



**Monitoring report form for CDM project activity
(Version 06.0)**

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

MONITORING REPORT

Title of the project activity	N2O ABATEMENT PROJECT AT NITRIC ACID PLANT NO. 11 AT AFRICAN EXPLOSIVES LTD. (AEL), SOUTH AFRICA	
UNFCCC reference number of the project activity	1364	
Version number of the PDD applicable to this monitoring report	02	
Version number of this monitoring report	04	
Completion date of this monitoring report	13/04/2018	
Monitoring period number	10	
Duration of this monitoring period	18/08/2016 – 07/02/2018 539 days	
Monitoring report number for this monitoring report	N/A	
Project participants	<ul style="list-style-type: none"> - AEL Mining Services Limited - N.serve Environmental Services GmbH - Nordic Environment Finance Corporation 	
Host Party	South Africa	
Sectoral scopes	Chemical industries (5)	
Applied methodologies and standardized baselines	AM0034 (Version 2)	
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 tCO ₂ e	271,793 tCO ₂ e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	392,008 tCO ₂ e	

SECTION A. Description of project activity**A.1. General description of project activity**

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Purpose of the project activity and measures taken to reduce GHG emissions

The sole purpose of the project activity is significantly reducing former levels of N₂O emissions from the production of nitric acid at AEL's nitric acid plant No. 11 ("AEL-11") in Modderfontein, South Africa, by implementation of a secondary N₂O abatement catalyst.

Brief description of the installed technology and equipment

Yara International ASA supplies the employed secondary N₂O abatement catalyst technology. An Automated Measuring System (AMS), consisting of stack gas volume flow meter, N₂O Analyzer, and respective data logging facilities, assures continuous monitoring of emission reductions. The AMS as well as its installation complies with the requirements of the European Standard EN 14181 as required by the methodology.

Relevant dates for the project activity

Registration Date: 08/02/2008

Installation of AMS: January 2006

The monitoring results for Oxidation Temperature and Pressure have been routinely discarded in the past and are therefore not available to establish the normal range. As a substitute, the technical manuals of the No. 11 nitric acid plant were used to derive these normal ranges. See section D.1. for details.

The parameters CL_{normal}, GS_{normal}, GC_{normal} and AFR_{max} were derived from the 5 historic campaigns that were defined in the PDD. The 5 campaigns are:

Campaign	Start date	End date	In-/Excluded
C10	29/05/2003	24/11/2003	Included
C12	27/05/2004	12/12/2004	Included
C13	15/12/2004	24/07/2005	Included
C14	27/07/2005	28/01/2006	Included
C15	03/02/2006	31/07/2006	Included

Baseline Campaign: BL – Campaign 20/07/2006 – 18/02/2007

Intermediate Campaign

Without secondary catalyst: 25/02/2007 – 18/08/2007

Installation of secondary catalyst: 12/09/2007

Starting Date of Crediting period: 08/02/2008

Project Campaigns completed prior to current monitoring period:

1. Campaign	PC1 - 12/09/2007-19/03/2008
2. Campaign	PC2 - 20/03/2008-28/09/2008
3. Campaign	PC3 - 04/10/2008-23/05/2009
4. Campaign	PC4 - 08/06/2009-27/12/2009
5. Campaign	PC5 - 30/12/2009-03/08/2010

6. Campaign	PC6 - 04/08/2010-16/11/2010
7. Campaign	PC7 - 19/11/2010-28/02/2011
8. Campaign	PC8 - 24/03/2011-06/08/2011
9. Campaign	PC9 - 22/08/2011-17/04/2012
10. Campaign	PC10 - 25/04/2012-04/10/2012
11. Campaign	PC11 - 13/10/2012-26/11/2012
12. Campaign	PC12 - 07/12/2012-05/06/2013
13. Campaign	PC13 - 17/06/2013 - 08/03/2014
14. Campaign	PC14 - 02/04/2014 - 22/10/2014
15. Campaign	PC15 - 23/10/2014 - 25/05/2015
16. Campaign	PC16 - 28/05/2015 - 05/01/2016
17. Campaign	PC17 - 06/01/2016 - 17/08/2016

Project Campaigns covered by current Monitoring/Verification Period:

18. Campaign	PC18 - 18/08/2016 - 04/04/2017
19. Campaign	PC19 - 05/04/2017 - 31/07/2017
20. Campaign	PC20 - 01/08/2017 - 07/02/2018

The crediting period ended on 07/02/2018. In accordance with AM_CLA_0204, only the N₂O concentration and flow rate data and the nitric acid production data within the crediting period was used to calculate the emission factors of the last project campaign. Hence, PC20 ended on 07/02/2018.

Total emission reductions achieved in this monitoring period

The total amount of emission reductions achieved in this monitoring period is 271,793 tCO₂e.

A.2. Location of project activity

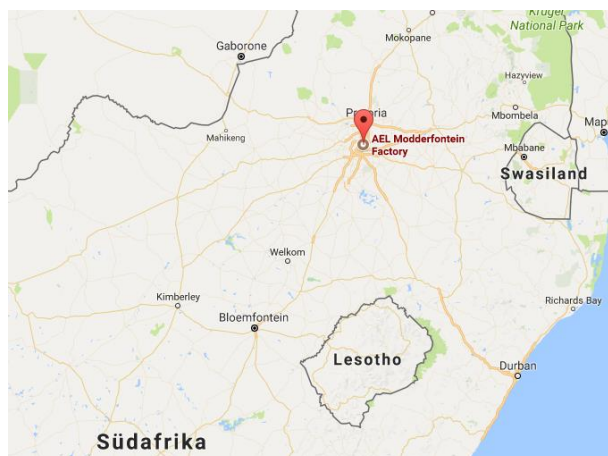
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Host Party: South Africa

Region/State/Province: Gauteng / Modderfontein

City/Town/Community: City of Johannesburg

Physical/Geographical location: 26°05'50" South, 28°10'26" East



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)	- AEL Mining Services Limited	No

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
United Kingdom of Great Britain and Northern Ireland	- N.serve Environmental Services GmbH	No
Switzerland	- N.serve Environmental Services GmbH - AEL Mining Services Limited	No
Norway	- Nordic Environment Finance Corporation	No

A.4. Reference to applied methodologies and standardized baselines

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1.

- a) AM0034 "Catalytic reduction of N₂O inside the ammonia burner of nitric acid plants" Version 2
For the baseline selection: AM0028 "Catalytic N₂O destruction in the tail gas of Nitric Acid or Caprolactam Production Plants" Version 03

- b) "Tool for the demonstration and assessment of additionality" Version 2

2.

a)

https://cdm.unfccc.int/filestorage/C/D/M/CDMWF_AM_HPMLB4XF5J1FZQGG1QSBKMKZSB_C570/EB27_repan05_AM0034_ver02.pdf?t=Uml8b3ozaXhlfDCM2pcvHuSecMfZyiZBQJL2

http://cdm.unfccc.int/filestorage/C/D/M/CDMWF_AM_637CJ1Q9DBD4SERKVARM51XNRC_KY0/EB27_repan08_AM0028_rev_ver03.pdf?t=VTv8b3ozaXo2fDDgNXrkiOmBuCIJYz-3YQg1

b)

<http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v7.0.0.pdf>

(Version 2 is not available on the UNFCCC website)

A.5. Crediting period type and duration

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Type: Non-renewable crediting period

Start date: 08/02/2008

End date 07/02/2018

Length: 10 years 0 months

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

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Description of the installed technology, technical processes and equipment

The project activity entails the installation and implementation of the following technical equipment and quality measures:

- 1.) secondary N₂O abatement technology
- 2.) Automated Monitoring System (AMS) for continuous N₂O measurement which is fully in compliance with European norm EN 14181 (for a detailed description, see Section C)
- 3.) training of local staff on installation, operation and maintenance of catalyst and monitoring equipment, etc. as well as implementation of quality check and quality assurance measures

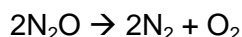
Catalyst Technology

AEL has contracted with Johnson Matthey plc who exclusively markets a secondary catalyst technology that has been developed by YARA International ASA (Norway). AEL has contracted

with Johnson Matthey plc to install the YARA 58 Y 1® catalyst system consisting of an additional base metal catalyst installed below the standard precious metal gauze pack. This technology is implemented inside the AEL-11 ammonia oxidation reactor.

W.C. Heraeus have supplied the precious metal gauze pack – i.e. the primary catalyst required for the actual production of nitric acid – to AEL for a number of years. The precious metal composition of that gauze pack remains unchanged during the crediting period of the project.

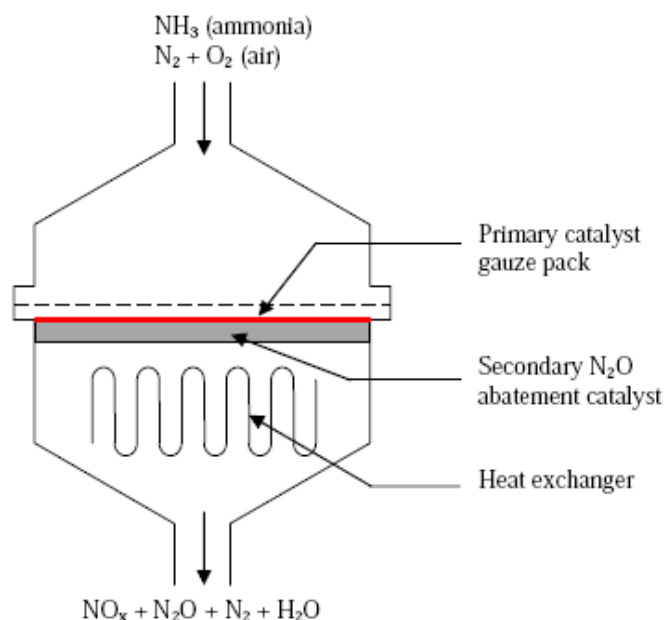
A secondary catalyst will reduce N₂O levels in the gas mix resulting from the primary ammonia oxidation reaction. A wide range of metals (e.g. Cu, Fe, Mn, Co and Ni) has shown to be of varied effectiveness in N₂O abatement catalysts. The YARA 58 Y 1® abatement catalyst is made of cylindrical pellets containing cobalt as an active ingredient. The catalyst has been tried and tested in a number of nitric acid plants in Europe. The abatement efficiency has been shown to be up to 80-90% in the following reaction:



If operated properly, the secondary catalyst system has a lifetime of several campaigns and may reduce N₂O emissions to a level satisfactorily below the baseline for about two years, before the catalyst material needs to be replaced. The YARA 58 Y 1® abatement catalyst does not contaminate the nitric acid produced in the respective nitric acid plant, neither with Cobalt nor with any of the other catalyst materials. It does not require additional heat or other energy input, because the temperature levels present inside the Ammonia Oxidation Reactor suffice to ensure its optimum abatement efficiency. There are no additional greenhouse gases or other emissions generated by the reactions at the N₂O abatement catalyst.

N₂O abatement catalyst installation

The secondary catalyst itself is easily installable during a routine plant shut-down and gauze change. The pellets are poured into the support basket / heat shield arrangement and raked level. The gauze pack is then installed above this bed using the support mechanism provided by the heat shield.



AEL's nitric acid plant No.11 operates at a pressure of around 4.5 bars inside the ammonia oxidation reactor.

Information on the implementation and actual operation of the project activity, including relevant dates

The determination of the permitted operating conditions for operating temperature, operating pressure, maximum ammonia flow rate, maximum ammonia to air ratio normal gauze supplier and normal gauze composition was undertaken by the validating DOE (as it was clarified by the CDM

EB in EB31 meeting that either validating or verifying DOE could undertake the task of determination of the permitted operating conditions). However the normal campaign length as well as the determination of the baseline emission factor was in the scope of the verifying DOE. These parameters were determined and verified within the course of the first verification. The baseline campaign was operated from 20/07/2006 until 18/02/2007.

The secondary catalyst was installed on the 12/09/2007, which is the starting date of the project activity. The project got registered by UNFCCC on the 08/02/2008, which is the starting date of the crediting period.

For a more detailed list of secondary catalyst installation, AMS installation, continued operating periods and other relevant dates for the project activity, see Section A.1, paragraph “*Relevant dates for the project activity*” above.

The events or situations that occurred during the monitoring period that may impact the applicability of the applied methodology

As to the characteristics of this specific project type certain production related events and incidents may affect the performance of the project or influence the monitoring of emission reductions in addition to possible failure of the installed monitoring equipment. The below table and lists demonstrates all relevant events and incidents related to production and/or emission monitoring which have occurred during actual operation within this specific monitoring period, as well as the measures taken for addressing any resulting problems and issues. Please note that AMS downtime is only listed below if the plant was operating at the time of the AMS downtime.

