



# **N.serve Environmental Services GmbH**

## **CDM Monitoring Report No. 1**

### **“N<sub>2</sub>O abatement project at nitric acid plant No. 11 at African Explosives Ltd. (AEL), South Africa”**

#### **UNFCCC Ref No. 1364**

Monitoring period

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Contents	Page
<b>1. INTRODUCTION.....</b>	<b>3</b>
<b>2. GENERAL DESCRIPTION OF THE PROJECT ACTIVITY .....</b>	<b>3</b>
2.1. PROJECT PARTICIPANTS .....	4
2.2. DEVIATIONS TO REGISTERED PDD .....	4
<b>3. TECHNOLOGY EMPLOYED BY THE PROJECT ACTIVITY.....</b>	<b>5</b>
3.1. CATALYST TECHNOLOGY .....	5
3.2. N <sub>2</sub> O ABATEMENT CATALYST INSTALLATION.....	5
3.3. TECHNOLOGY TRANSFER AND SAFETY ISSUES .....	5
<b>4. PROJECT BOUNDARY OF THE PROJECT ACTIVITY .....</b>	<b>5</b>
<b>5. BASELINE AND MONITORING METHODOLOGY APPLIED TO THE PROJECT ACTIVITY.....</b>	<b>7</b>
5.1. DETERMINATION OF THE PERMITTED OPERATING CONDITIONS OF THE NITRIC ACID PLANT TO AVOID OVERESTIMATION OF BASELINE EMISSIONS: .....	8
5.2. DETERMINATION OF BASELINE EMISSION FACTOR: MEASUREMENT PROCEDURE FOR N <sub>2</sub> O CONCENTRATION AND GAS VOLUME FLOW.....	8
5.3. CAMPAIGN LENGTH .....	9
5.4. LEAKAGE .....	10
5.5. PROJECT EMISSIONS.....	10
5.6. MINIMUM PROJECT EMISSIONS FACTOR .....	11
5.7. PROJECT CAMPAIGN LENGTH .....	11
5.8. EMISSION REDUCTIONS.....	11
5.9. DATA AND PARAMETERS FOR CALCULATION OF BASELINE CAMPAIGN EMISSIONS.....	12
5.10. DATA AND PARAMETERS FOR CALCULATION OF PROJECT CAMPAIGN EMISSIONS.....	12
<b>6. MONITORING PLAN: .....</b>	<b>13</b>
6.1. GENERAL DESCRIPTION OF THE MONITORING PLAN.....	13
6.2. APPLICATION OF EN 14181 PROCEDURES TO THE PROJECT .....	14
6.3. AMS CALIBRATION AND QA/QC PROCEDURES .....	15
6.4. DATA ACQUISITION SYSTEM.....	16
6.5. DESCRIPTION OF THE N.SERVE DATABASE MANAGEMENT SYSTEM (N.DBMS).....	17
6.6. MONITORING PROCEDURES FOR PARAMETERS OTHER THAN NCSG AND VSG.....	17
<b>7. GHG CALCULATIONS .....</b>	<b>18</b>
7.1. ANALYSIS OF HISTORICAL CAMPAIGN DATA.....	18
7.2. ANALYSIS OF BASELINE CAMPAIGN DATA .....	18
7.3. ANALYSIS OF PROJECT CAMPAIGN DATA .....	22
<b>ANNEX 1: DATA AND PARAMETERS FOR CALCULATION OF BASELINE CAMPAIGN EMISSIONS .....</b>	<b>1</b>
<b>ANNEX 2: DATA AND PARAMETERS FOR CALCULATION OF PROJECT CAMPAIGN EMISSIONS .....</b>	<b>1</b>

## 1. Introduction

African Explosives Ltd. (“AEL”), and N.serve Environmental Services GmbH have implemented a GHG emission reduction project at the AEL No. 11 nitric acid production plant in Modderfontein, east of the City of Johannesburg, South Africa. The GHG emission reductions are achieved by catalytic destruction of N<sub>2</sub>O.

The objective of this monitoring report is to calculate and clarify the GHG emission reduction quantity achieved by this project activity for periodic verification.

This monitoring report covers the activity from 08/02/2008 to 23/05/2009 as the 1<sup>st</sup> monitoring period. During the monitoring period three production campaigns were completed:

Campaign PC1 (12/09/2007-19/03/2008) and  
 Campaign PC2 (20/03/2008-28/09/2008) and  
 Campaign PC3 (04/10/2008-23/05/2009)

Starting date of the project activity :	12/09/2007
Registration date at UNFCCC:	08/02/2008
Registration No. at UNFCCC:	1364
Crediting period is:	08/02/2008 – 07/02/2018
Project scale:	large
Sectoral scope:	5: “Chemical Industry”
Host Party for the Project activity:	South Africa
City/ Town:	Modderfontein 1645

## 2. General description of the project activity

The sole purpose of the proposed project activity is to significantly reduce former levels of N<sub>2</sub>O emissions from the production of nitric acid at one of AELs’ nitric acid plants (the “AEL No. 11 Plant”) at Modderfontein, South Africa. The AEL No. 11 nitric acid plant was designed by Uhde and commissioned in 1979, it is a single burner dual pressure oxidation plant operated at 4,5 bar gauge.

