catalyst now the analyser switches periodically to the high measuring range. Therefore, a QAL2 for the high measuring range was performed in 2018.
QAL2 tests are performed at least every 5 years according to EN 14181:2014.

AST

In addition, Annual Surveillance Tests (AST) were 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 were performed annually. If a full QAL2 test was performed (at least every 5 years), an additional AST test is not necessary in that same year.

Calibration delay:

Natural gas flow meter (Monitoring parameter: $FC_{i,j,y}$):

The calibration was due 09/03/2019 (one year after the previous calibration). The calibration was postponed and it was finally performed 03/06/2019. For the period between the end of the validity of the calibration and the next Calibration the monitoring results were corrected according to "CDM-EB93-A05-STAN: CDM validation and verification standard for project activities" section 9.2.6 "Compliance with the calibration frequency requirements for measuring instruments". The maximum permissible error of the measuring equipment was applied as the error identified in the delayed calibration was below the maximum permissible error of the measuring equipment. The value was determined as stipulated in the paragraph 366 of the above mentioned VVS. Therefore, the error of 0,5 % was applied in a conservative manner for the period between the end of the validity of the previous calibration and the actual date of the calibration. The error was applied for the period from 09/03/2019 – 03/06/2019.

Nitric acid flow meter (Monitoring parameter: $P_{NA,n}$):

The calibration was due 10/03/2019 (one year after the previous calibration). The calibration was postponed and it was finally performed 03/06/2019. For the period between the end of the validity of the calibration and the next Calibration the monitoring results were corrected according to "CDM-EB93-A05-STAN: CDM validation and verification standard for project activities" section 9.2.6 "Compliance with the calibration frequency requirements for measuring instruments". The error identified in the delayed calibration was applied as it was higher than the maximum permissible error of the measuring equipment. The value was determined as stipulated in the paragraph 366 of the above mentioned VVS. Therefore, the error of 1,639 % was applied in a conservative manner for the period between the end of the validity of the previous calibration and the actual date of the calibration. The error was applied for the period from 10/03/2019 – 03/06/2019.

N2O Outlet Analyser (Monitoring parameter: $v_{i,t,db}$) and
Stackgas volume flow meter (Monitoring parameter: $V_{t,db}$)

The AST was due 16/09/2018 (one year after the previous AST). The AST was postponed due to several shutdowns of the Nitric Acid plant and it was finally performed 10/10/2018 – 12/10/2018. For the period between the end of the validity of the AST test and the next AST the monitoring results were corrected according to "CDM-EB93-A05-STAN: CDM validation and verification standard for project activities" section 9.2.6 "Compliance with the calibration frequency requirements for measuring instruments". The error identified in the delayed calibration test of the instruments for N2O concentration and Stack Gas Flow was applied because it was beyond the maximum permissible error of the measuring equipment. The value was determined as stipulated in the paragraph 366 of the above mentioned VVS.

For the N2O concentration the maximum error as determined during the QAL1 test is +/- 2.71 % (expressed as standard uncertainty) and +/- 5.31 % (expressed as expanded uncertainty). The error as determined during the calibration (AST) was +/- 2.85 % (expressed as standard uncertainty) and +/- 5.58 % (expressed as expanded uncertainty). Therefore, the error of 5.58 % was applied in a conservative manner for the period between the end of the validity of the AST and the actual date of the AST. The error was applied for the period from 16/09/2018 – 12/10/2018.

For the stack gas flow the maximum error as determined during the QAL1 is +/- 2.37 % (expressed as standard uncertainty) and +/- 4.65 % (expressed as expanded uncertainty). The error as determined during the calibration (AST) was +/- 2.94 % (expressed as standard uncertainty) and +/- 5.76 % (expressed as expanded uncertainty). Therefore, the error of 5.76 % was applied in a conservative manner for the period between the end of the validity of the AST and the actual date of the AST. The correction was applied for the period from 16/09/2018 – 12/10/2018.

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 was demonstrated that the AMS was 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 as outlined for the applicable parameter in section D.2.

N_2O-Analyser Zero Calibration

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

N_2O-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 was sufficient to regularly inspect its physical condition by means of visual and electric checks of the probe. 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 were 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_2O was the responsibility of the operational personal. All relevant data was 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 was 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 Durag system and drives and the main server as follows:

- All data collected by the Delta V DCS is stored on its internal hard drive for 1 month.
- The EnviNox^{TM} data is stored on the plant Durag system and is designed to carry the full crediting period + 2 years. This system comprises of two hard disc drives, as a backup to the process.
- 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.

