

**MONITORING REPORT FORM (CDM-MR) \***  
**Version 01 - in effect as of: 28/09/2010**

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\* as contained within the document entitled "Guidelines for completing the monitoring report form (CDM-MR)" (EB 54 meeting report, annex 34).

## MONITORING REPORT

Version 07; 22/08/2012

**TITLE: “N<sub>2</sub>O ABATEMENT PROJECT AT NITRIC ACID PLANT NO. 11 AT AFRICAN EXPLOSIVES LTD. (AEL), SOUTH AFRICA”**

**Reference Number: 1364**

**Monitoring period: No 02, 24/05/2009 – 16/11/2010**

### SECTION A. General description of the project activity

#### A.1. Brief description of the project activity:

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

The sole purpose of the project activity is to significantly reduce former levels of N<sub>2</sub>O emissions from the production of nitric acid at AEL's nitric acid plant No. 11 (“AEL-11”) in Johannesburg, Modderfontein, South Africa, by implementation of a secondary N<sub>2</sub>O abatement catalyst.

##### Brief description of the installed technology and equipments

The employed secondary N<sub>2</sub>O abatement catalyst technology is supplied by Johnson Matthey plc who exclusively markets a secondary catalyst technology that has been developed by YARA International ASA (Norway). Continuous monitoring of emission reductions is assured by an Automated Measuring System (AMS), consisting of stack gas volume flow meter, N<sub>2</sub>O Analyzer, and respective data logging facilities. 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 N<sub>2</sub>O analyser was replaced in September 2007, after the baseline measurement). 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.)

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:	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

Project Campaigns covered by current Monitoring/Verification Period:

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

##### Total emission reductions achieved in this monitoring period

The total amount of emission reductions achieved in this monitoring period is 391,122 t CO<sub>2</sub>e.

## **A.2. Project Participants**

<b>Name of Party involved</b>	<b>Project Participants</b>	<b>Party involved considered as project participant</b>
South Africa (host)	African Explosives Ltd (“AEL”)	No
United Kingdom of Great Britain and Northern Ireland	<ul style="list-style-type: none"><li>• N.serve Environmental Services GmbH, Germany (“N.serve”)</li><li>• Electrabel NV/SA</li></ul>	No
Switzerland	N.serve Environmental Services GmbH	No

## **A.3. Location of the project activity:**

The project activity is located in: Modderfontein (approx. 20 km north-east of Johannesburg). Postal address: PO Modderfontein 1645. Coordinates of the plant are 26°05’50’’ South and 28°10’26’’ East.

## **A.4. Technical description of the project**

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

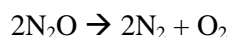
- 1.) secondary N<sub>2</sub>O abatement technology
- 2.) Automated Monitoring System (AMS) for continuous N<sub>2</sub>O measurement which is fully in compliance with European Standard EN 14181 (see Section C for more detail)
- 3.) training of local staff on installation, operation and maintenance of catalyst and monitoring equipment, etc. as well as implementation of quality check and quality assurance measures (see Section C for more detail)

### **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 that is installed below the standard precious metal gauze pack. This technology has been implemented inside the AEL-11 ammonia oxidation reactor.

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

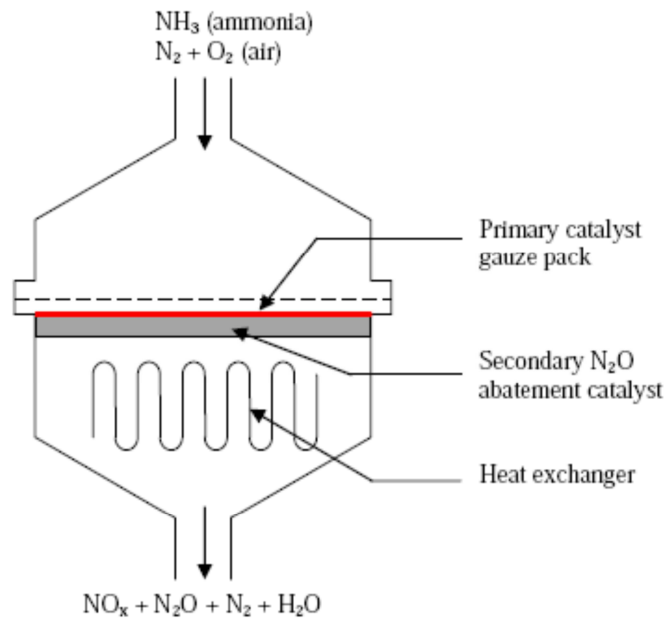
A secondary catalyst will reduce N<sub>2</sub>O levels in the gas mix resulting from the primary ammonia oxidation reaction. A wide range of metals (e.g. Cu, Fe, Mn, Co and Ni) have shown to be of varied effectiveness in N<sub>2</sub>O abatement catalysts. The YARA 58 Y 1® abatement catalyst is made 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 in the range of 70% - 90% in the following reaction:



If operated properly, the secondary catalyst system has a lifetime of several campaigns and may reduce N<sub>2</sub>O 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 N<sub>2</sub>O abatement catalyst.

### **N<sub>2</sub>O 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. Through the introduction of the secondary catalyst into the ammonia reactor, a slight pressure drop ( $\Delta P$ ) is expected to occur. This  $\Delta P$  may lead to a very slight reduction in ammonia conversion efficiency and hence a very small reduction in nitric acid output. In practice, this loss of production will be insignificant.

**A.5. Title, reference and version of the baseline and monitoring methodology applied to the project activity:**

This project activity is based on Approved Baseline and Monitoring methodologies AM0034 (Version 2): “Catalytic reduction of N<sub>2</sub>O inside the ammonia burner of nitric acid plants”. Furthermore, the project draws on approved baseline methodology AM0028 (Version 04.2) for the baseline scenario selection and employs the “Tool for the demonstration and assessment of additionality”.

**A.6. Registration date of the project activity:**

Registration Date of project activity: 08/02/2008

**A.7. Crediting period of the project activity and related information (start date and choice of crediting period):**

Crediting period: 10 years; Start date: 08/02/2008

**A.8. Name of responsible person(s)/entity(ies):**

Contact information of the person(s)/entity(ies) responsible for completing the monitoring report form (CDM-MR).

Mr. Martin Stilkenbäumer ([stilkenbaeumer@nserve.net](mailto:stilkenbaeumer@nserve.net))

Mr. Nikolaus Gutknecht-Stöhr ([gutknecht@nserve.net](mailto:gutknecht@nserve.net))

N.serve Environmental Services GmbH

Grosse Theaterstrasse 14

20354 Hamburg, Germany

Phone: +49 40 309 97 86-0

Fax: +49 40 309 97 86-10

**SECTION B. Implementation of the project activity****B.1. Implementation status of the project activity**

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

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 demonstrate 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.

#	Start of the event	End of the event	Campaign		Short description
			AEL designation	Project campaign	
	24/05/2009	08/06/2009			Shutdown of the plant for maintenance
1	08/06/2009 12:00		C21	4	Start of new campaign
2	09/06/2009 05:00	10/06/2009 18:00	C21	4	Shutdown - Fire on plant
3	11/06/2009 09:00	11/06/2009 21:00	C21	4	Shut down - Power failure due to water leak at substation
4	22/06/2009 05:00	24/06/2009 13:00	C21	4	Shutdown - Plant off line for capacity control
5	09/07/2009 05:00	12/07/2009 02:00	C21	4	shutdown - Fire on plant at oil accumulator
6	24/07/2009 09:00	24/07/2009 17:00	C21	4	Shutdown - Plant tripped on ratio
7	11/08/2009 19:00	15/08/2009 06:00	C21	4	Plant off line for capacity control; Ammonia bypassing the basket reacts with the Nitric oxide produced at the gauze to produce Nitrous oxide below the Nitrous oxide catalyst. This has resulted in higher levels of Nitrous oxide observed since the new catalyst has been installed
8	31/08/2009 12:00	02/09/2009 07:00	C21	4	Plant off line for capacity control
9	28/09/2009 19:00	29/09/2009 07:00	C21	4	Plants tripped due to lightening strike
10	29/09/2009 09:00	29/09/2009 11:00	C21	4	Plant trip
11	03/10/2009 12:00	04/10/2009 05:00	C21	4	Plant off line due to power failure
12	22/10/2009 22:00	23/10/2009 14:00	C21	4	All the plants off line due to a power failure
13	24/10/2009 12:00	24/10/2009 23:00	C21	4	Plant tripped on ratio
14	12/11/2009 10:00	12/11/2009 18:00	C21	4	Plant tripped on expander overspeed