Start date and hour	End date and hour	Campaign	Short Description
18/08/2016 00:00	18/08/2016 20:00	PC17/PC18	Gauze change & maintenance work
20/09/2016 13:00	22/09/2016 04:00	PC18	Low Steam Pressure
27/09/2016 20:00	03/10/2016 18:00	PC18	Repairs to No Comp and Maintenance
19/10/2016 02:00	19/10/2016 02:00	PC18	VSG - Flowmeter downtime
19/10/2016 03:00	19/10/2016 14:00	PC18	Tripped on Power Failure
26/10/2016 22:00	27/10/2016 14:00	PC18	Powerdip
29/10/2016 10:00	30/10/2016 16:00	PC18	Flyash tripped
31/10/2016 10:00	31/10/2016 13:00	PC18	Tripped on low NH3 level
01/11/2016 16:00	01/11/2016 16:00	PC18	VSG - Flowmeter downtime
01/11/2016 17:00	02/11/2016 05:00	PC18	Power failure
20/12/2016 10:00	23/12/2016 02:00	PC18	Bleacher air
25/01/2017 01:00	26/01/2017 20:00	PC18	Plant maintenance
31/01/2017 17:00	01/02/2017 22:00	PC18	Steam problems and cooling tower faulty
15/02/2017 08:00	16/02/2017 06:00	PC18	Instrumentation air fault
16/02/2017	16/02/2017	PC18	AMS downtime

07:00	08:00		
28/02/2017 01:00	28/02/2017 21:00	PC18	Instrumentation air fault
28/02/2017 23:00	02/03/2017 22:00	PC18	Instrumentation air fault
11/03/2017 00:00	11/03/2017 13:00	PC18	Air Compressors
21/03/2017 15:00	22/03/2017 14:00	PC18	Air Compressors
02/04/2017 23:00	05/04/2017 15:00	PC18/PC19	Gauze change
11/04/2017 12:00	11/04/2017 23:00	PC19	Tripped on power dip
12/04/2017 02:00	12/04/2017 09:00	PC19	Tripped on power dip
13/04/2017 13:00	16/04/2017 23:00	PC19	Tripped on power dip
12/05/2017 11:00	13/05/2017 16:00	PC19	Plant offline
14/05/2017 11:00	21/05/2017 19:00	PC19	Maintenance
24/05/2017 13:00	25/05/2017 02:00	PC19	Air supply issue
01/06/2017 08:00	02/06/2017 03:00	PC19	Steam issues
01/07/2017 05:00	31/07/2017 23:00	PC19/PC20	Big turn around and gauze change
07/2017	07/2017	PC19/PC20	Exchange of NAP flowmeter during plant turn around
01/08/2017 06:00	01/08/2017 13:00	PC20	Problems during plant start-up
01/08/2017 16:00	01/08/2017 21:00	PC20	Problems during plant start-up
30/08/2017 17:00	31/08/2017 23:00	PC20	Shut down due to gauze issues
01/09/2017 00:00	01/09/2017 23:00	PC20	AMS downtime
12/09/2017 11:00	12/09/2017 15:00	PC20	Steam supply issues
24/09/2017 12:00	24/09/2017 12:00	PC20	AMS downtime
24/09/2017 13:00	25/09/2017 02:00	PC20	Power failure
22/10/2017 08:00	25/10/2017 09:00	PC20	Steam issues
26/10/2017 12:00	26/10/2017 16:00	PC20	Steam issues
14/11/2017 13:00	19/11/2017 13:00	PC20	Maintenance
17/12/2017 16:00	18/12/2017 20:00	PC20	Plant tripped due to vibrations
02/02/2018 09:00	02/02/2018 23:00	PC20	Wabash boiler tripped
07/02/2018 23:00		PC20	End of crediting period

According to the methodology, the highest measured value in the campaign has to be applied for any downtime period of the AMS during the project campaigns. The downtime periods of the AMS and the applied values during the project campaigns of this monitoring period are stated in section E2.

No events or incidents of any relevance in regard to impacting the applicability of the methodology occurred during this monitoring period.

B.2. Post-registration changes

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

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No temporary deviations from the registered monitoring plan or applied methodology have been applied during this monitoring period.

B.2.2. Corrections

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No corrections to project information or parameters fixed at validation have been approved during this monitoring period or submitted with this monitoring report.

Prior to this monitoring period:

A Post Registration Change has been submitted to the UNFCCC on 23/12/2016. It has been approved on 13/02/2017 with the approval number PRC1364-001. The Post Registration Change contained Corrections, which are listed together with Permanent changes under B.2.5.

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

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No changes to the start date of the crediting period have been approved during this monitoring period or submitted with this monitoring report.

B.2.4. Inclusion of monitoring plan

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The monitoring plan was already included in the registered PDD.

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

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No permanent changes from the registered monitoring plan or applied methodologies have been approved during this monitoring period or submitted with this monitoring report.

Prior to this monitoring period:

A Post Registration Change has been submitted to the UNFCCC on 23/12/2016. It has been approved on 13/02/2017 with the approval number PRC1364-001.

The following main corrections have been applied to the new PDD next to editorials:

1. Transfer to PDD template ver 7
2. Updated name of PP as per previous acceptance of UNFCCC
3. Update of PPs as per UNFCCC project webpage
4. The baseline had been selected after the validation and was thus verified during the first verification. The PDD has been updated to be consistent with the actual baseline. The following changes have been made:
 - a. Correction of the ex-ante fixed parameters in accordance with the values verified during first verification.

- b. Deletion of reference to ISO9001/14001 verifier (SABS) in B.6.2 and B.7.1.
- c. Update of Section B.6.3 with regards to the actual values verified during first verification of the determination method and calculation of baseline campaign esp. parameter EF_{BL} .
- d. Specifications with regards to monitoring frequency or calibration details

B.2.6. Changes to project design

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No changes to project design of the project activity have been approved during this monitoring period or submitted with this monitoring report.

SECTION C. Description of monitoring system

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1. General Description of the AMS

A complete Automated Monitoring System (AMS) to monitor the mass emissions of N_2O at the stack of AELs No.11 nitric acid plant was installed and has been operated since January 2006. The Manufacturer and type of the first N_2O Analyser was Environnement S.A. MIR 9000. After the measurements for the baseline campaign were completed it was replaced by an ABB AO2040 Uras 14 NDIR analyser in 2007. Because of some technical difficulties with the Environnement MIR9000 analyser on the No. 9 plant, AEL has decided to install two completely new analysers (ABB Uras 14) in both the No. 9 and the No. 11 plant in 2007.

2. Sample point

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 tail gas of the plant downstream of all process equipment.

3. Sample Conditioning System

The gas sample is continuously taken via a heated probe and filter unit and a heated sample line. Before entering the analyzer the gas is treated by a dryer unit to avoid possible moisture effects.

4. Analyser

NCSG measurements: Environnement S.A. MIR 9000 (during baseline Campaign), ABB AO2040 Uras 14 during project campaigns.

5. Flow Meter

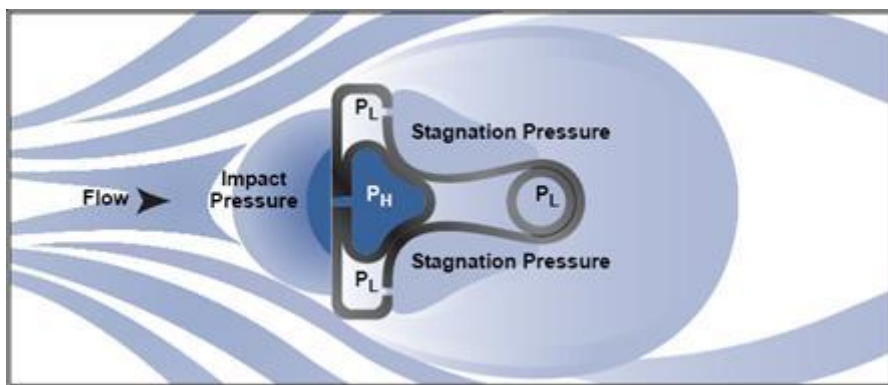
The Emerson Rosemount Flow Meter Annubar®, model no. 485, relies on the Averaging Pilot Tubes (APTs).

The Rosemount Annubar® 485 is a device used to measure the flow-velocity of a liquid, gas or steam fluid that passes through a pipe. It measures by creating a differential pressure (DP) that is proportional to the square of the velocity of the fluid in the pipe, in accordance with Bernoulli's theorem. This DP is measured and converted into a flow rate using a secondary device, such as a DP pressure transmitter.

The Annubar generates a DP by partially blocking the flow. The velocity of the fluid is decreased and stalled as it reaches the upstream surface of the Annubar sensor, thus creating the Impact Pressure. The Rosemount 485 Annubar® senses the impact pressure by utilizing a frontal slot design, which opens into the high pressure chamber.

This high pressure chamber connects directly into the DP transmitter for measurement.

As the fluid continues around the Annubar sensor, it creates a lower velocity profile on the back of the sensor, creating the low/suction pressure downstream. Individual ports, located on the backside of the Annubar sensor measure this low pressure. Working on the same principle as with high pressure, an average low pressure value is obtained in the low pressure chamber that connects directly into the transmitter for measurement. The resulting differential pressure is the difference between the impact (high) pressure reading and the suction (low) pressure reading as seen below.



6. Nitric acid production measurement

NAP is continuously measured and determined by a Coriolis mass flow meter. The product density and temperature as measured by the mass flow meter are used to calculate the concentration of the nitric acid produced. This value is then used to convert the total mass flow to 100% nitric acid produced. The correct measurement of acid concentration is checked by manual tests.

7. Monitoring plan and responsibilities

The emission reductions achieved by the project activity are monitored based on the approved monitoring methodology AM0034 (Version 2) as prepared by N.serve Environmental Services GmbH. It is the appropriate monitoring methodology to be used in conjunction with the baseline methodology AM0034, "Catalytic reduction of N₂O inside the ammonia burner of nitric acid plants". Its applicability depends on the same prerequisites as the mentioned baseline methodology.

AM0034 requires the use of the European Standard EN14181 (2004) "Stationary source emissions - Quality assurance of automated measuring systems" as a guidance for installing and operating the Automated Monitoring System (AMS) in the nitric acid plants for the monitoring of N₂O emissions.

As an operator of the nitric acid plants since 1932 and of the No. 11 nitric acid plant since 1979, AEL staff in general and its Instrument Department in particular is accustomed to operating technical equipment to a high level of quality standards.

The Production Manager (PM) has the overall responsibility for the ongoing operation of the project.

The Technical Manager (TM) has the overall responsibility for the CDM data.

The Engineering Team Manager Electrical/Instrument (ETM E/I) is responsible for the day-to-day calibration procedure and any adjustments required to the instruments as a result of the calibrations.

The Process Controller (PC) checks the analyser regularly to see if there are any abnormal occurrences. These checks are done using a plausibility checklist, which is filled in and filed, in the control room. If there are any problems the ETM E/I is notified so that the problem can be rectified.

Operation, maintenance, calibration and service intervals are being carried out by staff from the instrumentation department according to the vendor's specifications.

All monitoring procedures at AEL are also conducted and recorded in accordance with the well established procedures under ISO 9001/14001 which is regularly audited by an independent auditing firm accredited for ISO 9001/14001 certification.

AEL derives hourly averages for all of the monitored parameters and delivers these data to N.serve. Nikolaus Gutknecht-Stöhr, the Project Manager for this project at N.serve, is responsible for the correct analysis of the delivered data in accordance with the methodology.

8. Application of EN 14181 procedures to the project

In the following, it is described how the procedures given in EN 14181 for QAL1, 2 have been practically applied at AEL No. 11 plant. QAL 3 procedures are described in section 9 below.

QAL 1

In accordance with EN 14181 an AMS shall have been proven suitable for its measuring task (composition of the flue gas) by use of the QAL1 procedure as specified by EN ISO 14956. Using this standard, it shall be proven that the total uncertainty of the results obtained from the AMS meets the specification for uncertainty stated in the applicable regulations. Such suitability testing has to be carried out under specific conditions by an independent third party on a specific testing site. A test institute shall perform all relevant tests on two identical AMS. These two AMS have to be tested in the laboratory and field.

At the time of purchasing of the AMS by AEL, no AMS vendors had yet conducted the QAL 1 suitability testing for N₂O and it was not known if any vendors were in the process of obtaining this. The chosen gas analyser MIR9000 from Environnement however, has passed the QAL1 suitability for measurements of NO_x and other gaseous emissions. In addition QAL1 tests for N₂O were successfully performed in 2007 by an independent 3rd party testing laboratory with EN ISO/IEC 17025 accreditation. The Environnement S.A. MIR9000 analyser was used during the baseline campaign. Before start of the first project campaign it was replaced by an ABB AO2040 Uras 14 NDIR analyser.

According to ABB's own certificate, this analyser has an accuracy of better than 1% of range. This analyser has been certified¹ as meeting the requirements (QAL1) of the German emissions standards 17th BImSchV and 13th BImSchV (waste incineration plants, large furnaces and others) for the components NO, CO and SO₂. At the time of commissioning of the AMS by AEL no AMS was available that had been certified according with EN 14181 QAL1 for N₂O measurements. However, ABB has conducted and successfully completed the QAL1 tests² for the follow-up model of this analyser module within the same analyser series (ABB AO2040 Uras 26). Since there are no major technical differences between the two analyser models it can be assumed that the Analyser installed at the AEL No. 11 nitric acid plant meets the requirements of the QAL1 test in the same way as the follow-up model.

QAL2 and Standard Reference Measurements (SRM)

QAL2 is a procedure for the determination of the calibration function and its variability, and a test of the variability of the measured values of the AMS compared with the uncertainty given by legislation. 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). QAL 2 tests are to be performed at least every 5 years according to EN 14181 but also after major changes to the plant or changes or repairs to the AMS, which will influence the results obtained significantly.

A calibration function is 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 against the required uncertainty. According to EN14181, both the QAL 2 procedures and the SRM need to be conducted by an independent "testing house" or laboratory which has to be accredited to EN ISO/IEC 17025.

An annual surveillance test (AST) is performed between QAL2 tests to demonstrate that the AMS functions correctly, its performance remains valid and that the calibration function and variability derived during the QAL2 remains as previously determined.

9. AMS calibration and QA/QC procedures

AEL is certified according to ISO 9001 and 14001 standards for quality and environmental management respectively. The procedures for monitoring, regular calibrations and QA/QC are fully embedded into the procedures required by ISO 9001/14001 and documented in the applicable ISO

¹ TÜV Süddeutschland Bau und Betrieb GmbH (Report number 170 608), March 2003

² TÜV Süd Industrie Service GmbH, München (Report number 821029) June 2006

handbooks. The procedures are regularly audited by an independent auditing firm accredited for ISO 9001/14001 certification.

QAL 3

QAL3 is a procedure which is used to check drift and precision in order to demonstrate that the AMS is in control during its operation so that it continues to function within the required specifications for uncertainty.

This is achieved by conducting periodic zero and span checks on the AMS and then evaluating the results obtained using control charts. Zero and span adjustments or maintenance of the AMS, may be necessary depending on the results of this evaluation.

Analyser Zero and Span Calibrations

The N₂O analyzer is calibrated once per year by external QAL2 or AST according to EN 14181. In addition according to the QAL1 reports and manufacturers specifications it is recommended to perform a zero/span calibration once every three weeks for the ABB URAS 14 analyzer, however AEL decided to do it twice per week in order to have a closer control over the instrument. For the zero calibration pure nitrogen is used, for the span calibration a certified calibration gas is used. The results of the calibrations are recorded according to the related CDM procedure.