Audit function and management review

Internal audits are performed regularly in accordance with implemented quality and environmental management systems.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/Parameter	$EF_{default,y}$
Unit	$kgN_2O/tHNO_3$
Description	Default N_2O baseline emissions factor in the calendar year y of the monitoring period n

<table>
<tr><td>Source of data</td><td>According to ACM0019 Version 01.0.0, the default N_2O 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:

<table>
<tr><th>Year</th><th>Emissions factor ($kgN_2O/tHNO_3$)</th></tr>
<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>Year n</td><td>2.50</td></tr>
</table>
</td></tr>
<tr><td>Value(s) applied</td><td>2018: 2.80
2019: 2.70</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>Default value</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline emissions or baseline net GHG removals</td></tr>
<tr><td>Additional comments</td><td>The decrease in the value for the baseline emission factor over time is to reflect the technological development. Please note that the factual business as usual emissions are estimated to be 6.45 $kgN_2O/tHNO_3$.</td></tr>
</table>

Data/Parameter	GWP_{N2O}
Unit	tCO_2e/tN_2O
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/parameter	Calculation of baseline emissions or baseline net GHG removals and Calculation of project emissions or actual net GHG removals
Additional comments	-

Data/Parameter	R_u
Unit	Pa,m^3/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/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	-

Data/Parameter	MM_i
Unit	kg/mol
Description	Molecular mass of greenhouse gas *i* (N_2O)
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/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	-

Data/Parameter	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/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	-

Data/Parameter	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/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	-

Data/Parameter	$T_{open,n}$
Unit	%
Description	Fraction of time in monitoring period n during which the by-pass valve on the line feeding the tertiary N_2O abatement facility was open to vent the gas directly to the atmosphere.
Source of data	ACM0019 v.01.0.0
Value(s) applied	0
Choice of data or measurement methods and procedures	Default value
Purpose of data/parameter	Calculation of baseline emissions or baseline net GHG removals
Additional comments	No by-pass is foreseen in the project design and therefore no by-pass valve will be installed from the beginning of the project activity. If necessary, plant will shut down.

D.2. Data and parameters monitored

Data/Parameter	$P_{NA,n}$
Unit	$tHNO_3$
Description	Nitric Acid Produced
Measured/calculated/ default	Measured and Calculated
Source of data	The mass flow of HNO_3 is continuously measured by a mass flow meter. HNO_3 concentration is calculated on the DCS using density and temperature from DCS. The mass flow is then multiplied by the concentration to calculate the 100% HNO_3 mass flow. Density & acid concentration are crosschecked by laboratory analysis.
Value(s) of monitored parameter	297,790

Monitoring equipment	TAG number/ model specification of meter: FT 95023/ Micro Motion, Coriolis Mass flow Serial Number SN: 14206070 (Sensor) SN: 3811087 (Transmitter) Tag No. FT-95023 Overall measurement accuracy +/- 0.2% of the adjusted range Calibration frequency: annually Calibration dates: 09/03/2018, 03/06/2019 Density & acid concentration are crosschecked by laboratory analysis.
Measuring/reading/recording frequency	HNO3: Mass flow and concentration Continuously at 1 second intervals. Density & concentration analysis for crosschecks: approximately 12 samples per day are collected, which are sent to the plant laboratory for analysis. Another sample is taken daily to the central laboratory for analysis. This is for cross reference purposes.
Calculation method (if applicable)	Mass flow measurements (kg/h) are multiplied with acid concentration determined on the DCS to calculate $P_{NA,n}$ mass flow in tHNO3/h. This method of calculation is used instead of manual inputs of lab data into the DCS to prevent finger mistakes and is also done on a continuous basis at 1 second intervals.
QA/QC procedures	Maintenance and calibration of the flow meter and density meter has been applied under the internal QA/QC procedures implemented for this project activity. Omnia is accredited with ISO9001, ISO 14001 and OHS 18001. All plant equipment and piping are designed as per ASME standards and their maintenance/QAQC is based on relevant API standards, vendor recommendations and prevailing practices in fertilizer industry.
Purpose of data/parameter	Calculation of baseline emissions or baseline net GHG removals
Additional comments	Corrections due to delayed calibrations were applied

Data/Parameter	$F_{N2O,Tailgas,h}$
Unit	kgN_2O/h
Description	Mass Flow of N_2O in the gaseous stream of the tail gas in hours h
Measured/calculated/ default	Measured and Calculated
Source of data	N_2O concentration: Emerson N_2O Analyzer Stack gas volume flow: Durag Annubar D-FL 100 flow meter
Value(s) of monitored parameter	Average value for this monitoring period: 23.6769 applied for the determination of $Q_{N2O,tailgas,n}$ and overall Project Emissions. See calculation sheet and sample calculation of section E.2.
Monitoring equipment	N_2O concentration: Emerson N_2O Analyzer Stack gas volume flow: Durag Annubar D-FL 100 flow meter
Measuring/reading/recording frequency	Continuously / 1 second