15	14/11/2009 16:00	14/11/2009 20:00	C21	4	Plant off line due to power failure
16	27/12/2009 01:00	30/12/2009 07:00	C21	4	Bursting disk failure and gauze change
17	30/12/2009 07:00		C22	5	Start of new campaign
18	14/02/2010 16:00	14/02/2010 21:00	C22	5	Shutdown - Faulty ammonia evaporator level indicator
19	27/02/2010 00:00	27/02/2010 23:00	C22	5	No data for OPh, AFR and AIFR available. However this has no influence on calculations of project emissions since OPh, AFR and AIFR are only used to evaluate the Baseline campaign period
20	09/03/2010 00:00	09/03/2010 23:00	C22	5	No data for AFR and AIFR available. However this has no influence on calculations of project emissions since AFR and AIFR are only used to evaluate the Baseline campaign period
21	28/03/2010 16:00	29/03/2010 06:00	C22	5	Plant off line due to power failure
22	29/04/2010 12:00	01/05/2010 22:00	C22	5	Plant off line due to power failure and maintenance work done
23	25/05/2010 23:00	26/05/2010 10:00	C22	5	Plant off line for capacity control
24	25/06/2010 18:00	26/06/2010 05:00	C22	5	Plant off line due to power failure and instrumentation air tripped.
25	28/07/2010 08:00	28/07/2010 12:00	C22	5	Unsteady analyzer output, repair on sampling pump - NCSG data replaced by Campaign maximum
26	03/08/2010 01:00		C22	5	Plant taken off for maintenance and gauze inspection
27	04/08/2010 03:00		C22b	6	Start of new campaign after adding two fresh layers of gauze
28	18/08/2010 05:00	20/08/2010 04:00	C22b	6	Offline to repair leaking condenser tubes.
29	08/09/2010 16:00	09/09/2010 01:45	C22b	6	Plant off line due to power failure
30	08/09/2010 16:00	05/11/2010 08:00	C22b	6	AMS Data collection interrupted - NCSG and VSG data replaced by Campaign maximum
31	16/11/2010 17:00		C22b	6	Plant offline for maintenance and gauze change

During project campaign 6 for the period 08/09/2010 16:00 until 05/11/2010 08:00 the data collection was interrupted due to a faulty cable connection. The missing data for NCSG and VSG was replaced with the maximum hourly average value that was recorded during that project campaign (except for the period 08/09/2010 16:00 until 09/09/2010 02:00 when the plant was offline due to a power failure). The missing data for operating temperature (OT<sub>h</sub>) was replaced with the last measured value as a default value for this period in order to allow the automatic calculation of operating hours that is based on the measurement of OT<sub>h</sub> (except for the period 08/09/2010 16:00 until 09/09/2010 02:00 when the plant was offline due to a power failure). It was cross-checked by the downtime report and the nitric acid production reports that the plant was in operation for this period.

*NO events or incidents of any relevance in regard to impacting the applicability of the methodology occurred during this 2<sup>nd</sup> monitoring period.*

<b>B.2. Revision of the monitoring plan</b>
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The monitoring plan has not been revised.

<b>B.3. Request for deviation applied to this monitoring period</b>
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NO deviation was applied to this monitoring period.

<b>B.4. Notification or request of approval of changes</b>
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NO notifications or request for approval of changes of the project activity as described in the registered CDM-PDD have been made.



## SECTION C. Description of the monitoring system

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### 1. General Description of the AMS (ABB URAS 14)

A complete Automated Monitoring System (AMS) to monitor the mass emissions of N<sub>2</sub>O 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<sub>2</sub>O 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 MIR 9000 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

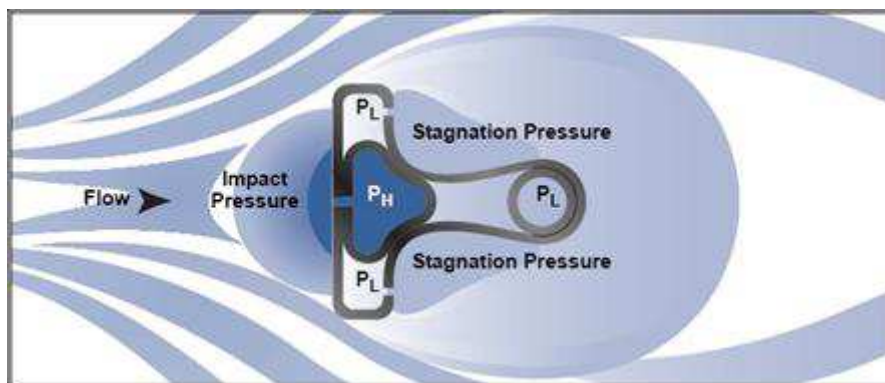
The Emerson Rosemount Flow Meter Annubar®, model no. 485, relies on the Averaging Pilot Tubes (APTs).

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. 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 (hereafter “N.serve”). It is the appropriate monitoring methodology to be used in conjunction with the baseline methodology AM0034, “Catalytic reduction of N<sub>2</sub>O 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 EN 14181 (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 N<sub>2</sub>O 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 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 the South African Bureau of Standards, 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. Albrecht von Ruffer, Managing Director of N.serve, is responsible for the correct analysis of the delivered data in accordance with the methodology.

## **7. Application of EN 14181 procedures to the project**

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

### **QAL1**

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 QAL1 suitability testing for N<sub>2</sub>O and it was not known if any vendors were in the process of obtaining this. The chosen gas analyser MIR 9000 from Environnement however, has passed the QAL1 suitability for measurements of NO<sub>x</sub> and other gaseous emissions. In addition QAL1 tests for N<sub>2</sub>O were successfully performed in 2007 by an independent 3<sup>rd</sup> party testing laboratory with EN ISO/IEC 17025 accreditation. The Environnement S.A. MIR 9000 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 certified<sup>1</sup> as meeting the requirements (QAL1) of the German emissions standards 17<sup>th</sup> BImSchV and 13<sup>th</sup> BImSchV (waste incineration plants, large furnaces and others) for the components NO, CO and SO<sub>2</sub>. At the time of commissioning of the AMS by AEL no AMS was available that had been certified according with EN 14181 QAL1 for N<sub>2</sub>O measurements. However, ABB has conducted and successfully completed the QAL1 tests<sup>2</sup> 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 QAL1 which is conducted off-site). QAL2 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 EN 14181, both the QAL2 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.

A series of QAL2 specific reference measurements using a the SRM method as per EN 14181 for guidance has been carried out at the plant for both above mentioned analysers separately by an accredited testing house (TÜV SÜD Industrie Service GmbH Germany; Müller BBM GmbH, Germany) to ensure the AMS' suitability, establish the calibration curve and test the variability of the measurements. The results of these SRM are available to the DOE as part of the verification process. The AMS calibration function as well as the total uncertainty of the AMS was determined. The results were applied in the calculation of EF<sub>BL</sub> and EF<sub>n</sub>.

An annual surveillance test (AST) is used 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.

According to the monitoring plan in the PDD it is not necessary to perform an AST by an accredited independent third party. Instead regular QAL3 procedures as periodic zero and span calibrations, checks of the analyser system and maintenance of the AMS are performed. However in addition to these calibrations, AEL decided to perform an AST test. For the N<sub>2</sub>O measurement at 11/06/2009 – 12/06/2009 and at 06/07/2010 an Annual Surveillance Test (AST) has been successfully performed by an accredited testing house. The test was performed in accordance with EN 14181. The AST test confirmed that the calibration function as determined during QAL2 is still valid and that the requirements for variability are fulfilled. For the stack gas flow measurement at 11/06/2009 – 12/06/2009 an AST test and at 06/07/2010 - 08/07/2010 a QAL2 test (including AST) has been successfully performed by an accredited testing house. The test was performed in accordance with EN 14181. The AST test confirmed that the calibration function as determined during QAL2 is still valid and that the requirements for variability are fulfilled. With the QAL2 test in 2010 a new QAL2 correction factor for stack gas flow was defined. This new factor was applied from the start of the campaign after the test onwards. This approach is conservative as the new correction factor is slightly lower than the old one and therefore this approach leads to less calculated CERs.

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

<sup>2</sup> TÜV Süd Industrie Service GmbH, München (Report number 821029) June 2006

In order to adhere the guidelines for assessing compliance with the calibration frequency requirements as stipulated in EB 52 annex 60 the maximum permissible error of the instruments for NCSG and VSG were applied. The error was applied in a conservative manner for the period between the scheduled AST or QAL2 test and the actual date of the AST or QAL2 test.

For NCSG the error was applied for the period from 08/06/2009 to 12/06/2009 (for the delay of the test in 2009) and for the period from 12/06/2010 to 06/07/2010 (for the delay of the test in 2010).

For VSG the error was applied for the period from 08/06/2009 to 12/06/2009 (for the delay of the test in 2009) and for the period from 12/06/2010 to 08/07/2010 (for the delay of the test in 2010). **8. 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 handbooks. The South African Bureau of Standards (SABS) is the designated auditor for these standards at AEL. Therefore, all of the monitoring equipment is subjected to the regular “SABS testing loops” as part of the ISO 9001/14001 procedures.