Calibration Gas

A certified N₂O Calibration gas (balance being N₂) with a precision of $\pm 2\%$ is used in the span calibrations. The calibration gas is certified by the supplier's laboratory.

Flow meter calibration procedures

The flow meter is calibrated once per year by external QAL2 or AST according to EN 14181. In addition the flow meter is calibrated at least once per year (the plant has to be shut down to conduct calibration) by the Instrument Department of AEL. The pressure transmitter is disconnected from the Annubar and the transmitter is then connected to an absolute pressure simulator that has been approved by an independent auditing firm.

If the deviation exceeds 1% of range, then the pressure transmitter is recalibrated and the previous procedure repeated.

The Annubar itself does not need to be calibrated since it is a physical device which will not have drift. Therefore, it is sufficient to regularly inspect the physical condition of the Annubar. Therefore, the Annubar is taken out of the stack once per year for physical inspection.

The results of these calibration procedures are then recorded in the Calibration Procedure log sheet.

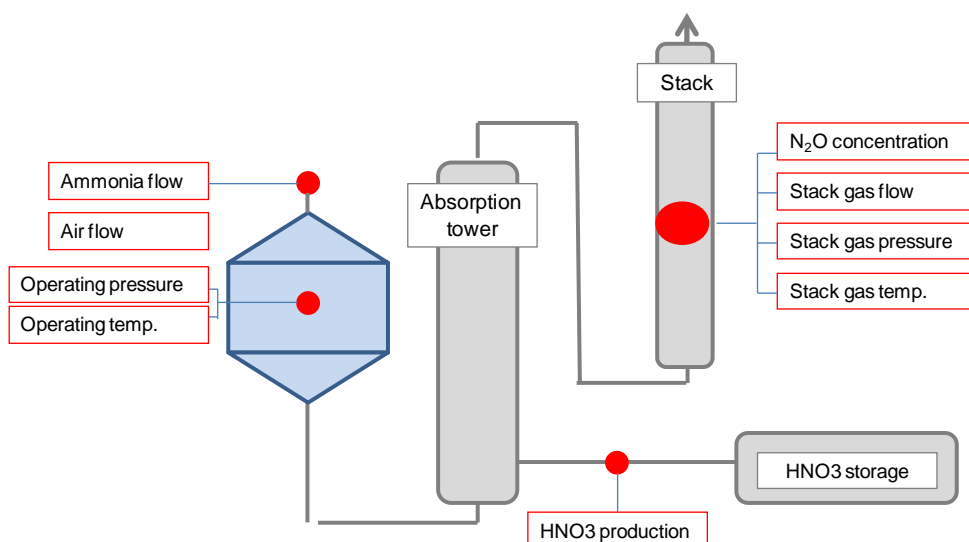


Figure: Monitoring Points for all relevant Parameters (NCSG, VSG, TSG, PSG, NAP, OTh, OPh, AFR, AIFR)

Training

Operations staff at the nitric acid plant who are responsible for the operation of the AMS and regular calibrations, visual and physical checks have been trained appropriately by the AMS vendors and AELs' own instrumentation engineers.

9.1. Data Acquisition System and Emergency Procedures

The analogue signal (4 to 20 mA) output from the Analyser and Flow meter are converted by the Programmable Logic Controller (PLC) into a digital signal which is then fed into the SCADA data acquisition and database system.

Each of AEL's two nitric acid plants has its own SCADA system on a dedicated PC near the respective plant itself. However, the two SCADA PCs are directly connected to each other and each of the PCs receives all of the measured data from the AMS and stores them. That way there is a constant redundancy of data acquisition and storage. In addition, the instrumentation engineer transfers the data at least once a week into AEL's main IT system as well as making a complete copy of that week's data (2-second, hourly and daily averages) onto an external disc drive. That way there are already four copies of the original and unchanged data stored in four different locations. In addition, the hourly data is sent to N.serve on a regular basis (e. g. after each campaign) where it is also stored.

The SCADA system automatically produces comma separated files stored in Microsoft Excel of the 2-second values and it also automatically produces hourly and daily average values for each of the measured parameters. The hourly averages are the basis of the analysis of the data for the purpose of the calculation of the emissions factors for the baseline and for the project campaigns. These are then extracted and converted into excel files which can then be imported into the N.serve Database Management System (N.DBMS).

N.serve Database Management System (N.DBMS)

All data necessary for the monitoring and verification procedures related to the project activity are transferred from the nitric acid plant's data acquisition system into N.serve's dedicated relational database management system ("N.DBMS") based on Microsoft Access 2002. Database management systems are designed for a structured storage of large amounts of data providing for minimum redundancy and maximum flexibility to allow best practice data analysis.

The N.DBMS is designed to conduct all the calculation steps required by the methodology in order to derive the baseline and project emissions factors and to calculate the amount of emission reductions resulting from the project activity.

The use of the N.DBMS system is described in the PDD and therefore part of the validated monitoring plan. However for the purpose transparency and easy cross checks all calculations are provided in an EXCEL calculation sheet.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

(Copy this table for each data or parameter.)

Data / Parameter:	B.1 NCSG_{BC}³
Unit	mg/Nm³
Description	N ₂ O concentration in the stack gas during the baseline campaign.
Source of data	NDIR N ₂ O gas analyser (Environnement S.A. MIR 9000)
Value(s) applied	Value applicable for regular project campaigns exceeding CL _{normal} or CL _{BL} : 1,630.03 Value applicable for Project Campaign 18: 1,630.03 Value applicable for Project Campaign 19: 1,505.73 Value applicable for Project Campaign 20: 1,624.23
Choice of data or measurement methods and procedures	AM0034 requires the determination of the concentration of N ₂ O in the stack gas. NCSG is continuously monitored with an NDIR gas analyser and monitoring results are taken and recorded for every two seconds of plant operation. Hourly means for NCSG are derived by the SCADA data acquisition system. NCSG data taken during times when the plant was operating outside the permitted operating range were eliminated. The remaining hourly average values were subjected to the following calculation steps: a) Calculate the sample mean (x) b) Calculate the sample standard deviation (s) c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation) d) Eliminate all data that lie outside the 95% confidence interval e) Calculate the new sample mean from the remaining NCSG values The value is converted from ppmv (the mean being 828.87 ppmv) as permitted by AM0034.

³ Please note that all baseline data and historic campaign data sets have been determined after the registration as a different baseline had been selected. Please refer to section E.1. below for further detail.

Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	<p>A complete QAL2 audit in accordance with EN 14181 was conducted on the AMS in February 2008. During the QAL2 reference measurements it was determined that the analyser consistently underestimates the N₂O concentration in the stack. As a result from the QAL2 calibration curve, it was determined that a correction factor of 1.104 has to be applied to all NCSG measurements. Therefore, the mean NCSG value will be multiplied by 1.104 before going into the calculation of BE_{BC}.</p> <p><i>Calibration information</i> <i>During Baseline period 20/07/2006 – 18/02/2007:</i> Bi-weekly Zero and span check and calibration in case of deviation >1% of range of analyzer against zero gas and certified calibration gas cylinder (internal calibration by AEL) Documentation in form of calibration reports and shewart charts. First check for baseline period: 18/07/2006 During the baseline period: check performed twice per week Last check for baseline period: 17/02/2007 Next check after baseline period: 20/02/2007</p> <p><i>Date of last external calibration:</i> QAL2 Test – 01/08/2007 - 04/08/2007 valid until August 2012 The calibration error as determined during the QAL2 test was retroactively applied to the NCSG results for the baseline period in order to correct the underestimation. Moreover the overall uncertainty of the AMS was applied in a conservative manner to the results of baseline emissions.</p>

Data / Parameter:	B.2 VSG_{BC}
Unit	Nm³/h
Description	Normal gas volume flow rate of the stack gas during the baseline campaign.
Source of data	Gas Volume Flow meter, Emerson Rosemount Annubar® Model 485
Value(s) applied	72,468

Choice of data or measurement methods and procedures	<p>AM0034 requires the determination of the gas volume flow (VSG) in the stack. VSG is continuously monitored with a flow meter and monitoring results are taken and recorded for every two seconds of plant operation. Hourly means for VSG are derived by the SCADA data acquisition system. VSG data taken during times when the plant was operating outside the permitted operating range were eliminated.</p> <p>The flow meter is ranged to a maximum flow of 150,000 m³/h (corresponding to normal m³ at a stack temperature of 113°C and stack pressure of 85.6 kPa (absolute) or 856 mbar) and a maximum differential pressure of 1.898 kPa (gauge). The flow meter was not re-ranged during the baseline campaign in order to avoid a confusion of the baseline date. Therefore, the measured VSG data have to be multiplied with a standard factor of 0.9594 in order to give the normal flow for the above assumed conditions.</p> <p>This factor will be readjusted in the QAL2-testing process that the AMS installed at the No. 11 plant will be subject to. This test will be conducted – in accordance with the requirements of AM0034 – for N₂O concentration and stack gas volume as specified by EN 14181.</p> <p>For the project campaigns, the flow meter will be readjusted to the appropriate range so that this factoring of the measured value is no longer necessary.</p> <p>Also, the corrected measured data need to be compensated for the actual prevailing temperature and pressure in the stack through the following calculation:</p> $\frac{P_s * V_s}{T_s} = \frac{P_a * V_a}{T_a}$ <p>Where: P refers to the Pressure (mbar) [conversion from kPa to mbar is a factor of 10] V the volumetric flow rate (m³/hr) T the temperature in Kelvin (Note 1 K = T (°C) + 273). Subscript “s” refers to the actual stack values Subscript “a” refers to the assumed stack conditions.</p> <p>This simplifies to:</p> $V_s = V_a * \frac{P_a}{T_a} * \frac{T_s}{P_s}$ <p>As an example</p> <p>The assumed stack temperature and pressure values are 113°C and 846 mbar. The measured values are: 115.16 °C and 842.59 mbar. Using a flow from the acquisition system of 73,165.32 and the conversion of 0.9594 gives a final flow of 70,873.28 Nm³/hr.</p> $73165.32 * 0.9594 * \frac{846 * (115.16 + 273)}{(273 + 113) * 842.59} = 70873.28$ <p>The resulting hourly average VSG values are now expressed in Nm³/h as required by AM0034 and where subsequently subjected to the following calculation steps:</p> <ol style="list-style-type: none"> Calculate the sample mean (x) Calculate the sample standard deviation (s) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation) Eliminate all data that lie outside the 95% confidence interval Calculate the new sample mean from the remaining VSG values
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Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	<p>The QAL2 test, performed by an independent 3rd party laboratory with EN ISO/IEC 17025 accreditation, include the test of the correct measurement of stack gas temperature and stack gas pressure by comparison of the AMS results of these parameters with the results of the reference measurement instruments of the testing laboratory. Moreover during the QAL2 test the correct normalization of the stack gas flow (VSG) to standard conditions is verified by comparison of the AMS results for normalized flow with the reference measurement results for normalized flow.</p> <p>During the QAL2 reference measurements it was determined that the flow meter consistently underestimates the total gas volume flow in the stack. As a result from the QAL2 calibration curve, it was determined that a correction factor of 1.01 will have to be applied to all VSG measurements. Therefore, the result of the above statistical analysis, i.e. the mean VSG value will be multiplied by 1.01 before going into the calculation of BE_{BC}.</p> <p><i>Calibration information</i> During Baseline period 20/07/2006 – 18/02/2007: Internal calibrations: after each campaign Date of internal calibration :19/07/2006 Date of internal calibration :23/02/2007 Date of last external calibration: QAL2 Test – 01/08/2007 - 04/08/2007 valid until August 2012 The calibration error as determined during the QAL2 test was retroactively applied to the NCSG results for the baseline period in a conservative manner. Moreover the overall uncertainty of the AMS was applied in a conservative manner to the results of baseline emissions.</p>

Data / Parameter:	B.3 BE_{BC}
Unit	tN₂O
Description	Total N ₂ O mass flow during baseline campaign
Source of data	Calculation from measured data.
Value(s) applied	Value applicable for regular project campaigns exceeding CL_{normal} or CL_{BL} : 651.983 Value applicable for Project Campaign 18: 651.983 Value applicable for Project Campaign 19: 602.267 Value applicable for Project Campaign 20: 649.666
Choice of data or measurement methods and procedures	The total mass N ₂ O emissions during the baseline campaign are determined as a product of NCSG, VSG and the total hours of operation during that baseline campaign: $BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC}$
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None

Data / Parameter:	B.4 OH_{BC}
Unit	Hours
Description	Operating hours
Source of data	Production log and Process Control System.
Value(s) applied	4,950

Choice of data or measurement methods and procedures	Required by AM0034 to determine the total mass emissions of N ₂ O during the baseline. Since the design plant operating temperature is between 820°C and 905°C, by definition the plant is offline if the temperature recorded is at or below 800°C. For practical purposes, each hour for which the ammonia oxidation temperature (OT _h) was recorded to be below 830°C is excluded from the determination of OH _{BC} .
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None

Data / Parameter:	B.5 NAP_{BC}
Unit	tHNO ₃
Description	Metric tonnes of 100% concentrated nitric acid produced during the baseline campaign.
Source of data	Nitric acid flow meter Manufacturer: EMERSON, Type: Coriolis mass flow meter CMF 300 Laboratory results for verification purposes
Value(s) applied	134,700
Choice of data or measurement methods and procedures	Required by AM0034 to calculate the average baseline emissions factor (EF _{BL}) per tonne of 100% concentrated nitric acid produced during that baseline campaign. NAP is determined by a mass balance calculation according to the following procedures: NAP is determined by a mass flow meter according to the following procedures: The density and temperature as measured by the mass flow meter is used to calculate the concentration of the nitric acid produced. This value is then used to convert the total mass flow to 100% nitric acid produced. The correct measurement of acid concentration is checked by manual tests.
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	The nitric acid flow meter is subject of external calibration procedures every 3 years. Calibration information During Baseline period 20/07/2006 – 18/02/2007: External calibration by: ALPRET Controls Specialists Date 25/04/2006 and 06/09/2007; although the calibration is valid for 3 years, it is done more frequently

Data / Parameter:	B.6 TSG
Unit	°C
Description	Temperature in the stack gas
Source of data	Stack temperature probe situated directly next to the volume flow meter;
Value(s) applied	Not applicable
Choice of data or measurement methods and procedures	AM0034 requires the determination of gas volume flow at normal conditions in the stack. In order to calculate from the measured VSG values to VSG at normal conditions, the actual temperature in the stack is measured by temperature probes inserted directly next to the flow meter inside the stack. The resulting measurements are applied to each hourly mean VSG value for calculation of normal volume flow.

Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	<p>The TSG result is automatically applied for calculating VSG at standard conditions</p> <p>Calibration information</p> <p>Calibration information</p> <p>During Baseline period 20/07/2006 – 18/02/2007</p> <p>Internal calibrations: after each campaign</p> <p>Date of internal calibration :19/07/2006</p> <p>Date of internal calibration :23/02/2007</p> <p>Date of last external calibration:</p> <p>QAL2 Test – 01/08/2007 - 04/08/2007 valid until August 2012</p>

Data / Parameter:	B.7 PSG
Unit	Pa (absolute)
Description	Pressure in the stack
Source of data	Stack pressure probe situated directly next to flow meter
Value(s) applied	Not applicable
Choice of data or measurement methods and procedures	AM0034 requires the determination of gas volume flow at normal conditions in the stack. In order to calculate from the measured VSG values to VSG at normal conditions, the actual pressure in the stack has to be determined and applied to each hourly mean VSG value.
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	<p>The PSG result is automatically applied for calculating VSG at standard conditions</p> <p>Calibration information</p> <p>Calibration information</p> <p>During Baseline period 20/07/2006 – 18/02/2007</p> <p>Internal calibrations: after each campaign</p> <p>Date of internal calibration :19/07/2006</p> <p>Date of internal calibration :23/02/2007</p> <p>Date of last external calibration:</p> <p>QAL2 Test – 01/08/2007 - 04/08/2007 valid until August 2012</p>

Data / Parameter:	B.8 EF_{BL}
Unit	tN ₂ O / tHNO ₃
Description	Emissions factor for baseline period
Source of data	Calculated from measured data (tons of N ₂ O emitted / tons of nitric acid produced)
Value(s) applied	<p>Value applicable for regular project campaigns exceeding CL_{normal} or CL_{BL}: 0.004647</p> <p>Value applicable for Project Campaign 18: 0.004647</p> <p>Value applicable for Project Campaign 19: 0.004293</p> <p>Value applicable for Project Campaign 20: 0.004631</p>

Choice of data or measurement methods and procedures	As required by AM0034 the plant specific baseline emissions factor representing the average N ₂ O emissions per tonne of nitric acid during the baseline campaign is derived by dividing the total mass of N ₂ O emissions by the total output of 100% concentrated nitric acid during the baseline campaign. The overall uncertainty of the monitoring system shall also be determined and the measurement error will be expressed as a percentage (<i>UNC</i>). The N ₂ O emission factor per tonne of nitric acid produced in the baseline period (EF_{BL}) shall then be reduced by the percentage uncertainty as follows: $EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100) (tN_2O/tHNO_3)$
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None

Data / Parameter:	B.9 UNC
Unit	%
Description	Calculated overall uncertainty of the Automated Monitoring System (AMS)
Source of data	UNC is determined by conducting reference measurements by an independent testing laboratory with EN ISO/IEC 17025 accreditation (QAL2).
Value(s) applied	3.99
Choice of data or measurement methods and procedures	In accordance with AM0034 the overall measurement uncertainty of the AMS is applied in the calculation of the baseline emissions factor (EF_{BL}). The overall total uncertainty of the AMS has been determined by an accredited ISO 17025 testing house during the on-site QAL2 audit.
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None

Data / Parameter:	B.10 AFR
Unit	tNH₃/h (converted from originally measured Nm³/h)
Description	Mean Ammonia gas flow rate to the ammonia oxidation reactor
Source of data	Differential pressure measurement (orifice plate) Type: D/P
Value(s) applied	Not applicable, monitored data of AFR will be used to determine if plant was operating outside of AFR_{max} .
Choice of data or measurement methods and procedures	The monitoring of AFR is required by AM0034 in order to determine AFR_{max} .
Purpose of data/parameters	
Additional comments	Calculation of baseline emissions or baseline net GHG removals by sinks
Unit	Calibration information During Baseline period 20/07/2006 – 18/02/2007 Calibration frequency: Once every six months. (only during plant shutdown between campaigns) Date of last calibrations: 31/05/2006, 01/11/2006: 19/02/2007

Data / Parameter:	B.11 AFR_{max}
Unit	tNH₃/h (converted from originally measured Nm³/h)

Description	Maximum Ammonia gas flow rate to the ammonia oxidation reactor																																			
Source of data	AFR data																																			
Value(s) applied	9.094																																			
Choice of data or measurement methods and procedures	<p>AFR_{max} is used to determine those periods where the plant may be operating outside of the permitted operating conditions.</p> <p>Historic data of daily NH₃ consumption was used to obtain determine the range of AFR for the five historic campaigns.</p> <p>Table: Maximum NH₃ gas flow to the AOR</p> <table><tr><th>Campaign No.</th><th>Start Date</th><th>End date</th><th>Total NH₃ consumed</th><th>Maximum NH₃ consumed per day</th></tr><tr><td></td><td></td><td></td><td>tonnes</td><td>tonnes</td></tr><tr><td>C10</td><td>29/05/03</td><td>24/11/03</td><td>34,914</td><td>219</td></tr><tr><td>C12</td><td>27/05/04</td><td>12/12/04</td><td>38,492</td><td>211</td></tr><tr><td>C13</td><td>15/12/04</td><td>24/07/05</td><td>43,187</td><td>206</td></tr><tr><td>C14</td><td>27/07/05</td><td>28/01/06</td><td>34,623</td><td>206</td></tr><tr><td>C15</td><td>03/02/06</td><td>31/07/06</td><td>28,824</td><td>198</td></tr></table> <p>After removing the top 2.5 percentile values the maximum daily flow rate was 218 tNH₃. This corresponds to an hourly maximum flow rate of 9.094 kgNH₃/h.</p>	Campaign No.	Start Date	End date	Total NH ₃ consumed	Maximum NH ₃ consumed per day				tonnes	tonnes	C10	29/05/03	24/11/03	34,914	219	C12	27/05/04	12/12/04	38,492	211	C13	15/12/04	24/07/05	43,187	206	C14	27/07/05	28/01/06	34,623	206	C15	03/02/06	31/07/06	28,824	198
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C14	27/07/05	28/01/06	34,623	206																																
C15	03/02/06	31/07/06	28,824	198																																
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks																																			
Additional comments	None																																			

Data / Parameter:	B.12 AIFR
Unit	% v/v
Description	Ammonia to air ratio into the ammonia oxidation reactor
Source of data	Measurements of AFR and primary air flow rates (measured by differential pressure measurement).
Value(s) applied	8.3 – 11.5 (AIFR will be used to determine AIFR_{max})
Choice of data or measurement methods and procedures	The monitoring of AIFR is required by AM0034 in order to determine AIFR _{max} . The allowable NH ₃ to Air ratio is taken from the controller data sheet (No. 11 Technical Manual, TM4, p250, June 1977). The range is 8.3 % v/v - 11.5 % v/v.
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	<p>Calibration information</p> <p>During Baseline period 20/07/2006 – 18/02/2007</p> <p>Calibration frequency: Once every six months.</p> <p>(only during plant shutdown between campaigns)</p> <p>Date of last calibrations: 31/05/2006, 01/11/2006: 19/02/2007</p>

Data / Parameter:	B.13 CL_{BL}
Unit	tHNO ₃
Description	Length of the baseline campaign measured in metric tonnes of 100% concentrated nitric acid produced during that baseline campaign.
Source of data	NAP _{BC}

Value(s) applied	134,700
Choice of data or measurement methods and procedures	<p>In accordance with AM0034 the baseline campaign length (CL_{BL}) has to be compared to the established average historic campaign length (CL_{normal}) measured in $tHNO_3$ which has been recorded for No. 11 in the past; and</p> <p>If $CL_{BL} \leq CL_{normal}$, then all N_2O values measured during the baseline campaign can be used for the calculation of EF_{BL} (subject to the elimination of data that was monitored during times where the plant was operating outside of the “permitted range”).</p> <p>If $CL_{BL} > CL_{normal}$, then N_2O values that were measured beyond the length of CL_{normal} during the production of the quantity of nitric acid (i.e. the final tonnes produced) are to be eliminated from the calculation of EF_{BL}.</p> <p>CL_{normal} for AEL No. 11 is: 127,302.4 tonnes of HNO_3</p> <p>CL_{BL} for AEL No. 11 is: 134.700 tonnes of HNO_3</p> <p>Therefore $CL_{BL} > CL_{normal}$ and all NCSG datasets were excluded from that operating hour onwards when the nitric acid production during the baseline campaign exceeded the CL_{normal} value.</p>
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None

Data / Parameter:	B.14 CL _{normal}																																
Unit	tHNO ₃																																
Description	Average length of the historic campaigns measured in metric tonnes of 100% concentrated nitric acid produced during the historic campaigns.																																
Source of data	Flow meter measurements as described in NAP.																																
Value(s) applied	127,302.4																																
Choice of data or measurement methods and procedures	<p>In accordance with AM0034 the average historic campaign length (CL_{normal}) is defined as the average campaign length for the historic campaigns that were used to define operating condition. CL_{normal} presents the cap on the length of the baseline campaign from which the baseline emissions factor will be derived.</p> <p>During the five historic campaigns, the following amounts of metric tonnes of 100% concentrated nitric acid have been produced:</p> <table><thead><tr><th>Campaign No</th><th>Start Date</th><th>End Date</th><th>Total HNO₃ produced</th></tr></thead><tbody><tr><td></td><td></td><td></td><td>tons</td></tr><tr><td>C10</td><td>29/05/2003</td><td>24/11/2003</td><td>125,098.7</td></tr><tr><td>C12</td><td>27/05/2004</td><td>12/12/2004</td><td>136,602.6</td></tr><tr><td>C13</td><td>15/12/2004</td><td>24/07/2005</td><td>146.720,2</td></tr><tr><td>C14</td><td>27/07/2005</td><td>28/01/2006</td><td>124,252.6</td></tr><tr><td>C15</td><td>03/02/2006</td><td>31/07/2006</td><td>103,837.7</td></tr><tr><td>Average</td><td></td><td></td><td>127,302.4</td></tr></tbody></table> <p>Therefore, the average historic campaign length (CL_{normal}) is 127,302.4 tonnes of 100% concentrated nitric acid.</p>	Campaign No	Start Date	End Date	Total HNO ₃ produced				tons	C10	29/05/2003	24/11/2003	125,098.7	C12	27/05/2004	12/12/2004	136,602.6	C13	15/12/2004	24/07/2005	146.720,2	C14	27/07/2005	28/01/2006	124,252.6	C15	03/02/2006	31/07/2006	103,837.7	Average			127,302.4
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Average			127,302.4																														
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks																																
Additional comments	None																																

Data / Parameter:	B. 15 AIFR_{max}
Unit	% v/v
Description	Maximum Ammonia to air ratio into the ammonia oxidation reactor.
Source of data	AIFR Data
Value(s) applied	11.5
Choice of data or measurement methods and procedures	<p>In accordance with AM0034 AIFR_{max} is used to determine those periods where the plant may be operating outside of the permitted operating conditions.</p> <p>The upper limits for ammonia flow and ammonia to air ratio shall be determined using one of the following three options, in preferential order:</p> <ul style="list-style-type: none"> a) Historical maximum operating data for hourly ammonia gas and ammonia to air ratio for the previous five campaigns (or fewer, if the plant has not been operating for five campaigns; excluding abnormal campaigns; or, b) If no data is available, calculation of the maximum permitted ammonia gas flow rates and ammonia to air ratio as specified by the ammonia oxidation catalyst manufacturer or for typical catalyst loadings; or c) If information for (b) above is not available, based on a relevant technical literature source. <p>Since no historical data were recorded and available, the allowable NH₃ to Air ratio is taken from the controller data sheet (No 11 Technical Manual, TM4, p250, June 1977). The range is 8.3% v/v - 11.5% v/v, therefore the maximum ammonia to air ratio is 11.5% v/v.</p>
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None

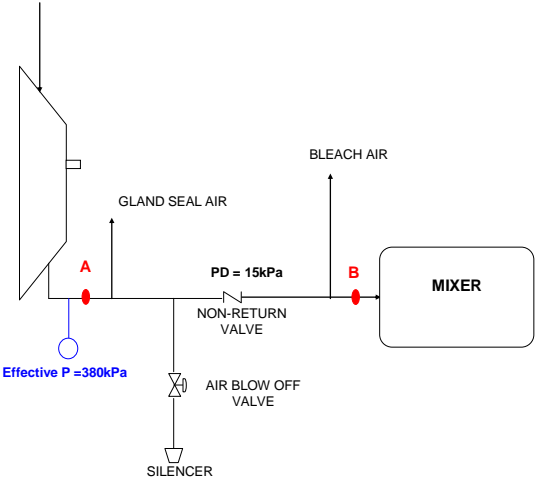
Data / Parameter:	B.16 OT_h
Unit	°C
Description	Oxidation temperature for each hour during the baseline campaign
Source of data	Monitoring results of a thermocouple inside the ammonia oxidation reactor.
Value(s) applied	Not applicable
Choice of data or measurement methods and procedures	<p>In accordance with AM0034 the oxidation temperature in the ammonia oxidation reactor (OT_h) has to be monitored and compared to the Normal range for oxidation temperature (OT_{normal}).</p> <p>VSG and NCSG data obtained during times when OT_h was above or below OT_{normal} has to be eliminated from the calculation of EF_{BL}.</p>
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	<p>Calibration information</p> <p>During Baseline period 20/07/2006 – 18/02/2007</p> <p>Calibration frequency: Once every six months, validity 8 month (only during plant shutdown between campaigns)</p> <p>Date of last calibrations: 17/08/2006, 14/03/2007</p>

Data / Parameter:	B.17 OT_{normal}
Unit	°C (min and max)

Description	Normal range operating temperature
Source of data	Design specifications and operating manual of the No. 11 nitric acid plant (Technical Manual (TM4 June 1977, p. 250) ⁴ .
Value(s) applied	820 to 905
Choice of data or measurement methods and procedures	<p>AM0034 requires the establishment of the normal range of operating temperatures in the ammonia oxidation reactor. Since no historical data for the No. 11 plant are available, the range of operating temperature of between 820°C and 905°C, as stipulated in the operating manual was applied to derive OT_{normal}.</p> <p>The measuring range of the thermocouples determining the oxidation temperatures is set accordingly, i.e. when the plant is offline, the temperature reading will continue to show 800°C.</p> <p>For practical purposes, all VSG and NCSG values taken during times when the plant was operating at below 820°C will be excluded.</p>
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None

Data / Parameter:	B.18 OP_n
Unit	kPa (gauge)
Description	Oxidation Pressure for each hour during the baseline campaign
Source of data	Monitoring results of a pressure transmitter on the ammonia oxidation reactor (ammonia to air mixer).
Value(s) applied	Not applicable.