Calculation method (if applicable)	• The monitoring system provides separate hourly average values for the N_2O concentration and the volume or mass flow of the tail gas based on 1 second interval readings that are recorded and stored electronically. These N_2O data sets are 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 EN 14181 must be applied to both the N_2O concentration and the volume or mass flow of the tail gas. The QAL 2 calibration factors are applied in the data storage system at the plant. • If the data for either the N_2O concentration or the volume or mass flow of the tail gas is 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. The hourly values are then aggregated as follows: $$Q_{N2O,tailgas,n} = \sum_{h=1}^{h=h_n} F_{N2O,tailgas,h} * 10^{-3}$$ $Q_{N2O,tailgas,n}$ = Amount of N_2O released through the tail gas of the project plant to the atmosphere in monitoring period *n* (tN_2O) $F_{N2O,tailgas,h}$ = Mass flow of N_2O in the gaseous stream of the tail gas in the hour h (kgN_2O/h) h_n = Number of hours in monitoring period n during which the plant was in operation
QA/QC procedures	As per EN 14181:2004 and EN 14181:2014 standards, the flow meter and the analyser 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. Initially, due to the high abatement efficiency of the N2O abatement catalyst the analyser operated in the low measuring range (0 – 100 ppm). Accordingly, the QAL2 was performed for this range only. Due to the decreasing efficiency of the N2O abatement catalyst now the analyser switches periodically to the high measuring range. Therefore, a QAL2 for the high measuring range was performed in 2018 QAL2 & 3 calibration schedules are performed according to plant internal procedures Refer to calibration overview table in Section C.
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	Corrections due to delayed calibrations were applied

Data/Parameter	h_n
Unit	Hours
Description	Number of hours in monitoring period n the plant was in operation

Measured/calculated/ default	Measured
Source of data	Omnia production log and continuous monitoring according to operational parameters
Value(s) of monitored parameter	7,629
Monitoring equipment	The total operating hours are logged continuously in the production log
Measuring/reading/recording frequency	Continuously/ 1 second
Calculation method (if applicable)	-
QA/QC procedures	-
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	The nitric acid plant was out of operation during 1,131 hours of this monitoring period: (see table below)

Begin of downtime	End of downtime	Time duration (hours
07/09/2018 06:00	13/09/2018 15:00	154
15/09/2018 12:00	22/09/2018 12:00	169
23/09/2018 12:00	25/09/2018 11:00	48
05/10/2018 06:00	06/10/2018 11:00	30
24/12/2018 11:00	11/01/2019 00:00	422
25/02/2019 17:00	26/02/2019 04:00	12
22/05/2019 17:00	23/05/2019 16:00	24
28/05/2019 14:00	08/06/2019 11:00	262
31/07/2019 15:00	01/08/2019 00:00	10
	total hours of plant downtime	**1,131**

Data/Parameter	$T_{open,n}$
Unit	%
Description	Fraction of time in monitoring period *n* during which the by-pass valve on the line feeding the tertiary N_2O abatement facility was open to vent the gas directly to the atmosphere.
Measured/calculated/ default	Measured
Source of data	N/A
Value(s) of monitored parameter	0
Monitoring equipment	N/A
Measuring/reading/recording frequency	N/A
Calculation method (if applicable)	N/A
QA/QC procedures	N/A

Purpose of data/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	No by-pass is foreseen in the project design and therefore no by-pass valve will be installed from the beginning of the project activity.

Data/Parameter	$PE_{FF,n}$
Unit	tCO_2e
Description	Project emissions related to fossil fuel input to the destruction facility and/or re-heater in monitoring period *n* (tCO_2)
Measured/calculated/ default	Calculated
Source of data	The emissions related to the operation of the N_2O destruction facility include only on-site emissions due to fossil fuel use as input to the N_2O destruction facility. Natural gas consumption will be measured by a mass-flow meter
Value(s) of monitored parameter	837.49
Monitoring equipment	-
Measuring/reading/recording frequency	Continuously/ 1 second
Calculation method (if applicable)	Calculated based on measurement of natural gas consumption according to the following formula, as provided in the applicable tool "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (Version 02): 2) $PE_{FF,n} = PE_{FC,i,j,}$ 3) $PE_{FC,j,n} = \sum_i FC_{i,j,y} * COEF_{i,n}$ $COEF_{i,n} = w_{C,i,y} * 44/12$ Where: $PE_{FC,j,n}$ = CO_2 emissions from fossil fuel combustion in process *j* in monitoring period *n* (tCO_2/n) $FC_{i,j,y}$ = Quantity of fuel type *i* combusted in the process *j* during the monitoring period *n* (mass or volume unit/n) $COEF_{i,n}$ = CO_2 emission coefficient of fuel type *i* in monitoring period *n* (tCO_2/mass or volume unit) i = fuel types combusted in process *j* during monitoring period *n* $w_{C,i,y}$ = Weighted mass average fraction of carbon in fuel type i in year y
QA/QC procedures	Maintenance and calibration of the mass flow meter is applied under the internal QA/QC procedures.
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	