#### Calibration Gas

A certified N<sub>2</sub>O Calibration gas (balance being N<sub>2</sub>) with a precision of  $\pm 2\%$  is used in the span calibrations. The calibration gas is certified by an independent laboratory (Modderfontein Laboratory Services).

Modderfontein Laboratory Services (Pty) Ltd. is an independent chemical analysis laboratory which is certified by the South African Bureau of Standards (SABS).

#### Analyser Zero and Span Calibrations

According to the QAL1 reports and manufacturers specifications it is recommended to perform a zero/span calibration every 7 days for the Environnement MIR 9000 analyzer and 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.

#### Flow meter calibration procedures

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 the South Africa Bureau of Standards (SABS).

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 devise 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.

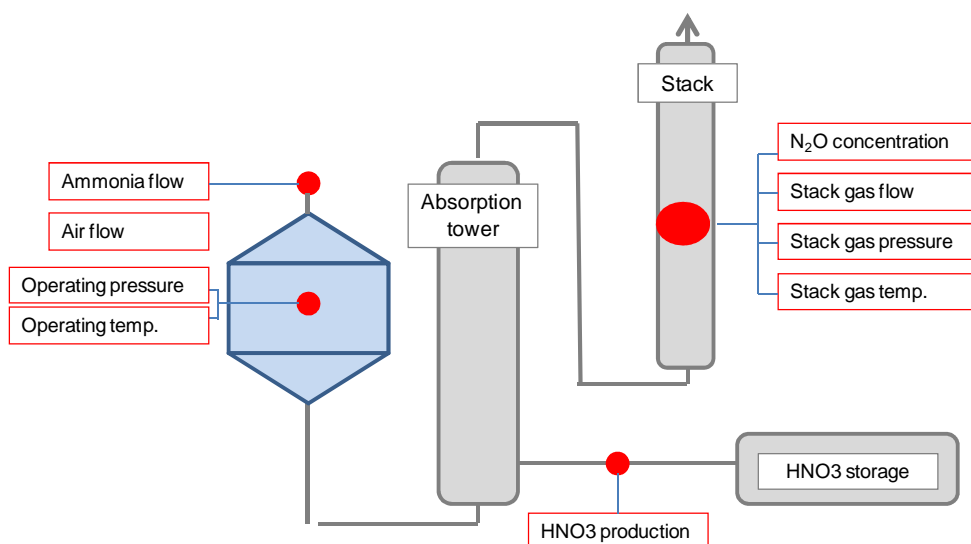


Figure: Monitoring Points for all relevant Parameters (NCSG, VSG, TSG, PSG, NAP, OT<sub>h</sub>, OP<sub>h</sub>, AFR

### 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.

### QAL3

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.

## **8.1 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 weeks 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 are sent to N.serve on a regular basis (e. g. after each campaign) where they are 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. For the purpose of plausibility checks and for transparency reasons all calculations are also provided in an EXCEL calculation sheet. This EXCEL calculation sheet will be submitted in addition to the N.DBMS documentation sheet along with the request for issuance to allow easy crosschecks and recalculations.

## SECTION D. Data and parameters

### D.1. Data and parameters determined at registration and not monitored during the monitoring period, including default values and factors

<b>Data / Parameter:</b>	<b>B.1 NCSG<sub>BC</sub></b>
Data unit:	<b>mg/Nm<sup>3</sup></b>
Description:	N <sub>2</sub> O concentration in the stack gas during the baseline campaign.
Source of data used:	NDIR N <sub>2</sub> O gas analyser (Environnement S.A. MIR 9000)
Value(s) :	Value applicable for <b>regular project campaigns</b> exceeding CL <sub>normal</sub> or CL <sub>BL</sub> : <b>1,630</b>  Value applicable for Project Campaign 4: <b>1,630</b> Value applicable for Project Campaign 5: <b>1,630</b> Value applicable for Project Campaign 6: N.A. because of the different gauze composition the EF <sub>BL</sub> default value was used
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Additional comment:	

<b>Data / Parameter:</b>	<b>B.2 VSG<sub>BC</sub></b>
Data unit:	<b>Nm<sup>3</sup>/h</b>
Description:	Normal gas volume flow rate of the stack gas during the baseline campaign.
Source of data used:	Gas Volume Flow meter, Emerson Rosemount Annubar® Model 485
Value(s) :	<b>72,468</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.3 BE<sub>BC</sub></b>
Data unit:	<b>tN<sub>2</sub>O</b>
Description:	Total N <sub>2</sub> O mass flow during baseline campaign
Source of data used:	Calculation from measured data.
Value(s) :	Value applicable for <b>regular project campaigns</b> exceeding CL <sub>normal</sub> or CL <sub>BL</sub> : <b>651,983</b>  Value applicable for Project Campaign 4: <b>651,983</b> Value applicable for Project Campaign 5: <b>651,983</b> Value applicable for Project Campaign 6: N.A. because of the different gauze composition the EF <sub>BL</sub> default value was used
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.4 OH<sub>BC</sub></b>
Data unit:	<b>hours</b>
Description:	Operating hours

Source of data used:	Production log
Value(s) :	<b>4,950</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.5 NAP<sub>BC</sub></b>
Data unit:	<b>tHNO<sub>3</sub></b>
Description:	Metric tonnes of 100% concentrated nitric acid produced during the baseline campaign.
Source of data used:	Coriolis mass flow meter measurements
Value(s) :	<b>134,700</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	The nitric acid flow meter is subject of external calibration procedures every 3 years.

<b>Data / Parameter:</b>	<b>B.6 TSG</b>
Data unit:	<b>°C</b>
Description:	Temperature in the stack gas
Source of data used:	Stack temperature probe situated directly next to the volume flow meter.
Value(s) :	<b>Not applicable</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	

<b>Data / Parameter:</b>	<b>B.7 PSG</b>
Data unit:	<b>Pa</b>
Description:	Pressure in the stack
Source of data used:	Stack temperature probe situated directly next to the volume flow meter.
Value(s) :	<b>Not applicable</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	The PSG result is automatically applied for calculating VSG at standard conditions

<b>Data / Parameter:</b>	<b>B.8 EF<sub>BL</sub></b>
Data unit:	<b>tN<sub>2</sub>O/tHNO<sub>3</sub></b>
Description:	Emissions factor for baseline period
Source of data used:	Calculated from measured data (tons of N <sub>2</sub> O emitted / tons of nitric acid produced)
Value(s) :	Value applicable for <b>regular project campaigns</b> exceeding CL <sub>normal</sub> or CL <sub>BL</sub> : <b>0.004647</b>  Value applicable for Project Campaign 4: <b>0.004647</b> Value applicable for Project Campaign 5: <b>0.004647</b> Value applicable for Project Campaign 6: 0,0045 (because of the different gauze composition the EF <sub>BL</sub> default value as per AM0034 was used)



Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.9 UNC</b>
Data unit:	%
Description:	Calculated overall uncertainty of the Automated Monitoring System (AMS)
Source of data used:	Engineering reports and calculations conducted by the manufacturer of the components of the AMS.
Value(s) :	<b>3.99</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline / Project emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.10 AFR</b>
Data unit:	tNH <sub>3</sub> /h
Description:	Mean Ammonia gas flow rate to the ammonia oxidation reactor
Source of data used:	Orifice plate
Value(s) :	Not applicable, monitored data of AFR will be used to determine if plant was operating outside of AFR <sub>max</sub> .
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.11 AFR<sub>max</sub></b>
Data unit:	tNH <sub>3</sub> /h
Description:	Maximum Ammonia gas flow rate to the ammonia oxidation reactor
Source of data used:	AFR data
Value(s) :	<b>9.094</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.12 AIFR</b>
Data unit:	% v/v
Description:	Mean Ammonia to air ratio into the ammonia oxidation reactor
Source of data used:	Measurements of AFR and primary air flow rates (measured by orifice plate).
Value(s) :	Not applicable, monitored data of AIFR will be used to determine if plant was operating outside of AIFR <sub>max</sub> .
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.13 CL<sub>BL</sub></b>
Data unit:	<b>tHNO<sub>3</sub></b>
Description:	Length of the baseline campaign measured in metric tonnes of 100% concentrated nitric acid produced during that baseline campaign.
Source of data used:	NAP <sub>BC</sub>
Value(s) :	<b>134,700</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.14 CL<sub>normal</sub></b>
Data unit:	<b>tHNO<sub>3</sub></b>
Description:	Average length of the historic campaigns measured in metric tonnes of 100% concentrated nitric acid produced during the historic campaigns.
Source of data used:	Coriolis Flow meter as described in NAP.
Value(s) :	<b>127,302.4</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline / Project emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B. 15 AIFR<sub>max</sub></b>
Data unit:	<b>% v/v</b>
Description:	Maximum Ammonia to air ratio into the ammonia oxidation reactor.
Source of data used:	Plant operating manual
Value(s) :	<b>11.5</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.16 OT<sub>h</sub></b>
Data unit:	<b>°C</b>
Description:	Oxidation temperature for each hour during the baseline campaign
Source of data used:	Monitoring results of three thermocouples inside the ammonia oxidation reactor and recorded by the data acquisition system.
Value(s) :	<b>Not applicable</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.17 OT<sub>normal</sub></b>
Data unit:	<b>°C (min and max)</b>
Description:	Normal range operating temperature

Source of data used:	Design specifications and operating manual of the No. 11 nitric acid plant (Technical Manual (TM4 June 1977, p. 250) <sup>3</sup> ).
Value(s) :	<b>820 to 905</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.18 OP<sub>h</sub></b>
Data unit:	<b>kPa (gauge)</b>
Description:	Oxidation Pressure for each hour during the baseline campaign
Source of data used:	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) :	<b>Not applicable.</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	The uncertainty of the pressure sensor is 0.125% according to the vendor. However, since the measurement uncertainty during the baseline campaign and during the project campaigns is the same, the two data series will always be comparable.