⁴ Copies of the technical plant manuals can be provided to the DOE upon request.

Choice of data or measurement methods and procedures	<p>In accordance with AM0034 the oxidation pressure in the ammonia oxidation reactor (OP_h) has to be monitored and compared to the Normal range for oxidation temperature (OP_{normal}). VSG and NCSG data obtained during times when OP_h was above or below OP_{normal} has to be eliminated from the calculation of EF_{BL}.</p> <p>AM0034 prescribes the monitoring and recording of the Oxidation Pressure for each hour (OP_h) during the baseline campaign. This would imply the measurement of pressure inside the Ammonia Oxidation Reactor. AEL has no such measurement equipment installed at that point; instead the available measurements for air pressure before the ammonia-air-mixer are used to determine OP_h.</p> <p>The pressure for the oxidation reactor is taken as the pressure at point B (air to mixer pressure). The permitted range for the oxidation pressure is inferred from the values given for point A (HP compressor discharge pressure range).</p> <p>Figure: Pressure points for No. 11</p>  <p>During the baseline campaign (as well as for project campaigns) OP is monitored as air pressure to the ammonia to air mixer. Unlike during historic campaigns, these data will be archived and analysed as required by AM0034.</p>
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	<p>Calibration information</p> <p>During Baseline period 20/07/2006 – 18/02/2007</p> <p>Calibration frequency: Once every six months. (only during plant shutdown between campaigns)</p> <p>Date of last calibrations: 31/05/2006, 01/11/2006: 19/02/2007</p>

Data / Parameter:	B.19 OP_{normal}
Unit	kPa (gauge) min and max
Description	Normal range of operating pressure in the ammonia oxidation reactor
Source of data	Design specifications and operating manual of the No. 11 nitric acid plant (Drawing No. D31 113-4, Sheet 2, December 1977; Operating Instructions No. M69.0300.2008, 1978; No 11 Plant Understanding, p. 10).
Value(s) applied	365 – 450

Choice of data or measurement methods and procedures	<p>AM0034 requires the establishment of the normal range of operating pressure in the ammonia oxidation reactor. Since no historical data for the No. 11 plant are available, the range of temperature stipulated in the operating manual was applied to derive OP_{normal}.</p> <p>The upper limit is 450 kPa. The lower limit is inferred from the effective discharge set point pressure, 380 kPa (Operating Instructions No. M69.0300.2008, 1978) and the pressure drop across the non-return valve (No 11 HNO₃ Plant Understanding, p. 10). The pressure recorded as the oxidation pressure is taken from Point A as contained in Figure 1 in table B. 18 above. The pressure drop given is 15 kPa. Since the NH₃-Air mixer appears downstream of the non-return valve it is assumed that the lower pressure limit in the mixer is 365 kPa. The oxidation pressure is measured in kPa.</p> <p>For dual-pressure processes, the pressure range suggested is 400 - 600 kPa (Ullmann's Encyclopedia of Industrial Chemistry, 6th Ed, Vol. 23, p3).</p>
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None

Data / Parameter:	B.20 GS_{normal}
Unit	Name of Supplier
Description	Gauze supplier for the operating condition (i.e. historic) campaigns
Source of data	Monitored / Invoices
Value(s) applied	W.C. Heraeus
Choice of data or measurement methods and procedures	<p>AM0034 requires the monitoring of the supplier of the ammonia oxidation catalyst gauze. The recorded information is not further processed in the methodology but it is used as a plausibility check against the information for GC.</p> <p>AEL has been using ammonia oxidation catalyst gauzes ("FTCplus") supplied by Heraeus for the past several years. The Heraeus FTCplus gauze contains significant levels of Palladium (approximately one third). The main motivation for this is that it leads to a weight reduction of the (more expensive) Platinum. A side effect of this gauze type is that the generation of N₂O in the ammonia oxidation process tends to be lower than with gauzes containing little or no Palladium.</p> <p>AEL has used FTCplus gauzes supplied by Heraeus during the baseline campaign and intends to continue using the same or very similar composition of gauzes for the foreseeable future.</p>
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None

Data / Parameter:	B.21 GS_{BL}
Unit	Name of Supplier
Description	Gauze supplier for the baseline condition campaign
Source of data	Monitored / Invoices
Value(s) applied	W.C. Heraeus
Choice of data or measurement methods and procedures	AM0034 requires the monitoring of the supplier of the ammonia oxidation catalyst gauze. The recorded information is not further processed in the methodology but it is used as a plausibility check against the information for GC.
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None

Data / Parameter:	B.23 GC _{normal}																																						
Unit	%																																						
Description	Gauze composition during the historic operating campaigns expressed as percentage by weight of the precious metals Platinum, Rhodium and, if applicable, Palladium comprising the Ammonia Oxidation Catalyst gauzes.																																						
Source of data	Monitored / Gauze supplier invoices																																						
Value(s) applied	Platinum (Pt) 56.5%; Rhodium (Rh) 3.8%; Palladium (Pd) 39.7%																																						
Choice of data or measurement methods and procedures	<p>In accordance with AM0034, if the composition of the ammonia oxidation catalyst used for the baseline campaign and after the implementation of the project are identical to that used in the campaign for setting the operating conditions (previous five campaigns), then there shall be no limitations on N₂O baseline emissions.</p> <p>Record of Gauze compositions installed during the historic campaigns⁵:</p> <table><tr><th rowspan="2">Campaign</th><th rowspan="2">Gauze Supplier</th><th colspan="3">Gauze Composition</th></tr><tr><th>Pt (%)</th><th>Rh (%)</th><th>Pd (%)</th></tr><tr><td>C10</td><td>Heraeus</td><td>58.3</td><td>3.9</td><td>37.9</td></tr><tr><td>C12</td><td>Heraeus</td><td>56.1</td><td>3.8</td><td>40.1</td></tr><tr><td>C13</td><td>Heraeus</td><td>56.4</td><td>3.8</td><td>39.8</td></tr><tr><td>C14</td><td>Heraeus</td><td>56.1</td><td>3.8</td><td>40.1</td></tr><tr><td>C15</td><td>Heraeus</td><td>55.4</td><td>3.8</td><td>40.8</td></tr><tr><td colspan="2">Average</td><td>56.5</td><td>3.8</td><td>39.7</td></tr></table>	Campaign	Gauze Supplier	Gauze Composition			Pt (%)	Rh (%)	Pd (%)	C10	Heraeus	58.3	3.9	37.9	C12	Heraeus	56.1	3.8	40.1	C13	Heraeus	56.4	3.8	39.8	C14	Heraeus	56.1	3.8	40.1	C15	Heraeus	55.4	3.8	40.8	Average		56.5	3.8	39.7
Campaign	Gauze Supplier			Gauze Composition																																			
		Pt (%)	Rh (%)	Pd (%)																																			
C10	Heraeus	58.3	3.9	37.9																																			
C12	Heraeus	56.1	3.8	40.1																																			
C13	Heraeus	56.4	3.8	39.8																																			
C14	Heraeus	56.1	3.8	40.1																																			
C15	Heraeus	55.4	3.8	40.8																																			
Average		56.5	3.8	39.7																																			
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks																																						
Additional comments	None																																						

Data / Parameter:	B.24 GC_{BL}
Unit	%
Description	Gauze composition during the baseline campaign expressed as percentage by weight of the precious metals Platinum, Rhodium and, if applicable, Palladium comprising the Ammonia Oxidation Catalyst gauzes.
Source of data	Monitored / Gauze supplier invoices
Value(s) applied	Platinum (Pt) 56%; Rhodium (Rh) 3.8%; Palladium (Pd) 40.2%
Choice of data or measurement methods and procedures	<p>A change in the composition of the ammonia oxidation catalyst in the baseline campaign to a composition other than that used in the previous five campaigns, is permissible without any limitation on the N₂O baseline emissions if the following conditions are met</p> <p>(i) The baseline catalyst composition is considered as common practice in the industry, or</p> <p>(ii) The change in catalyst composition is justified by its availability, performance, relevant literature etc.</p> <p>Otherwise, the baseline emission factor shall be set to the conservative IPCC default emission factor for N₂O from nitric acid plants which have not installed N₂O destruction measures (4.5 kgN₂O/tHNO₃).</p> <p>GC_{BL} at AEL's No. 11 nitric acid plant is the same as GC_{normal}; therefore, the results of the baseline campaign are fully valid and applicable.</p>

⁵ The figures shown here are rounded figures. More exact figures are commercially sensitive information but can be inspected by the DOE during the site visit and can be made available to the CDM EB upon request.

Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None

Data / Parameter:	B.26 EF_{reg}
Unit	tN₂O/tHNO₃
Description	Emissions cap for N ₂ O from nitric acid production set by government regulation
Source of data	Department of Environmental Affairs and Tourism
Value(s) applied	None
Choice of data or measurement methods and procedures	There is currently no regulation in South Africa that limits the emissions of N ₂ O from nitric acid production. However, the regulatory situation will be monitored by liaising with the responsible South African Environmental Authorities on a continuous basis. AEL has a well-established working relationship with the responsible authorities and exchanges information with their officials on a regular basis.
Purpose of data/parameters	Calculation of baseline emissions or baseline net GHG removals by sinks
Additional comments	None.

D.2. Data and parameters monitored

(Copy this table for each data or parameter.)

Data/Parameter	NCSG
Unit	mg /Nm³ (convertible from ppmv, if required)
Description	N ₂ O concentration in the stack gas during each project campaign.
Measured/calculated/default	Measured/Calculated - every 2 sec. used for calculation of campaign mean (average, after exclusion of extreme values and outliers)
Source of data	ABB AO2040 URAS 14 Continuous Emissions Analyser
Value(s) of monitored parameter	Value applicable for Project Campaign 18: 566.89 Value applicable for Project Campaign 19: 583.11 Value applicable for Project Campaign 20: 448.07

Monitoring equipment	<p>Type: <i>ABB AO2040 URAS 14 Continuous Emissions Analyser, non-dispersive infrared analyser</i></p> <p>Overall measurement accuracy (for N₂O): 1.60% (as per QAL2 report dated 08/12/2014) and 2.12% (as per QAL2 report dated 10/10/2017)</p> <p>Serial Number: <i>Instrument number 3.346854.7</i></p> <p>Calibration frequency:</p> <ul style="list-style-type: none"> - QAL2 every 5 years - AST every year <p>Date of last external calibration:</p> <ol style="list-style-type: none"> 1. QAL2 Test (including AST) – 23/09/2014 - 25/09/2014 valid until 22/09/2019 2. AST – 01/03/2016 – 02/03/2016 valid until 28/02/2017 3. QAL2 Test (including AST) – 26/04/2017 - 28/04/2017 valid until 25/04/2022 <p>Calibration delay:</p> <p>A QAL2 including an AST was conducted from 26/04/2017-28/04/2017. The previous QAL2 was still valid at that time, but the previous AST was only valid until 28/02/2017.</p> <p>In addition to the delayed AST, the calibration gas used for zero and span check and calibration expired on 23/08/2016. AEL only replaced the gas bottles on 18/05/2017 due to ongoing issues with the supplier. All zero and span checks in between those two dates were invalid. The instrumentation department conducted the first zero and span check on 23/05/2017 with the new bottle.</p> <p>In order to adhere the guidelines for assessing compliance with the calibration frequency requirements as stipulated in paragraph 369 of VVS the maximum permissible error of the instruments for NCSG were applied. The error was applied in a conservative manner for the period between the expiration date of the bottle and the first valid zero and span check after the installation of the new bottle. The period of delayed AST falls within this time. The more conservative error of the two QAL2 reports has been selected and it was applied for the period from 24/08/2016 to 22/05/2017.</p>
Measuring/reading/recording frequency	Continuously (every 2 seconds)
Calculation method (if applicable)	<p>AM0034 requires the determination of the concentration of N₂O in the stack gas. NCSG is continuously monitored with an NDIR gas analyser and monitoring results are taken and recorded for every two seconds of plant operation. Hourly means for NCSG are derived by the data acquisition system. NCSG data taken during times when the plant was out of operation were eliminated. Also readings that were taken during malfunction of the monitoring system were eliminated. The remaining hourly average values were subjected to the following statistical analysis:</p> <ol style="list-style-type: none"> a) Calculate the sample mean (x) b) Calculate the sample standard deviation (s) c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation) d) Eliminate all data that lie outside the 95% confidence interval e) Calculate the new sample mean from the remaining NCSG values
QA/QC procedures	<ul style="list-style-type: none"> - Bi-weekly zero and span check and calibration in case of deviation >1% of range of analyzer against zero gas and certified calibration gas cylinder (internal calibration by AEL) - every 5 years QAL2 test (including AST) according to EN 14181 (External by qualified institute) - yearly AST according to EN 14181 (External by qualified institute)

Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks
Additional comments	

Data/Parameter	VSG
Unit	Nm³/h
Description	Normal gas volume flow rate of the stack gas during each project campaign.
Measured/calculated/default	Measured/Calculated - every 2 sec. used for calculation of campaign mean (average, after exclusion of extreme values and outliers)
Source of data	Gas Volume Flow meter, Emerson Rosemount Annubar® Model 485
Value(s) of monitored parameter	Value applicable for Project Campaign 18: 76,967 Value applicable for Project Campaign 19: 80,127 Value applicable for Project Campaign 20: 78,899
Monitoring equipment	<p>Type: Tail gas flow by differential pressure principle Overall measurement accuracy: 2.082% (as per QAL 2 report dated 08/12/2014) and 1.451% (as per QAL2 report dated 10/10/2017) (<i>Combined uncertainty for the normalized stack gas flow at standard conditions</i>)</p> <p>Serial Number: <i>instrument number N/A</i> Date of last external calibration:</p> <ol style="list-style-type: none"> 1. QAL2 Test (including AST) – 23/09/2014 - 25/09/2014 valid until 22/09/2019 2. AST – 01/03/2016 – 02/03/2016 valid until 28/02/2017 3. QAL2 Test (including AST) – 26/04/2017 - 28/04/2017 valid until 25/04/2022 <p>Calibration delay: A QAL2 including an AST was conducted from 26/04/2017-28/04/2017. The previous QAL2 was still valid at that time, but the previous AST was only valid until 28/02/2017.</p> <p>In order to adhere the guidelines for assessing compliance with the calibration frequency requirements as stipulated in paragraph 369 of VVS the maximum permissible error of the instruments for VSG were applied. The error was applied in a conservative manner for the period between the scheduled AST and the actual date of the QAL2/AST. The more conservative error of the two QAL2 reports has been selected and it was applied for the period from 01/03/2017 to 25/04/2017.</p>
Measuring/reading/recording frequency	Continuously (every 2 seconds).