Data/Parameter	$w_{C,i,y}$
Unit	tC/mass unit of fuel type natural gas
Description	Weighted average mass fraction of carbon in fuel type *i* in year *y*

Measured/calculated/ default	Measured
Source of data	The following data source may be used if the relevant conditions apply: **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 **Option a)** Not received from Invoices but by request from supplier.
Value(s) of monitored parameter	2018: 0.731 2019: 0.734
Monitoring equipment	-
Measuring/reading/recording frequency	The mass fraction of carbon is obtained by request from supplier.
Calculation method (if applicable)	The weighted average mass fraction is calculated by using the composition obtained from the supplier and the monthly natural gas consumption.
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/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	The gas supplier provided a report for the average gas composition for every month. The weighted average mass fraction of carbon was then calculated based on the monthly natural gas consumption.

Data/Parameter	$FC_{i,j,y}$
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	The mass flow of natural gas is continuously measured by a mass flow meter.
Value(s) of monitored parameter	311.662
Monitoring equipment	TAG number/ model specification of meter: Micro Motion, Mass flow Serial Number: SN:14257727 (Sensor) SN: 3816752 (Transmitter) Tag No.: FT-95060 Overall measurement accuracy: +/- 0.5% of the adjusted range Calibration frequency: annually Calibration dates: 08/03/2018, 03/06/2019
Measuring/reading/recording frequency	Continuously/ 1 second

Calculation method (if applicable)	-
QA/QC procedures	Calibration schedules are performed according to plant internal procedure.
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	Corrections due to delayed calibrations were applied

Data/Parameter	$V_{t,db}$
Unit	Nm^3 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	Measurements from Durag Annubar flow meter
Value(s) of monitored parameter	Average Value: 131,575
Monitoring equipment	Durag Annubar Flow meter D-FL 100 Serial Number: 1223797 Tag No.: FT-95015 Calibration frequency: AST done every year and QAL2 every 5 years Calibration dates: QAL2/AST: 31/10/2016 – 02/11/2016 AST: 14/09/2017 – 15/09/2017 10/10/2018 – 12/10/2018
Measuring/reading/recording frequency	Continuously / 1 second
Calculation method (if applicable)	-
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. According to EN 14181, the flow meter will be 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/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	Calibration schedules are performed according to plant internal procedures As the gaseous stream is assumed to be dry, Option A of the tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" 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 ($C_{H2O,t,db,n}$) will be measured and it shall be demonstrated that it is less or equal to 0.05 kg H_2O/m^3 dry gas. See parameter $C_{H2O,t,db,n}$ below. In total during 45 hours of the monitoring period the instrument 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 Corrections due to delayed calibrations were applied.

Data/Parameter	$v_{i,t,db}$
Unit	m^3 gas i/m^3 dry gas

Description	Volumetric fraction of greenhouse gas i in a time interval t on a dry basis
Measured/calculated/ default	Continuously
Source of data	-
Value(s) of monitored parameter	Average value: 0.00009215
Monitoring equipment	Emerson N_2O Analyser NGA 2000 Serial Number: 9910103055428 Tag No.: AI-95005 Accuracy: QAL1: +/- 2.71 % QAL2: +/- 2.70 % AST: +/- 2.77 %. Calibration frequency: AST done every year, QAL2 every 5 years, QAL3 done automatically, zero every day, span every second day Calibration dates: QAL2/AST: 26/05/2015 - 29/05/2015 QAL2 Range 2: 10/10/2018 – 12/10/2018 AST: 14/09/2017 – 15/09/2017 10/10/2018 – 12/10/2018
Measuring/reading/recording frequency	Continuously/ 1 second
Calculation method (if applicable)	-
QA/QC procedures	Calibration includes zero verification with an inert gas (e.g. N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases have a certificate provided by the manufacturer and are under their validity period.
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	Calibration schedules are performed according to plant internal procedures. The N_2O concentration is measured in ppmv (= 10^{-6} m^3 N2O/ m³dry gas) and automatically converted to mg N2O / Nm³ dry gas (= 10^{-6} kg N2O/ Nm³ dry gas) by multiplication with the density of N2O within the data storage system at the plant. The QAL 2 calibration factor is also applied in the data storage system at the plant. The results from the data storage system in mg N2O / Nm³ dry gas are used for further calculation in the data calculation spreadsheet. In total during 87 hours of the monitoring period the N_2O 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 Corrections due to delayed calibrations were applied

Data/Parameter	$C_{H2O,t,db,n}$
Unit	kg H_2O/m^3 dry gas
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	0.006

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 14181:2004 or 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/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	Required for proving that the gaseous stream is dry.