<b>Data / Parameter:</b>	<b>B.19 OP<sub>normal</sub></b>
Data unit:	<b>kPa (gauge) min and max</b>
Description:	Normal range of operating pressure in the ammonia oxidation reactor .
Source of data used:	Plant operating manual
Value(s) :	<b>365 – 450</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.20 GS<sub>normal</sub></b>
Data unit:	<b>Name of Supplier</b>
Description:	Gauze supplier for the operating condition (i.e. historic) campaigns
Source of data used:	Monitored / Invoices
Value(s) :	<b>W.C. Heraeus</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.21 GS<sub>BL</sub></b>
Data unit:	<b>Name of Supplier</b>
Description:	Gauze supplier for the baseline condition campaign
Source of data used:	Monitored / Invoices
Value(s) :	<b>W.C. Heraeus</b>

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<sup>3</sup> Copies of the technical plant manuals can be provided to the DOE upon request.

Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	B.23 GC <sub>normal</sub>				
Data 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 used:	Monitored / Gauze supplier invoices				
Value(s) :	Platinum (Pt) 56.5%; Rhodium (Rh) 3.8%; Palladium (Pd) 39.7%				
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.				
Additional comment:	Record of Gauze compositions installed during the historic campaigns <sup>4</sup> :				
	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

<b>Data / Parameter:</b>	<b>B.24 GC<sub>BL</sub></b>
Data 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 used:	Monitored / Gauze supplier invoices
Value(s) :	<b>Platinum (Pt) 56%; Rhodium (Rh) 3.8%; Palladium (Pd) 40.2%</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline / Project emission calculations.
Additional comment:	None

<b>Data / Parameter:</b>	<b>B.26 EF<sub>reg</sub></b>
Data unit:	tN <sub>2</sub> O/tHNO <sub>3</sub>
Description:	Emissions cap for N <sub>2</sub> O from nitric acid production set by government regulation
Source of data used:	Department of Environmental Affairs and Tourism
Value(s) :	<b>None</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline / Project emission calculations.
Additional comment:	None.

<sup>4</sup> 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.

## D.2. Data and parameters monitored

<b>Data / Parameter:</b>	<b>NCSG</b>
Data unit:	<b>mg/Nm<sup>3</sup></b> (convertible from ppmv, if required)
Description:	N <sub>2</sub> 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:	NDIR N <sub>2</sub> O gas analyser (ABB AO2040 Uras-14)
Value(s) of monitored parameter:	Project Campaign 4: <b>441.61</b> Project Campaign 5: <b>192.04</b> Project Campaign 6: <b>258.95</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	<p>Type: N<sub>2</sub>O gas analyser, nondispersive infrared sensor (NDIR) spectrometry</p> <p>Measurement accuracy (for N<sub>2</sub>O): 2.69%</p> <p>Serial Number: <i>Instrument number 3.346854.7</i></p> <p>Calibration frequency:</p> <ul style="list-style-type: none"> <li>- <i>External calibration: QAL2 every 5 years;</i></li> <li>- <i>External calibration: AST every year;</i></li> <li>- <i>Internal calibration: twice per week manual calibration with test gas</i></li> </ul> <p>Date of last external calibration:</p> <p style="margin-left: 40px;"><i>QAL2 Test – 09/02/2008-11/02/2008 valid until 2013</i></p> <p style="margin-left: 40px;"><i>AST Test – 11/06/2009-12/06/2009 valid until 2010</i></p> <p style="margin-left: 40px;"><i>AST Test – 06/07/2010 valid until 2011</i></p>
Measuring/ Reading/ Recording frequency:	Continuously (every 2 seconds)
Calculation method (if applicable):	<p>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"> <li>a) Calculate the sample mean (x)</li> <li>b) Calculate the sample standard deviation (s)</li> <li>c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)</li> <li>d) Eliminate all data that lie outside the 95% confidence interval</li> <li>e) Calculate the new sample mean from the remaining NCSG values</li> </ol> <p>During the QAL2 reference measurements it was determined that the analyser consistently overestimates the N<sub>2</sub>O concentration in the stack. As a result from the QAL2 calibration curve, it was determined that a correction factor of 0.99 will have to be applied to all NCSG</p>

	<p>measurements. Therefore, the result of the above statistical analysis, i.e. the mean NCSG value will be multiplied by 0.99 before going into the calculation of <math>PE_n</math>.</p> <p>During project campaign 6 for the period 08/09/2010 16:00 until 05/11/2010 08:00 the data collection was interrupted due to a faulty cable connection. The missing data was replaced with the maximum hourly average value that was recorded during that project campaign.</p>
QA/QC procedures applied:	<p>Bi-weekly Zero and Span check and calibration performed by trained AEL personnel. Documentation in form of calibration reports and Shewart charts</p> <p>every 5 years QAL2 test (including AST) according to EN 14181 (External by qualified institute)</p> <p>yearly AST test according to EN 14181 (External by qualified institute)</p> <p>Calibration delay: In order to adhere the guidelines for assessing compliance with the calibration frequency requirements as stipulated in EB 52 annex 60 the maximum permissible error of the instrument for NCSG was applied. The error was applied in a conservative manner for the period between the scheduled AST test and the actual date of the AST test. For NCSG the error was applied for the period from 08/06/2009 to 12/06/2009 (for the delay of the test in 2009) and for the period from 12/06/2010 to 06/07/2010 (for the delay of the test in 2010).</p>

<b>Data / Parameter:</b>	<b>VSG</b>
Data unit:	<b>Nm<sup>3</sup>/h</b>
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:	Project Campaign 4: <b>78,109</b> Project Campaign 5: <b>77,173</b> Project Campaign 6: <b>83,845</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	<p>Type: Tail gas flow by differential pressure principle</p> <p>Overall measurement accuracy: 2.84% (<i>per QAL 2 report</i>)</p> <p>Combined uncertainty for the normalized stack gas flow at standard conditions: 2.96% (<i>per QAL 2 report</i>)</p> <p>Serial Number: <i>instrument number N/A</i></p> <p>Calibration frequency:</p> <ul style="list-style-type: none"> <li>- External calibration: QAL2 every 5 years;</li> <li>- External calibration: AST every year;</li> <li>- Internal calibrations: after each campaign (usually every 7 month)</li> </ul> <p>Date of last external calibration:</p>

	<p><i>QAL2 Test – 01/08/2007 – 03/08/2007 valid until 2012</i></p> <p><i>AST Test – 11/06/2009 – 12/06/2009 valid until 2010</i></p> <p><i>QAL2 Test (including AST) – 06/07/2010 – 08/07/2010 valid until 2015</i></p>
Measuring/ Reading/ Recording frequency:	Continuously (every 2 seconds).
Calculation method (if applicable):	<p>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 Nm<sup>3</sup>/h as required by AM0034 and where subsequently subjected to the following statistical analysis:</p> <ol style="list-style-type: none"> <li>Calculate the sample mean (x)</li> <li>Calculate the sample standard deviation (s)</li> <li>Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)</li> <li>Eliminate all data that lie outside the 95% confidence interval</li> <li>Calculate the new sample mean from the remaining VSG values</li> </ol> <p>During the QAL2 reference measurements in 2007 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 PE<sub>n</sub>.</p> <p>With the QAL2 test in 2010 a new QAL2 correction factor for stack gas flow was defined. This new factor was applied from the start of the campaign after the test onwards. This approach is conservative as the new correction factor of 0.96 is slightly lower than the old one and therefore this approach leads to less calculated CERs.</p> <p>During project campaign 6 for the period 08/09/2010 16:00 until 05/11/2010 08:00 the data collection was interrupted due to a faulty cable connection. The missing data was replaced with the maximum hourly average value that was recorded during that project campaign.</p>
QA/QC procedures applied:	<p>internal calibration at least once per year usually every 7 month 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 test according to EN 14181 (External by qualified institute)</p>