Calculation method (if applicable)	<p>AM0034 requires the determination of the gas volume flow (VSG) in the stack. VSG is continuously monitored with a flow meter and monitoring results are taken and recorded for every two seconds of plant operation. Hourly means for VSG are derived by the data acquisition system. Temperature and pressure is also continuously measured in the stack and the VSG values subsequently adjusted to derive the VSG at normal conditions (i.e. standard pressure and temperature).</p> <p>VSG data taken during times when the plant was out of operation were eliminated.</p> <p>The resulting hourly average VSG values are now expressed in Nm³/h as required by AM0034 and where subsequently subjected to the following statistical analysis:</p> <ol style="list-style-type: none"> Calculate the sample mean (x) Calculate the sample standard deviation (s) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation) Eliminate all data that lie outside the 95% confidence interval Calculate the new sample mean from the remaining VSG values
QA/QC procedures	<p>Internal calibration at least once per year usually every 7 months after each campaign (the plant has to be shut down to conduct calibration) by the Instrument Department of AEL.</p> <p>Every 5 years QAL2 test (including AST) according to EN 14181 (External by qualified institute)</p> <p>Yearly AST according to EN 14181 (External by qualified institute)</p>
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks
Additional comments	

Data/Parameter	PE_n
Unit	tN ₂ O
Description	Total mass N ₂ O emissions in each project campaign.
Measured/calculated/default	Calculated.
Source of data	Calculated from measured values.
Value(s) of monitored parameter	Value applicable for Project Campaign 18: 212.186 Value applicable for Project Campaign 19: 101.944 Value applicable for Project Campaign 20: 190.322
Monitoring equipment	Not applicable.
Measuring/reading/recording frequency	Not applicable.
Calculation method (if applicable)	$PE_n = VSG * NCSG * 10^{-9} * OH$ <p>A special correction function is applied to the results for NCSG and VSG values. These correction factors were determined during the QAL2 test according to EN 14181</p>
QA/QC procedures	Not applicable.
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks
Additional comments	

Data/Parameter	OH_n
Unit	Hours
Description	Total operating hours during each project campaign
Measured/calculated/default	Measured.
Source of data	Production log and continuous monitoring.
Value(s) of monitored parameter	Project Campaign 18: 4,874 Project Campaign 19: 1,733 Project Campaign 20: 4,276
Monitoring equipment	Not applicable.
Measuring/reading/recording frequency	The total operating hours are logged continuously.
Calculation method (if applicable)	Not applicable.
QA/QC procedures	The production logging process is subject to ISO 9001 procedures
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks
Additional comments	

Data/Parameter	NAP
Unit	tHNO₃
Description	Metric tonnes of 100% concentrated nitric acid during each project campaign.
Measured/calculated/default	Measured / Calculated.
Source of data	Nitric acid flow meter Emerson coriolis mass flow meter
Value(s) of monitored parameter	Project Campaign 18: 139,630 Project Campaign 19: 49,837 Project Campaign 20: 119,572
Monitoring equipment	Emerson coriolis mass flow meter CMF 300 Overall measurement accuracy: $\leq 0.1\%$ Until 07/2017 (exchanged during shut down) Serial Number: 11007573 From 07/2017 Serial Number: 14740820 Note that the new flow meter is the same model with the same measurement accuracy as the replaced flow meter. The flow meter was replaced during the shut-down and turn-around of the plant. Calibration frequency: no calibration required as per manufacturer specifications
Measuring/reading/recording frequency	NAP is determined by continuous measurement of the HNO ₃ production and concentration
Calculation method (if applicable)	NAP is determined by a mass flow meter according to the following procedures: The density and temperature as measured by the mass flow meter is used to calculate the concentration of the nitric acid produced. This value is then used to convert the total mass flow to 100% nitric acid produced. The correct measurement of acid concentration is checked by manual tests.
QA/QC procedures	NAP results are crosschecked against process parameters as ammonia consumption and against product stock levels and product consumption
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks

Additional comments	The design capacity of the plant is 775 metric tonnes per day, operating 365 days per year. This equals a total production of 348,647 tonnes for a period of 539 days. Therefore, the factual production of 309,039 tonnes during this monitoring period is below the design capacity of the plant.
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Data/Parameter	TSG
Unit	°C
Description	Temperature in the stack gas
Measured/calculated/default	Measured.
Source of data	Stack temperature probe situated directly next to the volume flow meter;
Value(s) of monitored parameter	Not applicable, directly used for normalization of tail gas volume flow measurement.
Monitoring equipment	<p>Type: Rosemont thermocouple, PT100_385 3-wire RTD</p> <p>Overall measurement accuracy: 2.55% (as per initial QAL2 report dated 06/09/2007. Note that the overall measurement accuracy for TSG and PSG has only been established during the initial QAL2 report. The value is not relevant as the combined error for VSG includes the error for TSG and PSG)</p> <p>Serial Number: <i>instrument number N/A</i></p> <p>Calibration frequency:</p> <ul style="list-style-type: none"> - External calibration: QAL2 every 5 years; - External calibration: AST every year; <p>Date of last external calibration:</p> <ol style="list-style-type: none"> 1. QAL2 Test (including AST) – 23/09/2014 - 25/09/2014 valid until 22/09/2019 2. AST – 01/03/2016 – 02/03/2016 valid until 28/02/2017 3. QAL2 Test (including AST) – 26/04/2017 - 28/04/2017 valid until 25/04/2022 <p>Calibration delay:</p> <p>A QAL2 including an AST was conducted from 26/04/2017-28/04/2017. The previous QAL2 was still valid at that time, but the previous AST was only valid until 28/02/2017.</p> <p>In order to adhere the guidelines for assessing compliance with the calibration frequency requirements as stipulated in paragraph 369 of VVS the maximum permissible error of the instruments for VSG were applied. For details, please refer to the Parameter VSG above.</p>
Measuring/reading/recording frequency	Continuously (every 2 seconds)
Calculation method (if applicable)	AM0034 requires the determination of gas volume flow at normal conditions in the stack. In order to calculate from the measured VSG values to VSG at normal conditions, the actual temperature in the stack is measured by a temperature probe as part of the flow meter. The resulting measurements are transferred to the data acquisition system and are applied to each VSG value for calculation of normal volume flow.
QA/QC procedures	<p>Internal calibration at least once per year usually every 4 months after each campaign (the plant has to be shut down to conduct calibration) by the Instrument Department of AEL. The validity of the internal calibrations is 1 year.</p> <p>every 5 years QAL2 test (including AST) according to EN 14181 (External by qualified institute)</p> <p>yearly AST according to EN 14181 (External by qualified institute)</p>
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks

Additional comments	
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Data/Parameter	PSG
Unit	Pa (absolute)
Description	Pressure in the stack
Measured/calculated/default	Measured.
Source of data	Stack pressure probe situated directly next to the volume flow meter.
Value(s) of monitored parameter	Not applicable, directly used for normalization of tail gas volume flow measurement.
Monitoring equipment	<p>Type: Rosemont</p> <p>Overall measurement accuracy: 0.7 % (as per initial QAL2 report dated 06/09/2007. Note that the overall measurement accuracy for TSG and PSG has only been established during the initial QAL2 report. The value is not relevant as the combined error for VSG includes the error for TSG and PSG)</p> <p>Serial Number: <i>instrument number N/A</i></p> <p>Date of last external calibration:</p> <ol style="list-style-type: none"> 1. QAL2 Test (including AST) – 23/09/2014 - 25/09/2014 valid until 22/09/2019 2. AST – 01/03/2016 – 02/03/2016 valid until 28/02/2017 3. QAL2 Test (including AST) – 26/04/2017 - 28/04/2017 valid until 25/04/2022 <p>Calibration delay:</p> <p>A QAL2 including an AST was conducted from 26/04/2017-28/04/2017. The previous QAL2 was still valid at that time, but the previous AST was only valid until 28/02/2017.</p> <p>In order to adhere the guidelines for assessing compliance with the calibration frequency requirements as stipulated in paragraph 369 of VVS the maximum permissible error of the instruments for VSG were applied. For details, please refer to the Parameter VSG above.</p>
Measuring/reading/recording frequency	Continuously (every 2 seconds).
Calculation method (if applicable)	AM0034 requires the determination of gas volume flow at normal conditions in the stack. In order to calculate from the measured VSG values to VSG at normal conditions, the actual pressure in the stack has to be determined and applied to each hourly mean VSG value. The measurements are taken continuously by a pressure probe inside the stack very close to the stack gas volume flow meter.
QA/QC procedures	
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks
Additional comments	

Data/Parameter	EF_n
Unit	tN₂O/tHNO₃
Description	Emissions factor for campaign n.
Measured/calculated/default	Calculated.
Source of data	Calculation from total mass N ₂ O emissions of campaign n (PE _n) and total nitric acid production (NAP _n)

Value(s) of monitored parameter	Project Campaign 18: 0.001520 Project Campaign 19: 0.002046 Project Campaign 20: 0.001592
Monitoring equipment	Not applicable.
Measuring/reading/recording frequency	Not applicable.
Calculation method (if applicable)	The campaign specific emissions factor for each campaign during the project's crediting period is calculated by dividing the total mass of N ₂ O emissions during that campaign by the total production of 100% concentrated nitric acid during that same campaign. For campaign <i>n</i> the campaign specific emission factor is: $EF_n = PE_n / NAP_n$
QA/QC procedures	Not applicable.
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks
Additional comments	

Data/Parameter	EF_{ma,n}
Unit	tN ₂ O/tHNO ₃
Description	Moving average emissions factor derived over time from campaign specific emissions factors.
Measured/calculated/default	Calculated.
Source of data	Calculation from campaign specific emissions factors (EF _n)
Value(s) of monitored parameter	Project Campaign 18: 0.001015 Project Campaign 19: 0.001069 Project Campaign 20: 0.001095
Monitoring equipment	Not applicable.
Measuring/reading/recording frequency	Not applicable.
Calculation method (if applicable)	In order to take into account possible long-term emissions trends over the duration of the project activity and to take a conservative approach the moving average emission factor is determined as follows: $EF_{ma,n} = (EF_1 + EF_2 + \dots + EF_n) / n$ This process is repeated for each campaign such that a moving average, EF _{ma,n} is established over time, becoming more representative and precise with each additional campaign.
QA/QC procedures	Not applicable.
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks
Additional comments	

Data/Parameter	EF_p
Unit	tN ₂ O/tHNO ₃
Description	Emissions factor used for the specific campaign <i>n</i> to determine the emission reductions of that campaign
Measured/calculated/default	Calculated.
Source of data	Calculation of EF _n and EF _{ma,n} .
Value(s) of monitored parameter	Project Campaign 18: 0.001520 Project Campaign 19: 0.002046 Project Campaign 20: 0.001592

Monitoring equipment	Not applicable.
Measuring/reading/recording frequency	Not applicable.
Calculation method (if applicable)	To calculate the total emission reductions achieved in a campaign, the higher of the two values $EF_{ma,n}$ and EF_n shall be applied as the emission factor relevant for the particular campaign to be used to calculate emissions reductions (EF_P). Thus: If $EF_{ma,n} > EF_n$ then $EF_P = EF_{ma,n}$ If $EF_{ma,n} < EF_n$ then $EF_P = EF_n$
QA/QC procedures	Not applicable.
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks
Additional comments	

Data/Parameter	EF_{min}
Unit	tN₂O/tHNO₃
Description	EF_{min} is equal to the lowest EF_n observed during the first 10 campaigns of the project crediting period.
Measured/calculated/default	Calculated.
Source of data	Calculations from EF_n
Value(s) of monitored parameter	0.000417
Monitoring equipment	Not applicable.
Measuring/reading/recording frequency	Not applicable.
Calculation method (if applicable)	A campaign-specific emissions factor shall be used to cap any potential long-term trend towards decreasing N ₂ O emissions that may result from a potential built up of platinum deposits. After the first ten campaigns of the crediting period of the project, the lowest EF_n observed during those campaigns will be adopted as a minimum (EF_{min}). If any of the later project campaigns results in a EF_n that is lower than EF_{min} , the calculation of the emission reductions for that particular campaign shall use EF_{min} and not EF_n .
QA/QC procedures	Not applicable.
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks
Additional comments	

Data/Parameter	EF_{reg}
Unit	tN₂O/tHNO₃
Description	Emissions cap for N ₂ O from nitric acid production set by government regulation
Measured/calculated/default	Default
Source of data	Government policies
Value(s) of monitored parameter	No regulations or other requirements exist
Monitoring equipment	Not applicable.
Measuring/reading/recording frequency	Each reporting period

Calculation method (if applicable)	Not applicable
QA/QC procedures	Not applicable.
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks
Additional comments	

Data/Parameter	CL_n
Unit	tHNO₃
Description	Length of each project campaign measured in metric tonnes of 100% concentrated nitric acid produced during that campaign.
Measured/calculated/default	Measured.
Source of data	NAP
Value(s) of monitored parameter	Project Campaign 18: 139,630 Project Campaign 19: 49,837 Project Campaign 20: 119,572
Monitoring equipment	See comments for NAP above
Measuring/reading/recording frequency	See comments for NAP above
Calculation method (if applicable)	In accordance with AM0034 the project length (CL _n) has to be compared to the established average historic campaign length (CL _{normal}); and if the length of each individual project campaign CL _n is longer than or equal to the average historic campaign length CL _{normal} , then all N ₂ O values measured during the baseline campaign can be used for the calculation of EF (subject to the elimination of data from the operational parameters analysis). If CL _n < CL _{normal} , recalculate EF _{BL} by eliminating those N ₂ O values that were obtained during the production of tonnes of nitric acid beyond the CL _n (i.e. the last tonnes produced) from the calculation of EF _n .
QA/QC procedures	See comments for NAP above
Purpose of data/parameter	Calculation of project emissions or actual net GHG removals by sinks
Additional comments	

Data/Parameter	OP_h
Unit	kPa (gauge)
Description	Oxidation Pressure for each hour
Measured/calculated/default	Measured.
Source of data	Pressure probe at ammonia to air mixer.
Value(s) of monitored parameter	Not applicable. Used to determine when plant is operating outside of permitted range during baseline campaign.