Data/Parameter	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: 139.86
Monitoring equipment	Thermocouples Part of Durag Annubar measuring system D-FL 100 Serial Number: 02389948/49490828 Tag No.: TT-95075 Accuracy: not specified Calibration frequency: AST done every year and QAL2 every 5 years Calibration dates: QAL2/AST: 31/10/2016 – 02/11/2016 AST: 14/09/2017 – 15/09/2017 10/10/2018 – 12/10/2018
Measuring/reading/recording frequency	Continuously/ 1 second
Calculation method (if applicable)	-
QA/QC procedures	Periodic calibration against a primary device is provided by an independent accredited laboratory is mandatory. According to EN 14181, the flow meter (including the parameter T_t) is 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/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	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

Data/Parameter	P_t
Unit	Pa
Description	Pressure of the gaseous stream in time interval t
Measured/calculated/ default	Measured

Source of data	Pressure probe Part of Durag Annubar measuring system D-FL 100 Serial Number: 1220831 Tag No.: PT-95043 Accuracy: not specified Calibration frequency: AST done every year and QAL2 every 5 years Calibration dates: QAL2/AST: 31/10/2016 – 02/11/2016 AST: 14/09/2017 – 15/09/2017 10/10/2018 – 12/10/2018
Value(s) of monitored parameter	Average value 85,754
Monitoring equipment	Pressure probe
Measuring/reading/recording frequency	Continuously/ 1 second
Calculation method (if applicable)	-
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. According to EN 14181, the flow meter (including the parameter P_t) is 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/parameter	Calculation of project emissions or actual net GHG removals
Additional comments	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.

Data/Parameter	ER_n
Unit	tCO_2e
Description	Emission reduction in monitoring period
Measured/calculated/ default	Calculated
Source of data	-
Value(s) of monitored parameter	188,474
Monitoring equipment	-
Measuring/reading/recording frequency	-
Calculation method (if applicable)	$ER_n = BE_n - PE_n$
QA/QC procedures	-
Purpose of data/parameter	Calculation of project emissions or actual net GH removals
Additional comments	-

D.3. Implementation of sampling plan

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Not applicable

SECTION E. Calculation of emission reductions or net anthropogenic removals

E.1. Calculation of baseline emissions or baseline net removals

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Baseline emissions:

The calculation of the baseline emissions or baseline net GHG removals sinks has been established in accordance with ACM0019 Version 01.0.0. The formulae are numbered according to the numbering in the registered PDD.

$$(1) \quad BE_n = P_{NA,n} * EF_{BL,\,N2O,n} * GWP_{N2O} * 10^{-3}$$

Where:

BE_n	= Baseline emissions in monitoring period n (tCO_2e)
$P_{NA,n}$	= Nitric acid produced in the monitoring period n ($tHNO_3$)
$EF_{BL,\,N2O,n}$	= Baseline N_2O emission factor for nitric acid production in the monitoring period n ($kgN_2O/tHNO_3$).
GWP_{N2O}	= Global Warming Potential of N_2O valid for the commitment period (298 tCO2e/tN2O)

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

Year	BE_n	P_{NA}	$EF_{BL,N2O,n}$	GWP_{N2O}	
2018	**98,878.44**	118,502.44	2.80	298	0.001
2019	**144,254.70**	179,287.48	2.70	298	0.001
Total	**243,133.14**				

Determination of the baseline N_2O emission factor ($EF_{BL,N2O,n}$)

The baseline N_2O emission factor in the monitoring period n ($EF_{BL,N2O,n}$) shall be determined as a default emission factor $EF_{default,y}$ given for each calendar year y for which BE_n is calculated (see monitoring table for $EF_{default,y}$), as follows:

$$(2) \quad EF_{BL,\,N2O,n} = EF_{default,\,y}$$

Where:

$EF_{BL,\,N2O,n}$	= Baseline N_2O emission factor for nitric acid production in the monitoring period n ($kgN_2O/tHNO_3$).
$EF_{default,\,y}$	= Default N_2O baseline emissions factor in the calendar year of the monitoring period n ($kgN_2O/tHNO_3$) (see list of $EF_{default,\,y}$ values under D.1.).

Year	$EF_{BL,\,N2O,n}$	$EF_{default,n}$
2018	2.80	2.80
2019	2.70	2.70

E.2. Calculation of project emissions or actual net removals

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Project emissions include emissions of N_2O which have not been destroyed by the project activity and, in case of the installation of a tertiary N_2O abatement facility, CO_2 emissions resulting from the operation of the N_2O abatement facility.

Project emissions are calculated using the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (Version 02) referred to in ACM0019.