	<p>Calibration delay: In order to adhere the guidelines for assessing compliance with the calibration frequency requirements as stipulated in EB 52 annex 60 the maximum permissible error of the instruments for VSG was applied. The combined error for Stack gas flow, TSG and PSG was applied to the results for VSG (applied value: 2.96%). The error was applied in a conservative manner for the period between the scheduled AST test and the actual date of the AST test. For VSG the error was applied for the period from 08/06/2009 to 12/06/2009 (for the delay of the test in 2009) and for the period from 12/06/2010 to 08/07/2010 (for the delay of the test in 2010).</p>
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<b>Data / Parameter:</b>	<b>PE<sub>n</sub></b>
Data unit:	<b>tN<sub>2</sub>O</b>
Description:	Total mass N <sub>2</sub> O emissions in each project campaign.
Measured /Calculated /Default:	Calculated.
Source of data:	Calculated from measured values.
Value(s) of monitored parameter:	Project Campaign 4: <b>153.27</b> Project Campaign 5: <b>75.177</b> Project Campaign 6: <b>50.58</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	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> <p>QAL2 correction functions are applied in the calculation</p>
QA/QC procedures applied:	Not applicable.

<b>Data / Parameter:</b>	<b>OH<sub>n</sub></b>
Data unit:	<b>Hours</b>
Description:	Total operating hours during each project campaign
Measured /Calculated /Default:	Measured.
Source of data:	Process Control System.
Value(s) of monitored parameter:	Project Campaign 4: <b>4,444</b> Project Campaign 5: <b>5,073</b> Project Campaign 6: <b>2,451</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type,	Not applicable.



accuracy class, serial number, calibration frequency, date of last calibration, validity)	
Measuring/ Reading/ Recording frequency:	The total operating hours are logged continuously.
Calculation method (if applicable):	Not applicable.
QA/QC procedures applied:	The production logging process is subject to ISO 9001 procedures

<b>Data / Parameter:</b>	<b>NAP</b>
Data unit:	<b>tHNO<sub>3</sub></b>
Description:	Metric tonnes of 100% concentrated nitric acid during each project campaign.
Measured /Calculated /Default:	Measured / Calculated.
Source of data:	Coriolis mass flow meter measurements.
Value(s) of monitored parameter:	Project Campaign 4: <b>129,361</b> Project Campaign 5: <b>150,111</b> Project Campaign 6: <b>72,510</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Emerson CMF 300, Coriolis mass flow meter Overall measurement accuracy: $\leq 0,1 \%$ Serial Number: 414940 Calibration frequency: once every 3 years (although the calibration is valid for 3 years, it is done more frequently) Date of last calibration: <i>24/02/2009 valid until 2012</i>
Measuring/ Reading/ Recording frequency:	Continuously
Calculation method (if applicable):	NAP is determined in the following way: 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 applied:	Subjected to complete SABS testing loops as part of the ISO 9001/14001 procedures. The mass flow meter is calibrated in regular intervals.

<b>Data / Parameter:</b>	<b>TSG</b>
Data unit:	<b>°C</b>
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
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	<p>Type: Rosemont thermocouple, PT100_385 3-wire RTD  Overall measurement accuracy: 2.55% (per QAL2 report)  Serial Number: <i>instrument number N/A</i>  Calibration frequency:  - <i>External calibration: QAL2 every 5 years;</i>  - <i>External calibration: AST every year;</i>  - <i>Internal calibrations: after each campaign (usually every 7 month)</i></p> <p>Date of last external calibration:  <i>QAL2 Test – 01/08/2007 – 03/08/2007 valid until 2012</i>  <i>AST Test – 11/06/2009 – 12/06/2009 valid until 2010</i>  <i>QAL2 Test (including AST) – 06/07/2010 – 08/07/2010 valid until 2015</i></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.
QA/QC procedures applied:	<p>internal calibration at least once per year usually every 7 month 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 test according to EN 14181 (External by qualified institute)</p> <p>Calibration delay: In order to adhere the guidelines for assessing compliance with the calibration frequency requirements as stipulated in EB 52 annex 60 the maximum permissible error of the instruments for VSG was applied. The combined error for Stack gas flow, TSG and PSG was applied to the results for VSG. The error was applied in a conservative manner for the period between the scheduled AST test and the actual date of the AST test. For VSG the error was applied for the period from 08/06/2009 to 12/06/2009 (for the delay of the test in 2009) and for the period from 12/06/2010 to 08/07/2010 (for the delay of the test in 2010).</p>

<b>Data / Parameter:</b>	<b>PSG</b>
Data unit:	<b>bar (absolute)</b>
Description:	Pressure in the stack
Measured /Calculated /Default:	Measured.

Source of data:	Stack pressure probe situated directly next to flow meter
Value(s) of monitored parameter:	Not applicable, directly used for normalization of tail gas volume flow measurement.
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	<p>Type: Rosemont</p> <p>Overall measurement accuracy: 0.7 % (per QAL2 report)</p> <p>Serial Number: <i>instrument number N/A</i></p> <p>Calibration frequency:</p> <ul style="list-style-type: none"> <li>- <i>External calibration: QAL2 every 5 years;</i></li> <li>- <i>External calibration: AST every year;</i></li> <li>- <i>Internal calibrations: after each campaign (usually every 7 month)</i></li> </ul> <p>Date of last external calibration:</p> <p><i>QAL2 Test – 01/08/2007 – 03/08/2007 valid until 2012</i></p> <p><i>AST Test – 11/06/2009 – 12/06/2009 valid until 2010</i></p> <p><i>QAL2 Test (including AST) – 06/07/2010 – 08/07/2010 valid until 2015</i></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 applied:	<p>internal calibration at least once per year usually every 7 month 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 test according to EN 14181 (External by qualified institute)</p> <p>Calibration delay: In order to adhere the guidelines for assessing compliance with the calibration frequency requirements as stipulated in EB 52 annex 60 the maximum permissible error of the instruments for VSG was applied. The combined error for Stack gas flow, TSG and PSG was applied to the results for VSG. The error was applied in a conservative manner for the period between the scheduled AST test and the actual date of the AST test. For VSG the error was applied for the period from 08/06/2009 to 12/06/2009 (for the delay of the test in 2009) and for the period from 12/06/2010 to 08/07/2010 (for the delay of the test in 2010).</p>

<b>Data / Parameter:</b>	<b>EF<sub>n</sub></b>
Data unit:	tN <sub>2</sub> O/tHNO <sub>3</sub>
Description:	Emissions factor for campaign n.

Measured /Calculated /Default:	Calculated.
Source of data:	Calculation from total mass N <sub>2</sub> O emissions of campaign n (PE <sub>n</sub> ) and total nitric acid production (NAP <sub>n</sub> )
Value(s) of monitored parameter:	Project Campaign 4: <b>0.00118</b> Project Campaign 5: <b>0.00050</b> Project Campaign 6: <b>0.00070</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	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 <sub>2</sub> 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 applied:	Not applicable.

<b>Data / Parameter:</b>	<b>EF<sub>ma,n</sub></b>
Data unit:	tN <sub>2</sub> O/tHNO <sub>3</sub>
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 <sub>n</sub> )
Value(s) of monitored parameter:	Project Campaign 4: <b>0.00107</b> Project Campaign 5: <b>0.00096</b> Project Campaign 6: <b>0.00091</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	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 <sub>ma,n</sub> is established over time, becoming more representative and precise with each additional campaign.

QA/QC procedures applied:	Not applicable.
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<b>Data / Parameter:</b>	<b>EF<sub>p</sub></b>
Data unit:	<b>tN<sub>2</sub>O/tHNO<sub>3</sub></b>
Description:	Emissions factor used for the specific campaign n to determine the emission reductions of that campaign
Measured /Calculated /Default:	Calculated.
Source of data:	Calculation of EF <sub>n</sub> and EF <sub>ma,n</sub> .
Value(s) of monitored parameter:	Project Campaign 4: <b>0.00118</b> Project Campaign 5: <b>0.00096</b> Project Campaign 6: <b>0.00091</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	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 <sub>ma,n</sub> and EF <sub>n</sub> shall be applied as the emission factor relevant for the particular campaign to be used to calculate emissions reductions (EF <sub>p</sub> ). Thus:  If EF <sub>ma,n</sub> > EF <sub>n</sub> then EF <sub>p</sub> = EF <sub>ma,n</sub>  If EF <sub>ma,n</sub> < EF <sub>n</sub> then EF <sub>p</sub> = EF <sub>n</sub>
QA/QC procedures applied:	Not applicable.