Monitoring equipment	<p>Type: Yokogawa Press Tx – pressure transmitter Overall measurement accuracy: 1.7% Serial Number: F576FB671708 Tag Number: PT-76002-1 Installation location: Compressor floor</p> <p>During project campaigns the calibration of operational parameters is not relevant. However the calibration dates are listed below for information only: 11/11/2015, 19/08/2016, 03/04/2017, 31/07/2017 Validity: Each calibration is valid until the restart of the plant after the gauze change.</p> <p>Calibration frequency: Once every campaign (only during plant shutdown between campaigns)</p>
Measuring/reading/recording frequency	The measurement results are taken by the data acquisition and evaluation system. The system directly calculates hourly averages.
Calculation method (if applicable)	See above
QA/QC procedures	The instrument is subject to internal calibrations after each campaign. The QA/QC procedures are part of the ISO 9001 procedures.
Purpose of data/parameter	Not applicable
Additional comments	

Data/Parameter	OT _h
Unit	°C
Description	Oxidation temperature in the ammonia oxidation reactor (AOR) for each hour.
Measured/calculated/default	Measured.
Source of data	Thermocouples inside the ammonia oxidation reactor
Value(s) of monitored parameter	Not applicable. Used to determine when plant is operating outside of permitted range during baseline campaign or if the plant is out of operation.
Monitoring equipment	<p>Type: Thermocouple Products Type: K310 S/steel Thermocouple Overall measurement accuracy: +/-1% Serial Number: TP3285-3290 Tag-Number: 76159-1 to -5 Installation location: reactor</p> <p>During project campaigns the calibration of operational parameters is not relevant. The thermocouples are calibrated by the supplier and the installation dates are listed below for information only: 11/11/2015; 19/08/2016, 03/04/2017, 31/07/2017 Validity: Each calibration is valid until the restart of the plant after the gauze change.</p> <p>Calibration frequency: Once every campaign (only during plant shutdown between campaigns)</p>
Measuring/reading/recording frequency	The measurement results are taken by the data acquisition and evaluation system. The system directly calculates hourly averages.
Calculation method (if applicable)	See above.
QA/QC procedures	The temperature probes are exchanged before every gauze change. They have been calibrated prior to installation by the supplier.
Purpose of data/parameter	Not applicable

Additional comments	
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Data/Parameter	AFR
Unit	kgNH₃/h (converted from originally measured Nm³/h)
Description	Ammonia gas flow rate to the ammonia oxidation reactor.
Measured/calculated/default	Measured.
Source of data	Differential pressure measurement Manufacturer: Yokogawa Type: D/P
Value(s) of monitored parameter	Not applicable, monitored data of AFR will be used to determine if the plant operating outside of AFR _{max} during the baseline campaign or for plausibility checks
Monitoring equipment	Type: Yokogawa Orifice plate with D.P. transmitter Overall measurement accuracy: 1.25% Serial Number: F570FD073708 TAG Nr: FT-76003-1 During project campaigns the calibration of operational parameters is not relevant. However the calibration dates are listed below for information only: 11/11/2015, 19/08/2016, 03/04/2017, 31/07/2017 Validity: Each calibration is valid until the restart of the plant after the gauze change. Calibration frequency: After each campaign (only during plant shutdown between campaigns)
Measuring/reading/recording frequency	The measurement results are taken by the data acquisition and evaluation system. The system directly calculates hourly averages.
Calculation method (if applicable)	See above
QA/QC procedures	The instrument is subject to internal calibrations after each campaign, which are part of the ISO 9001 procedures.
Purpose of data/parameter	Not applicable
Additional comments	

Data/Parameter	AIFR
Unit	% v/v
Description	Ammonia to air ratio into the ammonia oxidation reactor
Measured/calculated/default	Calculated (primary air flow measured as basis for AIFR).
Source of data	Calculation for each hour of plant operation based on measurements of AFR and primary air flow rates.
Value(s) of monitored parameter	Not applicable, monitored data of AIFR will be used to determine if the plant operating outside of AIFR _{max} during the baseline campaign or for plausibility checks

Monitoring equipment	<p>Equipment for Air Flow-rate to AOR:</p> <p>Endress & Hauser Deltabar S Overall measurement accuracy: 1.25% Serial Number: JA08710109D TAG Nr: FT-76002-1</p> <p>During project campaigns the calibration of operational parameters is not relevant. However the calibration dates are listed below for information only: 11/11/2015, 19/08/2016, 03/04/2017, 31/07/2017 Validity: Each calibration is valid until the restart of the plant after the gauze change. Calibration frequency: After each campaign (only during plant shutdown between campaigns)</p>
Measuring/reading/recording frequency	The measurement results are taken by the data acquisition and evaluation system. The system directly calculates hourly averages.
Calculation method (if applicable)	The calculation of AIFR is based on the measurement of AFR and primary air flow-rate. The AFR measurement is described in section AFR above. The measurement of primary air flow-rate to AOR is based on differential pressure measurement principle.
QA/QC procedures	The instrument is subject to internal calibrations after each campaign, which are part of the ISO 9001 procedures.
Purpose of data/parameter	Not applicable.
Additional comments	

Data/Parameter	GS_{project}
Unit	Name of Supplier
Description	Gauze supplier for the project campaign
Measured/calculated/default	Not applicable.
Source of data	Monitored / Invoices
Value(s) of monitored parameter	W.C. Heraeus
Monitoring equipment	Not applicable.
Measuring/reading/recording frequency	Not applicable.
Calculation method (if applicable)	Not applicable.
QA/QC procedures	Not applicable.
Purpose of data/parameter	Not applicable.
Additional comments	

Data/Parameter	GC_{project}
Unit	%
Description	Gauze composition during the project campaign expressed as % by weight of the precious metals Platinum, Rhodium and, if applicable, Palladium comprising the Ammonia Oxidation Catalyst gauzes.
Measured/calculated/default	Not applicable.
Source of data	Monitored / Gauze supplier invoices

Value(s) of monitored parameter		Project campaign 18	Project campaign 19	Project campaign 20
	Platinum (Pt)	56%	56%	56%
	Rhodium (Rh)	4%	4%	4%
	Palladium (Pd)	40%	40%	40%
Monitoring equipment	Not applicable.			
Measuring/reading/recording frequency	Not applicable.			
Calculation method (if applicable)	Not applicable.			
QA/QC procedures	Not applicable.			
Purpose of data/parameter	Not applicable.			
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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The results of the N.DBMS data analysis are exported to EXCEL spreadsheets for further analysis and presentation.

It should be noted that all values presented in excel tables are displayed (in the tables) as rounded values due to the function of excel as a program. However, actual calculations have been conducted using the exact values, which explains possible differences compared to calculating with the rounded parameter values as displayed in the tables. This applies to all presented excel tables not only those related to baseline emission calculations.

Analysis of Historical campaign data and determination of permitted operating ranges

The determination of the permitted operating conditions for operating temperature, operating pressure, maximum ammonia flow rate, maximum ammonia to air ratio, normal gauze supplier and normal gauze composition was undertaken by the validating DOE (as it was clarified by the CDM EB in EB31 meeting that either the validating or verifying DOE could undertake the task of determination of the permitted operating conditions). However, the normal campaign length as well as the determination of the baseline emission factor was in the scope of the verifying DOE.

The monitoring results for Oxidation Temperature and Pressure have been routinely discarded in the past and are therefore not available to establish the normal range. As a substitute, the technical manuals of the No. 11 nitric acid plant were used to derive these normal ranges.

Since no historical data were recorded and available, the allowable NH₃ to Air ratio AIFR_{max} was derived from technical plant manuals (controller data sheet).

The parameters CL_{normal}, GS_{normal}, GC_{normal} and AFR_{max} were derived from the 5 historic campaigns that were defined in the PDD. The 5 campaigns are:

Campaign	Start date	End date	In-/Excluded
C10	29/05/2003	24/11/2003	Included
C12	27/05/2004	12/12/2004	Included

C13	15/12/2004	24/07/2005	Included
C14	27/07/2005	28/01/2006	Included
C15	03/02/2006	31/07/2006	Included

Oxidation temperature (min – max): 820 °C – 905 °C

Oxidation pressure (min – max): 365,000 Pa – 450,000 Pa

Maximum ammonia flow rate: 9.094 t/h

Maximum ammonia to air ratio: 0.115 or 11.5%

CL_{normal}: 127,302.4 t HNO₃

As Baseline the campaign C16 (20/07/2006 – 18/02/2007) was selected.

Analysis of Baseline campaign data

As the baseline campaign for AEL No. 11 the campaign C16 (20/07/2006 – 18/02/2007) was used.

Analysis of Baseline campaign data

As the baseline campaign for AEL No. 11 the campaign C16 was used. The baseline campaign was in operation in the period 20/07/2006 – 18/02/2007. The baseline monitoring data, baseline calculation and baseline results were determined during the first verification and were verified by the DOE during the first verification.

The results are as follows:

NCSG _{BL}	mg/Nm ³	1,630.03
QAL2 NCSG		1.104
VSG _{BL}	Nm ³ /h	72,468.01
QAL2 VSG		1.01
OH _{BL}	H	4,950.00
NAP _{BL}	t HNO ₃	134,699.80
BE	t N ₂ O	651.98
UNC	%	3.99
EF _{BL}	kgN ₂ O/tHNO ₃	4.647

Resulting EF_{BL}

The EF_{BL} derived from this analysis of historic and baseline data is 4.647 kgN₂O/tHNO₃.

Sample calculation for baseline emissions (BE) and Emission factor (EF):

BE [tN₂O] = 72,468 [Nm³/h] * 1.01 * 1,630.03 * 1.104 [mg/Nm³] * 10⁻⁹ * 4,950 [h] = 651.98 [tN₂O]

EF [kgN₂O/tHNO₃] = 651.98 [tN₂O] / 134,699.8 [tHNO₃] * 10³ * (1 – 3.99/100) = 4.647 [kgN₂O/tHNO₃]

Note that small deviations occur due to rounding. Please refer to the calculation excel file for details.

Adjustment of Baseline Emission Factor if CL_n < CL_{normal}

If the length of an individual project campaign CL_n is longer than or equal to the average historic campaign length CL_{normal} or longer or equal than the baseline campaign length CL_{BL}, then all N₂O

values measured during the baseline campaign can be used for the calculation of EF_{BL} . If $CL_n < CL_{normal}$ or CL_{BL} , EF_{BL} has to be recalculated by eliminating those N_2O values that were obtained during the production of tonnes of nitric acid beyond the CL_n (i.e. the last tonnes produced) from the calculation of EF_{BL} .

CL_n is longer than CL_{BL} for PC18, therefore no adjustment of the Baseline emissions factor EF_{BL} is necessary. However, CL_n is shorter than CL_{BL} for PC19 and PC20, therefore an adjustment of the Baseline emissions factor EF_{BL} is necessary. EF_{BL} is recalculated by eliminating those N_2O values that were obtained during the production of tonnes of nitric acid beyond the CL_{BL} (i.e. the last tonnes produced) from the calculation of EF_{BL} . This was the case at 30/09/2006 10:00 for PC19 and 25/01/2007 20:00 for PC20. All N_2O data measured from the respective hour on got excluded for the recalculation of EF_{BL} .

		PC 19	PC 20
NCSG _{BL}	mg/Nm ³	1,505.73	1,624.23
QAL2 NCSG		1.104	1.104
VSG _{BL}	Nm ³ /h	72,468	72,468
QAL2 VSG		1.010	1.010
OH _{BL}	h	4,950	4,950
NAP _{BL}	t HNO ₃	134,700	134,700
BE	t N ₂ O	602.267	649.666
UNC	%	3.99	3.99
EF_{BL}	kg N₂O/t HNO₃	4.293	4.631

Adjustment of Baseline emissions factor due to EF_{reg}

Should N_2O emissions regulations that apply to nitric acid plants be introduced in the host country or jurisdiction covering the location of the project activity, such regulations shall be compared to the calculated baseline emission factor for the project (EF_{BL}). If the regulatory limit is lower than the baseline factor determined for the project, the regulatory limit shall serve as the new baseline emission factor, that is:

if $EF_{BL} > EF_{reg}$,

then the baseline N_2O emission factor shall be EF_{reg} for all calculations.

where:

Variable Definition

EF_{BL} Baseline emissions factor (tN₂O/tHNO₃)

EF_{reg} Emissions level set by newly introduced policies or regulations (tN₂O/tHNO₃).