Project emissions are calculated as follows:

$$(3) \quad PE_n = PE_{N2O,n} + PE_{CO2,tertiary,n}$$

Where:

PE_n	= Project emissions in monitoring period n (tCO_2e)
$PE_{N2O,n}$	= Project emissions of N_2O from the project plant in monitoring period n (tCO_2e)
$PE_{CO2,tertiary,n}$	= Project emissions of CO_2 from the operation of the tertiary N_2O abatement facility in monitoring period n (tCO_2)

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

Year	PE_n	$PE_{N2O,n}$	$PE_{CO2,tertiary,n}$
2018	**23,095.87**	22,806.44	289.43
2019	**31,562.56**	31,014.50	548.07
Total	**54,658.43**		

The amount of N_2O emissions from the project activity includes two emission sources:

- The N_2O contained in the tail gas stream of the plant which is released to the atmosphere and;
- In the case of a tertiary N_2O abatement, the N_2O contained in any by-pass streams to the tertiary N_2O abatement facility.

$$PE_{N2O,n} = (Q_{N2O,tail\ gas,n} + Q_{N2O,by\text{-}pass,n}) * GWP_{N2O} \quad (4)$$

Where:

$PE_{N2O,n}$	= Project emissions of N_2O from the project plant in monitoring period (tCO2e)
$Q_{N2O,tail\ gas,n}$	= Amount of N_2O released through the tail gas of the project plant to the atmosphere in monitoring period n (tN_2O)
$Q_{N2O,by\text{-}pass,n}$	= Amount of N_2O released through the by-pass to a tertiary N_2O abatement system to the atmosphere in monitoring period n (tN_2O)
GWP_{N2O}	= Global warming potential of N_2O valid for the commitment period (298 tCO_2e/tN_2O)

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

Year	$PE_{N2O,n}$	$Q_{N2O,tail\ gas,n}$	$Q_{N2O,by\text{-}pass,n}$	GWP_{N2O}
2018	**22,806.44**	76.53	0	298
2019	**31,014.50**	104.08	0	298
Total	**53,820.94**			

According to the methodology and for keeping up flexibility in the event of a possible by-pass installation at a later point of time the parameter $T_{open,n}$ will be monitored throughout the crediting period and has been added to section D.2.

<u>Determination of $Q_{N2O,tail\ gas,n}$</u>

The amount of N_2O emissions from the tail gas stream of the project plant is 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_2O concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is maintained throughout the crediting period based on the European Norm 14181 (2004), or any more recent update of that standard;
- The monitoring system provides separate hourly average values for the N_2O concentration and the volume or mass flow of the tail gas based on 1 second interval readings that are recorded and stored

electronically. These N_2O data sets are 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 EN 14181 are 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;
- 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 is 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 is applied to any such hour. Values observed during five operating hours before and after a plant start-up and shut-down is excluded for the determination of the maximum values.

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 ($CH_2O_{,t,db,n}$) 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 ($F_{i,t}$), which is calculated as follows:

$$F_{i,t} = V_{t,db} * v_{i,t,db} * \rho_{i,t} \quad (5)$$

With

$$\rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t} \quad (6)$$

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 N_2O in the gaseous stream in a time interval t on a dry basis (m^3 gas N_2O/m^3 dry gas)
$\rho_{i,t}$ = Density of greenhouse gas N_2O in the gaseous stream in a time interval t (kg gas N_2O/m^3 gas N_2O)
P_t = Absolute pressure of the gaseous stream in time interval t (Pa)
MM_i = Molecular mass of greenhouse gas N_2O (kg/kmol)
R_u = Universal ideal gases constant ($Pa.m^3/kmol.K$)
T_t = Temperature of the gaseous stream in time interval t (K)

Sample calculation for equation (5) applying average values for the monitoring period:

$F_{i,t}$	$V_{t,db}$	$v_{i,t,db}$	$\rho_{i,t}$
23.813	131,575	0.0000921	1.964

Calculation for equation (6) applying standard condition values:

$\rho_{i,t}$	P_t	MM_{N2O}	Ru	T_t
1.964	101.33	44.02	8.31	273.150

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

$$Q_{N2O,tailgas,n} = \sum_{h=1}^{h=h_n} F_{N2O,tailgas,h} * 10^{-3} \quad (7)$$

Where:

$Q_{N2O,tailgas,\ n}$ = Amount of N_2O released through the tail gas of the project plant to the atmosphere in monitoring period n (tN_2O)
$F_{N2O,\ tailgas,h}$ = Mass flow of N_2O in the gaseous stream of the tail gas in the hour h (kgN_2O/h)
h_n = Number of hours in monitoring period n during which the plant was in operation

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

Year	$Q_{N2O,tail\ gas,n}$	$\sum F_{N2O,tail\ gas,h}$	
2018	**76.532**	76,531.69	0.001
2019	**104.075**	104,075.49	0.001
Total	**180.607**		

During any periods in which a tertiary abatement system is by-passed, $F_{N2O,tailgas,h}$ is set to zero in order to avoid double counting of project emissions.