<b>Data / Parameter:</b>	<b>EF<sub>min</sub></b>
Data unit:	<b>tN<sub>2</sub>O/tHNO<sub>3</sub></b>
Description:	EF <sub>min</sub> is equal to the lowest EF <sub>n</sub> observed during the first 10 campaigns of the project crediting period.
Measured /Calculated /Default:	Calculated.
Source of data:	Calculations from EF <sub>n</sub>
Value(s) of monitored parameter:	Only applicable after 10 project campaigns
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	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 <sub>2</sub> 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 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 $EF_n$ .
QA/QC procedures applied:	Not applicable.

<b>Data / Parameter:</b>	<b><math>CL_n</math></b>
Data unit:	<b><math>tHNO_3</math></b>
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 4: <b>129,361</b> Project Campaign 5: <b>150,111</b> Project Campaign 6: <b>72,510</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	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 $N_2O$ 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 $N_2O$ 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 $EF_n$ .
QA/QC procedures applied:	See comments for NAP above

<b>Data / Parameter:</b>	<b><math>OP_h</math></b>
Data unit:	<b>kPa (gauge)</b>
Description:	Oxidation Pressure for each hour
Measured /Calculated /Default:	Measured.
Source of data:	Discharge of the air compressor before the ammonia to air mixer
Value(s) of monitored parameter:	<b>Not applicable. Used to determine when plant is operating outside of permitted range during baseline campaign or if the plant is out of operation.</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable.

Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Continuously
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Subject to ISO 9001/14001 procedures.

<b>Data / Parameter:</b>	<b>OT<sub>h</sub></b>
Data unit:	°C
Description:	Oxidation temperature in the ammonia oxidation reactor (AOR) for each hour.
Measured /Calculated /Default:	Measured.
Source of data:	Monitoring results of three thermocouples inside the ammonia oxidation reactor and recorded by the data acquisition system.
Value(s) of monitored parameter:	<b>Not applicable. Used to determine when plant is operating outside of permitted range during baseline campaign or if the plant is out of operation.</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable
Measuring/ Reading/ Recording frequency:	Continuously
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Subject to ISO 9001/14001 procedures.

<b>Data / Parameter:</b>	<b>AFR</b>
Data unit:	<b>tNH<sub>3</sub>/h</b>
Description:	Ammonia gas flow rate to the ammonia oxidation reactor.
Measured /Calculated /Default:	Measured.
Source of data:	Orifice plate
Value(s) of monitored parameter:	<b>Not applicable, monitored data of AFR will be used to determine if the plant operating outside of AFR<sub>max</sub> during the baseline campaign or for plausibility checks</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable
Measuring/ Reading/	The ammonia flow is continuously measured by orifice plate.

Recording frequency:	
Calculation method (if applicable):	Not applicable
QA/QC procedures applied:	Subject to ISO 9001/14001 procedures.

<b>Data / Parameter:</b>	<b>AIFR</b>
Data 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:	<b>Not applicable, monitored data of AIFR will be used to determine if the plant operating outside of AIFR<sub>max</sub> during the baseline campaign or for plausibility checks</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if applicable):	AIFR is calculated from AFR and the primary air flow to the ammonia oxidation reactor. The airflow rate is measured by orifice plate and expressed in kg/h and is then converted to Nm <sup>3</sup> /h, which is used in the ratio calculation.
QA/QC procedures applied:	Subject to ISO 9001/14001 procedures.

<b>Data / Parameter:</b>	<b>GS<sub>project</sub></b>
Data unit:	<b>Name of Supplier</b>
Description:	Gauze supplier for the project campaign
Measured /Calculated /Default:	Not applicable.
Source of data:	Monitored / Invoices
Value(s) of monitored parameter:	<b>W.C. Heraeus</b>
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if applicable):	Not applicable.
QA/QC procedures applied:	Not applicable.



<b>Data / Parameter:</b>	<b>GC<sub>project</sub></b>			
Data unit:	<b>%</b>			
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:	<b>Campaign</b>	<b>Platinum</b>	<b>Rhodium</b>	<b>Palladium</b>
	PC4	54.53%	3.74%	41.73%
	PC5	56.0%	3.8%	40.2%
	PC6	61.7%	4.0%	34.3%
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable.			
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.			
Measuring/ Reading/ Recording frequency:	Not applicable.			
Calculation method (if applicable):	Not applicable.			
QA/QC procedures applied:	Not applicable.			

## SECTION E. Emission reductions calculation

### E.1. Baseline emissions calculation

>>

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. For the purpose of plausibility checks and for transparency reasons all calculations are also provided in an EXCEL calculation sheet. This EXCEL calculation sheet will be submitted in addition to the N.DBMS documentation sheet along with the request for issuance to allow easy crosschecks and recalculations.

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.

Historic data of daily  $\text{NH}_3$  consumption was used to determine the range of AFR for the five historic campaigns (excluding abnormal campaigns). After removing the top 2.5 percentile values the maximum daily flow rate was derived which was then converted into an hourly Ammonia flow rate, which was used to determine AIFR.

The following data was established from the above mentioned sources as permitted operating conditions:

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%  
 $\text{CL}_{\text{normal}}$ : 127,302.4 t  $\text{HNO}_3$

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 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:

$\text{NCSG}_{\text{BL}}$	mg/Nm <sup>3</sup>	1,630.03
QAL2 NCSG		1.10
$\text{VSG}_{\text{BL}}$	Nm <sup>3</sup> /h	72,468.01
QAL2 VSG		1.01
$\text{OH}_{\text{BL}}$	h	4,950

NAP <sub>BL</sub>	t HNO <sub>3</sub>	134,699.80
BE	t N <sub>2</sub> O	651.98
UNC		3.99
EF <sub>BL</sub>	kg N <sub>2</sub> O/t HNO <sub>3</sub>	4.647

#### **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  $CL_{normal}$ , then all N<sub>2</sub>O values measured during the baseline campaign can be used for the calculation of EF<sub>BL</sub>. If  $CL_n < CL_{normal}$ , EF<sub>BL</sub> has to be recalculated by eliminating those N<sub>2</sub>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<sub>BL</sub>.

*Since for the first two campaigns (Project Campaign 4 and Project Campaign 5) of this monitoring period  $CL_n > CL_{BL}$ , the above determined EF<sub>BL</sub> is valid and will be used for the calculation of respective emission reduction. For Project Campaign 6 of this monitoring period  $CL_n < CL_{BL}$ . However due to the difference in gauze composition for Project campaign 6 (gauze composition in project campaign different from gauze composition in baseline campaign) the default baseline emission factor of 4.5 kgN<sub>2</sub>O/tHNO<sub>3</sub> is used for project campaign 6.*

#### **Adjustment of Baseline emissions factor due to EF<sub>reg</sub>**

Should N<sub>2</sub>O 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<sub>BL</sub>). 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<sub>2</sub>O emission factor shall be EF<sub>reg</sub> for all calculations.

where:

Variable Definition

EF<sub>BL</sub> Baseline emissions factor (tN<sub>2</sub>O/tHNO<sub>3</sub>)

EF<sub>reg</sub> Emissions level set by newly introduced policies or regulations (tN<sub>2</sub>O/tHNO<sub>3</sub>).

Such EF<sub>reg</sub> 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<sub>2</sub>O regulation for nitric acid plants in South Africa therefore no adjustment of the Baseline emissions factor EF<sub>BL</sub> is necessary.**

### **E.2. Project emissions calculation**

>>

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 (Nm <sup>3</sup> /h)
NCSG	Mean concentration of N <sub>2</sub> O in the stack gas for the project campaign (mgN <sub>2</sub> O/Nm <sup>3</sup> )
PE <sub>n</sub>	Total N <sub>2</sub> O emissions of the n <sup>th</sup> project campaign (tN <sub>2</sub> O)

OH	Is the number of hours of operation in the specific monitoring period (h)
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Based on the total N<sub>2</sub>O emissions of each project campaign the specific project campaign emission factor is calculated as:

$$EF_n = PE_n / NAP_n$$

Where:

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

Before calculation of the Project Emissions (PE) the same statistical analysis as for the calculation of the baseline emission factor (EF<sub>BL</sub>) 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.

### Analysis of Project campaign data

#### Query 1 (Raw data): Analysis of the raw campaign data

This set of data shows a summary of the collected raw data for both complete project campaigns.