Such EF_{reg} shall be determined according to the nature of the regulation (e.g. in terms of absolute emission, by-product rate, concentration in stack gas), as described in the approved methodology AM0028.

There is currently no N_2O regulation for nitric acid plants in South Africa therefore no adjustment of the Baseline emissions factor EF_{BL} is necessary.

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

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Project emissions are calculated according to the following formula:

$$PE_n = VSG * NCSG * 10^{-9} * OH$$

Variable	Definition
VSG	Mean stack gas volume flow rate for the project campaign (m ³ /h)
NCSG	Mean concentration of N ₂ O in the stack gas for the project campaign (mgN ₂ O/m ³)
PE _n	Total N ₂ O emissions of the n th project campaign (tN ₂ O)
OH	Is the number of hours of operation in the specific monitoring period (h)

Based on the total N₂O emissions of each project campaign the specific project campaign emission factor is calculated as:

$$EF_n = PE_n / NAP_n$$

Where:

Variable	Definition
EF _n	Project Emission Factor for n th project campaign (kgN ₂ O/tHNO ₃)
PE _n	Total N ₂ O emissions of the n th project campaign (tN ₂ O or kgN ₂ O)
NAP _n	Campaign length of the n th project campaign (tHNO ₃)

Before calculation of the Project Emissions (PE) the same statistical analysis as for the calculation of the baseline emission factor (EF_{BL}) is applied to the monitoring raw data (hourly average values) of each project campaign.

The respective correction functions for NCSG and VSG as determined during the relevant QAL2 test are applied within the calculation.

AMS Downtime

According to the methodology, the highest measured value in the campaign will be applied for any downtime period of the AMS.

The following replacement values were established:

- PC18: 1,039.08 mgN₂O/Nm³ (maximum NCSG value); 85,563.59 Nm³/h (maximum VSG value)
- PC19: 683,15 mgN₂O/Nm³ (maximum NCSG value); 84,424.62 Nm³/h (maximum VSG value)
- PC20: 744.27 mgN₂O/Nm³ (maximum NCSG value); 90,927.90 Nm³/h (maximum VSG value)

The values were used during analyser downtime (when there was no plant shutdown and the AMS was down) in the following periods:

Start date and hour	End date and hour	Campaign	Parameter	Replacement Value	Unit
19/10/2016 02:00	19/10/2016 02:00	PC18	VSG	85,563.59	Nm ³ / h
01/11/2016 16:00	01/11/2016 16:00	PC18	VSG	85,563.59	Nm ³ / h
16/02/2017 07:00	16/02/2017 08:00	PC18	VSG	85,563.59	Nm ³ / h
16/02/2017 07:00	16/02/2017 08:00	PC18	NCSG	1,039.08	mg N2O / Nm ³
01/09/2017 00:00	01/09/2017 23:00	PC20	VSG	90,927.90	Nm ³ / h
01/09/2017 00:00	01/09/2017 23:00	PC20	NCSG	744.27	mg N2O / Nm ³
24/09/2017	24/09/2017	PC20	VSG		Nm ³ / h

12:00	12:00			90,927.90	
24/09/2017	24/09/2017				
12:00	12:00	PC20	NCSG	744.27	mg N ₂ O / Nm ³

Analysis of Project campaign data

The following table shows the number of data sets and the respective amount of NAP during the campaigns included in this monitoring period:

Campaign	Data sets	NAP (in tHNO ₃)
PC18	5,424	139,630
PC19	2,832	49,837
PC20	4,584	119,572

Incomplete and implausible monitoring data sets have been eliminated. The following exclusion criteria according to plant operation trip values were applied; all datasets recorded during times when the plant was not in operation are excluded:

$$OT_h > 820\text{ }^{\circ}\text{C}$$

The remaining number of datasets is the number of operating hours. The table below shows the operating hours for each campaign included in this monitoring period:

Campaign	Operating hours (OH)
PC18	4,874
PC19	1,733
PC20	4,276

By applying the 95% confidence interval on the remaining NCSG and VSG values mavericks and outliers are excluded. The 95% confidence interval for NCSG and VSG values is derived and the outliers excluded individually for VSG and NCSG. Hence, the remaining number of data sets may differ between NCSG and VSG. The resulting mean values for NCSG and VSG are applied for calculation of the Project emissions (PE).

Relevant Project Emissions (PE_n) and respective Project Emission Factors (EF_n)

The resulting values for NCSG_n, VSG_n, OH_n, NAP_n, project emissions (PE_n) and project emission factor (EF_n) for the project campaigns covered by this monitoring report are:

Value	Unit	PC18	PC19	PC20
NCSG _n	mg/Nm ³	566.89	583.11	448.07
QAL2 NCSG		1.0058	1.0354	1.0354
VSG _n	Nm ³ /h	76,967	80,127	78,899
QAL2 VSG		0.992	1.216	1.216
OH _n	H	4,874	1,733	4,276
NAP _n	t HNO ₃	139,630	49,837	119,572
PE _n	t N ₂ O	212.186	101.944	190.322
EF _n	kg N ₂ O/t HNO ₃	1.520	2.046	1.592

Please refer to the submitted excel calculation spread sheet for further detail of the calculation.

Project Campaign Length

If the length of each individual project campaign CL_n is longer than or equal to the average historic campaign length CL_{normal} or to the baseline campaign length whichever is shorter, then all N_2O values measured during the baseline campaign can be used for the calculation of EF (subject to the elimination of data from the operational limits analysis, see above under recalculation of Baseline Emission factor).

Sample calculation for campaign emissions (PE) and Emission factor (EF_n) for the 18th project campaign:

$$PE [tN_2O] = 76,967 [Nm^3/h] * 0.992 * 567 [mg/Nm^3] * 1.006 * 4,874 [h] * 10^{-9} = 212.2 [tN_2O]$$

$$EF [kgN_2O/tHNO_3] = 212.2 [tN_2O] / 139,630 [tHNO_3] * 10^3 = 1.52 [kgN_2O/tHNO_3]$$

Sample calculation for campaign emissions (PE) and Emission factor (EF_n) for the 19th project campaign:

$$PE [tN_2O] = 80,127 [Nm^3/h] * 1.216 * 583 [mg/Nm^3] * 1.035 * 1,733 [h] * 10^{-9} = 101.9 [tN_2O]$$

$$EF [kgN_2O/tHNO_3] = 101.9 [tN_2O] / 49,837 [tHNO_3] * 10^3 = 2.05 [kgN_2O/tHNO_3]$$

Sample calculation for campaign emissions (PE) and Emission factor (EF_n) for the 20th project campaign:

$$PE [tN_2O] = 78,899 [Nm^3/h] * 1.216 * 448 [mg/Nm^3] * 1.035 * 4,276 [h] * 10^{-9} = 190.3 [tN_2O]$$

$$EF [kgN_2O/tHNO_3] = 190.3 [tN_2O] / 119,572 [tHNO_3] * 10^3 = 1.59 [kgN_2O/tHNO_3]$$

Note that small deviations occur due to rounding. The figures stated here reflect the correct values as of the excel calculation. Please refer to the calculation excel file for details.

E.3. Calculation of leakage emissions

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No leakage occurs under this project type.

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

Emission reductions

A **moving average emissions factor** must be calculated at the end of a campaign n as follows:

$$EF_{ma,n} = (EF_1 + EF_2 + \dots + EF_n) / n$$

This process is repeated for each campaign such that a moving average, $EF_{ma,n}$, is established over time, becoming more representative and precise with each additional campaign.

To calculate the total emission reductions achieved in a campaign according to the formula below, the higher of the two values $EF_{ma,n}$ and EF_n shall be applied as the emission factor relevant for the particular campaign to be used to calculate emissions reduction s (EF_p). Thus:

$$\text{If } EF_{ma,n} > EF_n \text{ then } EF_p = EF_{ma,n}$$

$$\text{If } EF_{ma,n} < EF_n \text{ then } EF_p = EF_n$$

In addition a campaign-specific **minimum emissions factor** (EF_{min}) shall be used to cap any potential long-term trend towards decreasing N_2O emissions that may result from a potential built up of platinum deposits. After the first ten campaigns of the crediting period of the project, the lowest EF_n observed during those campaigns will be adopted as a minimum emission factor (EF_{min}). If any of the later project campaigns results in an EF_n that is lower than EF_{min} , the calculation of the emission reductions for that particular campaign shall use EF_{min} and not EF_n . As the project campaigns of this current monitoring period includes only the 9th project campaign consideration of EF_{min} is not yet of relevance.

The emission reductions for the project activity during this monitoring period are determined by deducting the campaign-specific emission factor from the baseline emission factor and multiplying the result by the production output of 100% concentrated nitric acid over the campaign period and the GWP of N_2O :

$$ER = (EF_{BL} - EF_p) * NAP * 10^{-3} * GWP_{N_2O} (tCO_2e)$$

Sample calculation of emission reductions:

18 th PC: ER [tCO ₂ e] =	(4.647 - 1.520) [kg N ₂ O/t HNO ₃] *	139,630 [t HNO ₃] *	10 ⁻³ *	298 =	130,135	[tCO₂e]
19 th PC: ER [tCO ₂ e] =	(4.293 - 2.046) [kg N ₂ O/t HNO ₃] *	49,837 [t HNO ₃] *	10 ⁻³ *	298 =	33,374	[tCO₂e]
20 th PC: ER [tCO ₂ e] =	(4.631 - 1.592) [kg N ₂ O/t HNO ₃] *	119,572 [t HNO ₃] *	10 ⁻³ *	298 =	108,284	[tCO₂e]

Note that small deviations occur due to rounding. The figures stated here reflect the correct values as of the excel calculation. Please refer to the calculation excel file for details. The final result is rounded down.

Where:

Variable	Definition
ER	Emission reductions of the project for the specific campaign (tCO ₂ e)
NAP	Nitric acid production for the project campaign (tHNO ₃). The maximum value of NAP shall not exceed the design capacity.
EF _{BL}	Baseline emissions factor (kgN ₂ O/tHNO ₃)
EF _p	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of EF _{ma,n} and EF _n) (kgN ₂ O/tHNO ₃)
GWP _{N₂O}	Global Warming Potential of N ₂ O (tCO ₂ e/tN ₂ O)

The resulting emission reductions (ER) for each of the project campaigns covered by this monitoring report and all relevant monitoring results are summarized in the table below:

		Project campaign 18 (PC18): 18/08/2016 - 04/04/2017	Project campaign 19 (PC19): 05/04/2017 - 31/07/2017	Project campaign 20 (PC20): 01/08/2017 - 07/02/2018
NCSG _{BL}	mg/Nm ³	1,630.03	1,505.73	1,624.23
QAL2 NCSG		1.104	1.104	1.104
VSG _{BL}	Nm ³ /h	72,468	72,468	72,468
QAL2 VSG		1.010	1.010	1.010
OH _{BL}	h	4,950	4,950	4,950
NAP _{BL}	t HNO ₃	134,700	134,700	134,700
BE	t N ₂ O	651.983	602.267	649.666
UNC		3.99	3.99	3.99
EF_{BL}	kg N₂O/t HNO₃	4.647	4.293	4.631
NCSG _n	mg/Nm ³	566.89	583.11	448.07
QAL2 NCSG		1.0058	1.0354	1.0354
VSG _n	Nm ³ /h	76,967	80,127	78,899
QAL2 VSG		0.992	1.216	1.216
OH _n	h	4,874	1,733	4,276
NAP _n	t HNO ₃	139,630	49,837	119,572
PE _n	t N ₂ O	212.186	101.944	190.322
EF _n	kg N ₂ O/t HNO ₃	1.520	2.046	1.592
EF _{ma,n}	kg N ₂ O/t HNO ₃	1.015	1.069	1.095
EF _{min}	kg N ₂ O/t HNO ₃	0.417	0.417	0.417
EF_p	kg N₂O/t HNO₃	1.520	2.046	1.592
GWP	tCO ₂ e/tN ₂ O	298	298	298
ER	tCO₂e	130,135	33,374	108,284
Total	tCO₂e	271,793		

	Baseline GHG emissions or baseline net GHG removals (t CO ₂ e)	Project GHG emissions or actual net GHG removals (t CO ₂ e)	Leakage GHG emissions (t CO ₂ e)	GHG emission reductions or net anthropogenic GHG removals (t CO ₂ e)		
				Before 01/01/2013	From 01/01/2013	Total amount
PC18	193,367	63,231	0	0	130,135	130,135
PC19	63,754	30,379	0	0	33,374	33,374
PC20	165,000	56,716	0	0	108,284	108,284
Total	422,120	150,326	0	0	271,793	271,793

Note that small deviations might occur due to rounding. The figures stated here reflect the correct values as of the excel calculation. Please refer to the calculation excel file for details. The final result for each campaign is rounded down.

AM0034 requires calculating emission reductions by establishing product related baseline and project emission factors and multiplying the difference with the nitric acid production. The baseline emissions and the project emissions stated in the summary of calculations have been calculated only for the purpose of this table. The calculations are not in line with the methodology.

Comparison of design capacity and actually achieved production during this monitoring period

The design capacity of the plant is 775 metric tonnes per day, operating 365 days per year. This equals a total production of 348,647 tonnes for a period of 539 days. Therefore, the factual production of 309,039 tonnes during this monitoring period is below the design capacity of the plant.

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 ₂ e)	Amount estimated ex ante (t CO ₂ e)
271,793 (calculated for a monitoring period of 539 days)	392,008 (calculated for a monitoring period of 539 days)

E.6. Remarks on increase in achieved emission reductions

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Not applicable as the actual GHG emission reductions achieved during this monitoring period are below the values estimated in ex-ante calculation of the registered PDD.