$$Q_{N2O,\ by\text{-}pass;n} = EF_{BL,\ N2O,n} * P_{NA.n} * T_{open,n} * 10^{-3} \quad (8)$$

Where:

$Q_{N2O,\ by\text{-}pass;n}$ = Amount of N_2O released through the by-pass to a tertiary N_2O abatement system to the atmosphere in monitoring period n (tN_2O)
$EF_{BL,\ N2O,n}$ = Default N_2O baseline emissions factor in the calendar year y of the monitoring period n ($kgN_2O/t\ HNO_3$)
$P_{NA.n}$ = Nitric acid produced in the monitoring period n ($tHNO_3$)
$T_{open,n}$ = Fraction of time in monitoring period n during which the by-pass valve on the line feeding the tertiary N_2O abatement facility was open to vent the gas directly to the atmosphere.

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

Year	$Q_{N2O,by\text{-}pass,n}$	$EF_{BL,N2O,n}$	P_{NA}	$T_{open,n}$	
2018	**0.00**	2.80	118,502	0	0.001
2019	**0.00**	2.70	179,287	0	0.001
Total	**0.00**				

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:

<u>Project emissions from the operation of the tertiary N_2O abatement facility ($PE_{CO2,tertiary,n}$)</u>

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:

$$PE_{CO2,tertiary,n} = PE_{FF,n} \quad (9)$$

Where:

$PE_{CO2,tertiary,n}$ = Project emissions of CO_2 from the operation of the tertiary N_2O abatement facility in monitoring period n (tCO_2)
$PE_{FF,n}$ = Project emissions related to fossil fuel input to the destruction facility and/or re-heater in monitoring period n ($t\ CO_2$)

For the determination of the project emissions related to the operation of the tertiary abatement system in monitoring period n the project proponents are required to use the latest version of the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion.”

The parameter $PE_{FC,j,y}$ used in the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” corresponds to the parameter $PE_{FF,n}$ in the applied methodology:

$$PE_{FF,n} = PE_{FC,i,j,} \quad (10)$$

CO_2 emissions from fossil fuel combustion in process j are calculated based on the quantity of fuels combusted and the CO_2 emission coefficient of those fuels, as follows:

$$PE_{FC,j,n} = \sum_i FC_{i,j,y} * COEF_{i,n} \quad (11)$$

Where:

$PE_{FC,j,n}$ = CO_2 emissions from fossil fuel combustion in process j in monitoring period n (tCO_2/n)
$FC_{i,j,y}$ = Quantity of fuel type i combusted in the process j during the monitoring period n (mass or volume unit/n)

$COEF_{i,n}$= CO_2 emission coefficient of fuel type i in monitoring period n (tCO2/mass or volume unit)
i = fuel types combusted in process j during monitoring period n

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

Year	$PE_{CO2,tertiary,n}$	$\sum FC_{i,j,y}$	$COEF_{i,n}$
2018	**289.425**	108.004	2.680
2019	**548.066**	203.658	2.691
Total	**837.491**		

As data about the chemical composition of the fuel type i is available $COEF_{i,n}$ is calculated based on its chemical composition of the fossil fuel type i using Option A of the “Tool to calculate project or leakage CO2 emissions from fossil fuel combustion” (Version 02):

$$COEF_{i,n} = w_{C,i,y} * 44/12 \quad (12)$$

Where:

$COEF_{i,n}$ = CO_2 emission coefficient of fuel type i in monitoring period n (tCO_2/mass or volume unit)
$w_{C,i,y}$ = Is the weighted average mass fraction of carbon in fuel type i in monitoring period n (tC/mass unit of the fuel)

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

Year	$COEF_{i,n}$	$w_{C,i,y}$	
2018	**2.680**	0.731	44/12
2019	**2.691**	0.734	44/12

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

2018 Natural Gas properties

Component	Atoms Carbon per molecule	Molar weight	mol Fraction	Molar weight - weighted	Carbon content Molar weight - weighted	mass fraction of carbon in fuel = wc,i,y
		g/mol	%	g/mol	g/mol	
Carbon		12.011				
Nitrogen	0	28.013	1.948	0.546	0.000	
Carbon dioxide	1	44.010	0.033	0.015	0.004	
Methane	1	16.043	93.889	15.063	11.277	
Ethane	2	30.070	2.072	0.623	0.498	
Propane	3	44.096	0.946	0.417	0.341	
i Butane	4	58.120	0.259	0.151	0.125	
n Butane	4	58.120	0.289	0.168	0.139	
i pentane	5	72.150	0.100	0.072	0.060	
n pentane	5	72.150	0.077	0.055	0.046	
Hexane	6	86.180	0.167	0.144	0.120	
			Total	17.252	12.609	**0.731**