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 21 08.06.09 - 27.12.09									
Project campaign 4 Query 1: Without parameter limits 68									
Parameter	OH	AFR	AIFR	Oph	OTh	NCSG	VSG	NAP	
Unit	h	t NH3 / h	ratio	Pa	°C	mg N2O / Nm3	Nm3 / h	t HNO3	
Count	4,850	4,850	4,850	4,850	4,850	4,850	4,850		
Minimum		0.01	0.00	152.00	801	0.00	0		
Maximum		8.66	1.0	425,671.0	902	2,662	86,029		
Mean		7.48	0.11	355,285.7	889	456	71,436		
Standard deviation		2.283	0.08	103,748.14	27	468	21,520		
95% confidence level (1.96 * Std.dev.)		4.47	0.15	203,346.35	53	917	42,180		
Sum	4,850								129,361
Limits acc. to consistency check									
Lower limit									
Upper limit									

According to this Query 1, the NAP value of Project campaign 4 is 129,361 t of nitric acid

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 22 30.12.09 - 03.08.10									
Project campaign 5 Query 1: Without parameter limits 68									
Parameter	OH	AFR	AIFR	Oph	OTh	NCSG	VSG	NAP	
Unit	h	t NH3 / h	ratio	Pa	°C	mg N2O / Nm3	Nm3 / h	t HNO3	
Count	5,188	5,188	5,140	5,188	5,188	5,188	5,188		
Minimum		0.00	0.00	0.00	801	0.00	0		
Maximum		8.61	1.0	425,257.0	901	363	86,775		
Mean		7.90	0.11	378,740.6	893	190	75,421		
Standard deviation		1.427	0.07	60,798.62	14	35	11,766		
95% confidence level (1.96 * Std.dev.)		2.80	0.14	119,165.30	28	69	23,061		
Sum	5,188								150,111
Limits acc. to consistency check									
Lower limit									
Upper limit									

According to this Query 1, the NAP value of Project campaign 5 is 150,111 t of nitric acid

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 22b 04.08.10 - 16.11.10									
Project campaign 6 Query 1: Without parameter limits 108									
Parameter	OH	AFR	AIFR	Oph	OTH	NCSG	VSG	NAP	
Unit	h	t NH3 / h	ratio	Pa	°C	mg N2O / Nm3	Nm3 / h	t HNO3	
Count	2,520	2,520	2,520	2,520	2,520	2,520	2,520		
Minimum		0.00	0.00	0.00	0	0.00	0		
Maximum		8.58	0.4	426,044.0	897	300	86,197		
Mean		3.49	0.05	171,920.7	889	251	81,106		
Standard deviation		4.041	0.06	198,517.41	61	46	13,936		
95% confidence level (1.96 * Std.dev.)		7.92	0.12	389,094.12	119	90	27,315		
Sum	2,520								72,510
Limits acc. to consistency check									
Lower limit									
Upper limit									

According to this Query 1, the NAP value of Project campaign 6 is 72,510 t of nitric acid

These tables give the raw results for NAP, OH, NCSG, VSG and EF<sub>n</sub>.

### Query 2: Elimination of faulty data outside operational limits

In this query (Query 2), the operational limits of the plant are applied. Lines of data in which at least one value indicates that the plant is out of operation (trip values) are completely eliminated from further analysis. The design “trip” temperature, i.e. the temperature inside the ammonia oxidation reactor below which the plant shuts down automatically has been applied to exclude such lines of data. During the project, the “trip temperature” of 820 °C will be applied as the exclusion criterion for determining those hours during which the plant was offline during a campaign.

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 21 08.06.09 - 27.12.09									
Project campaign 4 Query 2: With operational limits 72									
Parameter	OH	AFR	AIFR	Oph	OTH	NCSG	VSG	NAP	
Unit	h	t NH3 / h	ratio	Pa	°C	mg N2O / Nm3	Nm3 / h	t HNO3	
Count	4,444	4,444	4,444	4,444	4,444	4,444	4,444		
Remaining share of data sets	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%		
Minimum		1.23	0.07	88,015.00	820	100	13,379		
Maximum		8.66	0.10	425,671.0	902	2,662	86,029		
Mean		8.15	0.10	385,717.7	897	496	77,754		
Standard deviation		0.444	0.002	21,133.662	5.9	469	5,051		
95% confidence level (1.96 * Std.dev.)		0.870	0.003	41,421.978	11.5	919	9,899		
Sum	4,444								129,361
Limits acc. to consistency check									
Lower limit					820				
Upper limit									

As a result of this query the number of operation hours OH of Project campaign 4 is 4,444 h.

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 22 30.12.09 - 03.08.10									
Project campaign 5 Query 2: With operational limits 92									
Parameter	OH	AFR	AIFR	Oph	OTH	NCSG	VSG	NAP	
Unit	h	t NH3 / h	ratio	Pa	°C	mg N2O / Nm3	Nm3 / h	t HNO3	
Count	5,073	5,073	5,025	5,073	5,073	5,073	5,073		
Remaining share of data sets	97.8%	97.8%	97.8%	97.8%	97.8%	97.8%	97.8%		
Minimum		0.00	0.09	0.00	842	130	37,117		
Maximum		8.61	0.10	425,257.0	901	323	86,775		
Mean		8.07	0.10	386,706.3	896	194	77,083		
Standard deviation		0.819	0.001	29,204.613	2.7	25	4,041		
95% confidence level (1.96 * Std.dev.)		1.605	0.002	57,241.042	5.3	48	7,921		
Sum	5,073								150,111
Limits acc. to consistency check									
Lower limit					820				
Upper limit									

As a result of this query the number of operation hours OH of Project campaign 5 is 5,073 h.

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 22b 04.08.10 - 16.11.10									
Project campaign 6 Query 2: With operational limits 112									
Parameter	OH	AFR	AIFR	Oph	OTH	NCSG	VSG	NAP	
Unit	h	t NH3 / h	ratio	Pa	°C	mg N2O / Nm3	Nm3 / h	t HNO3	
Count	2,451	2,451	2,451	2,451	2,451	2,451	2,451		
Remaining share of data sets	97.3%	97.3%	97.3%	97.3%	97.3%	97.3%	97.3%		
Minimum		0.00	0.00	0.00	856	139	47,896		
Maximum		8.58	0.10	426,044.0	897	300	86,197		
Mean		3.59	0.04	176,274.8	895	258	83,338		
Standard deviation		4.056	0.048	199,436.273	2.4	21	4,141		
95% confidence level (1.96 * Std.dev.)		7.950	0.095	390,895.095	4.7	41	8,116		
Sum	2,451								72,510
Limits acc. to consistency check									
Lower limit					820				
Upper limit									

As a result of this query the number of operation hours OH of Project campaign 6 is 2,451 h.

### Query 6: application of confidence interval to eliminate outliers

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.

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 21 08.06.09 - 27.12.09									
Project campaign 4 Q6: Q2 + confidence levels 76 80 72									
Parameter	OH	AFR	AIFR	Oph	OTh	NCSG	VSG	NAP	
Unit	h	t NH3 / h	ratio	Pa	°C	mg N2O / Nm3	Nm3 / h	t HNO3	
Count						4,242	4,399		
Remaining share of data sets									
Minimum		1.228	0.07	88,015.00	820	100	68,127		
Maximum		8.66	0.10	425,671.0	902	1,415	86,029		
Mean		8.15	0.10	385,717.7	897	441.61	78,109		
Standard deviation		0.444	0.002	21,133.662	5.9	404	3,336		
95% confidence level (1.96 * Std.dev.)		0.870	0.003	41,421.978	11.5	792	6,539		
Sum	4,444							129,361	
Limits acc. to consistency check									
Lower limit					820	-424	67,855		
Upper limit						1,415	87,653		
						0.9900	1.0100		
Campaign emissions	PE	= VSG * NCSG * Oh * 10 <sup>-9</sup>					t N2O	153.27	
Emission factor	EF_n	= PE / NAP * 10 <sup>3</sup>					kg N2O / t HNO3	1.18	

As a result of this query the mean NCSG value for Project campaign 4 is 441.61 mg N2O / Nm3

As a result of this query the mean VSG value for Project campaign 4 is 78,109 Nm3 / h

As a result of this query the result for EFn for Project campaign 4 is 1.18 kg N2O / t HNO3

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 22 30.12.09 - 03.08.10									
Project campaign 5 Q6: Q2 + confidence levels 96 100 92									
Parameter	OH	AFR	AIFR	Oph	OTh	NCSG	VSG	NAP	
Unit	h	t NH3 / h	ratio	Pa	°C	mg N2O / Nm3	Nm3 / h	t HNO3	
Count						4,906	4,965		
Remaining share of data sets									
Minimum		0.000	0.09	0.00	842	145	69,166		
Maximum		8.61	0.10	425,257.0	901	242	84,997		
Mean		8.07	0.10	386,706.3	896	192.04	77,173		
Standard deviation		0.819	0.001	29,204.613	2.7	21	3,748		
95% confidence level (1.96 * Std.dev.)		1.605	0.002	57,241.042	5.3	40	7,346		
Sum	5,073							150,111	
Limits acc. to consistency check									
Lower limit					820	145	69,162		
Upper limit						242	85,004		
						0.9900	1.0100		
Campaign emissions	PE	= VSG * NCSG * Oh * 10 <sup>-9</sup>					t N2O	75.18	
Emission factor	EF_n	= PE / NAP * 10 <sup>3</sup>					kg N2O / t HNO3	0.50	

As a result of this query the mean NCSG value for Project campaign 5 is 192.04 mg N2O / Nm3

As a result of this query the mean VSG value for Project campaign 5 is 77,173 Nm3 / h

As a result of this query the result for EFn for Project campaign 5 is 0.50 kg N2O / t HNO3

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 22b 04.08.10 - 16.11.10									
Project campaign 6 Q6: Q2 + confidence levels 116 120 112									
Parameter	OH	AFR	AIFR	Oph	OTh	NCSG	VSG	NAP	
Unit	h	t NH3 / h	ratio	Pa	°C	mg N2O / Nm3	Nm3 / h	t HNO3	
Count						2,419	2,337		
Remaining share of data sets									
Minimum		0.000	0.00	0.00	856	217	75,229		
Maximum		8.58	0.10	426,044.0	897	275	86,197		
Mean		3.59	0.04	176,274.8	895	258.95	83,845		
Standard deviation		4.056	0.048	199,436.273	2.4	20	3,364		
95% confidence level (1.96 * Std.dev.)		7.950	0.095	390,895.095	4.7	39	6,594		
Sum	2,451							72,510	
Limits acc. to consistency check									
Lower limit					820	217	75,222		
Upper limit						299	91,453		
						0.9900	0.9600		
Campaign emissions	PE	= VSG * NCSG * Oh * 10 <sup>-9</sup>					t N2O	50.58	
Emission factor	EF_n	= PE / NAP * 10 <sup>3</sup>					kg N2O / t HNO3	0.70	

As a result of this query the mean NCSG value for Project campaign 6 is 258.95 mg N2O / Nm3

As a result of this query the mean VSG value for Project campaign 6 is 83,845 Nm3 / h

As a result of this query the result for EFn for Project campaign 6 is 0.70 kg N2O / t HNO3

### Relevant Project Emissions (PE<sub>n</sub>) and respective Project Emission Factors (EF<sub>n</sub>)

The resulting project emissions (PE<sub>n</sub>) and project emission factor (EF<sub>n</sub>) for the project campaigns covered by this monitoring report are:

Campaign	PE	EF <sub>n</sub>
4 <sup>th</sup> project campaign	153.27 tN <sub>2</sub> O	1.18 kgN <sub>2</sub> O/tHNO <sub>3</sub>
5 <sup>th</sup> project campaign	75.18 tN <sub>2</sub> O	0.50 kgN <sub>2</sub> O/tHNO <sub>3</sub>
6 <sup>th</sup> project campaign	50.58 tN <sub>2</sub> O	0.70 kgN <sub>2</sub> O/tHNO <sub>3</sub>

### **Project Campaign Length**

If the length of each individual project campaign CL<sub>n</sub> is longer than or equal to the average historic campaign length CL<sub>normal</sub> or to the baseline campaign length whichever is shorter, then all N<sub>2</sub>O 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).

Since for the first two campaigns (Project Campaign 4 and Project Campaign 5) of this monitoring period CL<sub>n</sub> > CL<sub>BL</sub>, the above determined EF<sub>BL</sub> is valid and will be used for the calculation of respective emission reduction. For Project Campaign 6 of this monitoring period CL<sub>n</sub> < CL<sub>BL</sub>. However due to the difference in gauze composition for Project Campaign 6 (gauze composition in project campaign different from gauze composition in baseline campaign) the default baseline emission factor of 4.5 kgN<sub>2</sub>O/tHNO<sub>3</sub> is used for Project Campaign 6.

### **E.3. Leakage calculation**

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No leakage occurs under this project type.

### **E.4. Emission reductions calculation / table**

>>

#### **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<sub>ma,n</sub>, 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<sub>ma,n</sub> and EF<sub>n</sub> shall be applied as the emission factor relevant for the particular campaign to be used to calculate emissions reduction s (EF<sub>p</sub>). Thus:

If EF<sub>ma,n</sub> > EF<sub>n</sub> then EF<sub>p</sub> = EF<sub>ma,n</sub>

If EF<sub>ma,n</sub> < EF<sub>n</sub> then EF<sub>p</sub> = EF<sub>n</sub>

In addition a campaign-specific *minimum emissions factor* (EF<sub>min</sub>) shall be used to cap any potential long-term trend towards decreasing N<sub>2</sub>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<sub>n</sub> observed during those campaigns will be adopted as a minimum emission factor (EF<sub>min</sub>). If any of the later project campaigns results in a EF<sub>n</sub> that is lower than EF<sub>min</sub>, the calculation of the emission reductions for that particular campaign shall use EF<sub>min</sub> and not EF<sub>n</sub>. As this project campaign of this current monitoring period is only the 8th project campaign consideration of EF<sub>min</sub> 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<sub>2</sub>O according to:

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

Where:

Variable	Definition
ER	Emission reductions of the project for the specific campaign (tCO <sub>2</sub> e)
NAP	Nitric acid production for the project campaign (tHNO <sub>3</sub> ). The maximum value of NAP shall not exceed the design capacity.
EF <sub>BL</sub>	Baseline emissions factor (kgN <sub>2</sub> O/tHNO <sub>3</sub> )
EF <sub>p</sub>	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of EF <sub>ma,n</sub> and EF <sub>n</sub> ) (kgN <sub>2</sub> O/tHNO <sub>3</sub> )
GWP <sub>N<sub>2</sub>O</sub>	Global Warming Potential of N <sub>2</sub> O (310 tCO <sub>2</sub> e/tN <sub>2</sub> 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:

Parameter	Unit	Project campaign 4	Project campaign 5	Project campaign 6
<b>Baseline</b>				
NCSG <sub>BL</sub>	mg/Nm <sup>3</sup>	1,630.03	1,630.03	
QAL2 NCSG		1.10	1.10	
VSG <sub>BL</sub>	Nm <sup>3</sup> /h	72,468.01	72,468.01	
QAL2 VSG		1.01	1.01	
OH <sub>BL</sub>	h	4,950.00	4,950.00	
NAP <sub>BL</sub>	t HNO <sub>3</sub>	134,699.80	134,699.80	
BE	t N <sub>2</sub> O	651.98	651.98	
UNC		3.99	3.99	
EF <sub>BL</sub>	kg N <sub>2</sub> O/t HNO <sub>3</sub>	<b>4.65</b>	<b>4.65</b>	<b>4.50</b>
<b>Project campaigns</b>				
NCSG <sub>n</sub>	mg/Nm <sup>3</sup>	441.61	192.04	258.95
QAL2 NCSG		0.99	0.99	0.99
VSG <sub>n</sub>	Nm <sup>3</sup> /h	78,109	77,173	83,845
QAL2 VSG		1.01	1.01	0.96
OH <sub>n</sub>	h	4,444	5,073	2,451
NAP <sub>n</sub>	t HNO <sub>3</sub>	129,361	150,111	72,510
PE <sub>n</sub>	t N <sub>2</sub> O	153.27	75.18	50.58
EF <sub>n</sub>	kg N <sub>2</sub> O/t HNO <sub>3</sub>	1.18	0.50	0.70
EF <sub>ma,n</sub>	kg N <sub>2</sub> O/t HNO <sub>3</sub>	1.07	0.96	0.91
EF <sub>min</sub>	kg N <sub>2</sub> O/t HNO <sub>3</sub>	N/A	N/A	N/A
EF <sub>p</sub>	kg N <sub>2</sub> O/t HNO <sub>3</sub>	<b>1.18</b>	<b>0.96</b>	<b>0.91</b>
<b>Emission reductions</b>				
GWP	tCO <sub>2</sub> e/tN <sub>2</sub> O	310.00	310.00	310.00
ER	tCO <sub>2</sub> e	<b>138,844</b>	<b>171,681</b>	<b>80,597</b>
<b>Total ER for the monitoring period</b>			<b>391,122</b>	

#### E.5. Comparison of actual emission reductions with estimates in the CDM-PDD

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This section shall include a comparison of actual values of the emission reductions achieved during the monitoring period with the estimations in the registered CDM-PDD.

Item	Values applied in ex-ante calculation of the registered CDM-PDD	Actual values reached during the monitoring period
Emission reductions (tCO <sub>2</sub> e)	<b>394,190</b>	<b>391,122</b>



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

&gt;&gt;

The estimated annual emission reductions as of the registered PDD are 265,460 tCO<sub>2</sub>e. The total monitoring period covers 542 days and the respective estimated emission reductions for the monitoring period are 394,190 tCO<sub>2</sub>e. This is reasonably close to the actual emission reductions of 391,122 tCO<sub>2</sub>e achieved during this monitoring period.

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**History of the document**

Version	Date	Nature of revision
01	EB 54, Annex 34 28 May 2010	Initial adoption.
<b>Decision Class:</b> Regulatory <b>Document Type:</b> Guideline, Form <b>Business Function:</b> Issuance		