Table 3: Natural Gas properties 2018

2019 Natural Gas properties

Component	Atoms Carbon per molecule	Molar weight	mol Fraction	Molar weight - weighted	Carbon content Molar weight - weighted	mass fraction of carbon in fuel = wc,i,y
		g/mol	%	g/mol	g/mol	
Carbon		12.011				
Nitrogen	0	28.013	1.656	0.464	0.000	
Carbon dioxide	1	44.010	0.010	0.004	0.001	
Methane	1	16.043	94.607	15.178	11.363	
Ethane	2	30.070	2.029	0.610	0.487	
Propane	3	44.096	0.835	0.368	0.301	
i Butane	4	58.120	0.248	0.144	0.119	
n Butane	4	58.120	0.255	0.148	0.123	
i pentane	5	72.150	0.093	0.067	0.056	
n pentane	5	72.150	0.075	0.054	0.045	
Hexane	6	86.180	0.106	0.092	0.077	
			Total	17.130	12.572	**0.734**

Table 4: Natural Gas properties 2019

E.3. Calculation of leakage emissions

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According to the methodology any leakage emissions sources are deemed to be negligible.

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals (t CO_2e)	Project GHG emissions or actual net GHG removals (t CO_2e)	Leakage GHG emissions (t CO_2e)	GHG emission reductions or net anthropogenic GHG removals (t CO_2e)		
				Before 01/01/2013	From 01/01/2013	Total amount
2018	98,878.44	23,095.87	0.00	0.00	75,782.57	75,782.57
2019	144,254.70	31,562.56	0.00	0.00	112,692.14	112,692.14
Total	**243,133.14**	**54,658.43**	**0.00**	**0.00**	**188,474**	**188,474**

E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante for this monitoring period in the PDD (t CO_2e)
188,474	**323,097**

E.5.1. Explanation of calculation of "amount estimated ex ante for this monitoring period in the PDD"

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For the calculation of the estimated emission reductions in the PDD it was taken into account:

- The confirmed capacity of 400,000 tHNO3/year,
- A default factor (EFdefault,y) (see D.1) for calculating baseline emissions (BEn),
  Please note that factual business as usual emissions are assumed to be approximately 6.45 kgN2O/tHNO3. However, as defined in the methodology, instead of factual business as usual emissions, the default factor is used in order to calculate credible emission reductions.
- An expected reduction efficiency of 98% and
- Project emissions from the operation of the tertiary N2O abatement facility: PEFC,j,n = 905 tCO2e (ex-ante calculation) for the operation of the tertiary system.

From the table of estimated emission reductions in the PDD the yearly projected value for the years 2018 and 2019 was taken into account on a pro rata basis according to the duration of the monitoring period in the specific year.

The estimated value of emission reductions in the PDD for 2018 was 330,299 t CO2e. The actual duration of this monitoring period in 2018 was 153 days. Therefore, the estimated amount for this monitoring period is calculated as 330,299 t CO2e divided by 365 days multiplied by 153 days resulting in 138,454 t CO2e.

The estimated value of emission reductions in the PDD for 2019 was 317,899 t CO2e. The actual duration of this monitoring period in 2019 was 212 days. Therefore, the estimated amount for this monitoring period is calculated as 317,899 t CO2e divided by 365 days multiplied by 212 days resulting in 184,643 t CO2e.

The total amount of estimated emission reductions during this monitoring period is the sum of the values for 2018 and 2019. The value is calculated as 138,454 t CO2e plus 184,643 t CO2e resulting in 323,097 t CO2e.

The results are illustrated in the table below:

Year	**EFdefault,y (kgN2O/ tHNO3)**	**ERn (tCO2e)**	**Days during this Monitoring period**	**ER per year of Monitoring period**
04/2012	3.90	175,011		
2013	3.70	441,899		
2014	3.50	417,099		
2015	3.40	404,699		
2016	3.20	379,899		
2017	3.00	355,099		
2018	2.80	330,299	153	138,454
2019	2.70	317,899	212	184,643
2020	2.50	293,099		
2021	2.50	293,099		
03/2022	2.50	73,274		
Total		**3,481,376**		**323,097**

E.6. Remarks on increase in achieved emission reductions

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Not Applicable:
The achieved emission reductions were below the expected value.

E.7. Remarks on scale of small-scale project activity

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Not Applicable

Document information

Version	*Date*	*Description*
07.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Add a section on remarks on the observance of the scale limit of small-scale project activity during the crediting period; • Add "changes specific to afforestation or reforestation project activity" as a possible post-registration changes; • Clarify the reporting of net anthropogenic GHG removals for A/R project activities between two commitment periods; • Make editorial improvements.
06.0	7 June 2017	Revision to: • Ensure consistency with version 01.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Make editorial improvements.
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
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 (EB 70, 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).
01.0	28 May 2010	EB 54, Annex 34. Initial adoption.

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