To produce nitric acid, ammonia (NH<sub>3</sub>) is reacted with air over precious metal – normally a platinum/rhodium (Pt-Rh) alloy – catalyst gauze pack in the ammonia oxidation reactor of nitric acid plants. The main product of this reaction is NO, which is metastable at the conditions present in the ammonia oxidation reactor and therefore reacts with the available oxygen to form NO<sub>2</sub>, which is later absorbed in water to form HNO<sub>3</sub> – nitric acid. Simultaneously, undesired side reactions yield nitrous oxide (N<sub>2</sub>O), nitrogen and water. N<sub>2</sub>O is a potent greenhouse gas with a Global Warming Potential (GWP) of 310. The project activity involves the installation

of a new N<sub>2</sub>O abatement technology; a pelletized catalyst that will be installed inside the ammonia oxidation reactor, underneath the precious metal gauzes. This catalyst will in large part reduce the baseline N<sub>2</sub>O emissions.

By implementing the project activity, a new, clean technology has been transferred to South Africa that is not even common industrial practice in Annex 1 countries. Also, the project leads to an enhancement of skills as employees are trained to operate both the N<sub>2</sub>O abatement catalyst and the Automated Monitoring System.

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 financial benefits from the sale of Certified Emission Reductions (“CERs”) will be used to offset the capital and operating costs of the project to provide for its continued operation throughout the crediting period.

## 2.1. Project participants

Name of Party involved (*) ((host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
South Africa (host)	African Explosives Ltd (“AEL”)	No
United Kingdom	N.serve Environmental Services GmbH, Germany (“N.serve”).	No

## 2.2. Deviations to registered PDD

### Determination of the amount of Nitric Acid production:

In the registered PDD it was described that the amount of nitric acid production is determined by a combination of a mass balance calculation and online measurements with a coriolis flow meter. However, it was determined during the initial verification that it leads to more reliable data with better quality assurance to use only the results from the coriolis flow meter. Therefore all NAP related results were changed to the data from the coriolis flow meter and the calculations were amended accordingly.

### 3. Technology employed by the project activity

The project activity entails a transfer of

- State-of-the art N<sub>2</sub>O abatement technology which is not even applied in Annex I countries.
- Specialised monitoring equipment
- Staff training for installation, operation and maintenance of catalyst & monitoring equipment, etc.

The financing of this technology is facilitated by the CDM. Hence, the CDM enables nitric acid plants in non-Annex 1 countries to become the pioneers of N<sub>2</sub>O abatement of the global nitric acid industry.

AEL has installed a secondary abatement catalyst at the beginning of the first project campaign that started before the successful registration of the AEL No. 11 plant as a CDM project.

#### 3.1. Catalyst Technology

AEL has contracted with Heraeus to install its N<sub>2</sub>O reduction catalyst (HR-SC) system. The catalyst is made of precious metal coated mini raschig rings (Al<sub>2</sub>O<sub>3</sub>).

The catalyst does not require additional heat or other energy over and above the temperature that is present inside the Ammonia Oxidation Reactor anyway. There are no additional greenhouse gases or other emissions generated by the reactions on at the N<sub>2</sub>O abatement catalyst.

#### 3.2. 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 mini raschig rings 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.

#### 3.3. Technology transfer and safety issues

The catalyst implementation does not lead to increased NO<sub>x</sub> emissions. Neither is the environment directly or indirectly harmed in any other way. AEL will ensure that the chosen N<sub>2</sub>O abatement catalyst vendor will take back the catalyst at the end of its useful life and refine, recycle or dispose of it according to the then prevailing EU standards.

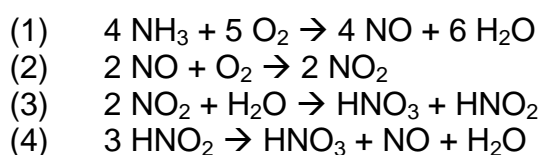
Once installed, the catalyst itself and the AMS is operated by the local AEL-employees.

### 4. Project boundary of the project activity

The boundary of the project activity includes the complete process equipment of the AEL No.11 nitric acid plant.

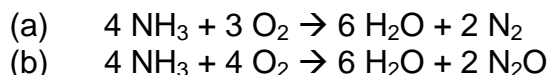
The gases relevant to the proposed project activity (and the nitric acid plant which is subject to it) originate from the ammonia oxidation process that takes place at the precious metal gauzes inside the plant's ammonia oxidation reactor.

The main product of this reaction is NO created by oxidising ammonia (NH<sub>3</sub>) with atmospheric oxygen (O<sub>2</sub>) (reaction 1). NO readily oxidises further to form NO<sub>2</sub> (reaction 2) and thereafter put to react with water to form a mix of nitric and nitrous acid (reaction 3). Finally, nitrous acid is also transformed into nitric acid (reaction 4), entailing an emission of NO, which is partially oxidised to NO<sub>2</sub> (reaction 2). These intended chemical reactions (main reactions) are the following:



The ammonia oxidation process (see reaction 1 above) yields the desired NO molecules with a 90 to 95% probability, depending on the maintenance of the accurate temperature and pressure parameters inside the ammonia burner.

However, these main reactions entail the formation of several unwanted gaseous by-products that usually are emitted into the atmosphere. The undesired by-products result from the following reactions (side reactions) that also occur in the ammonia oxidation process:



Side reaction (a) is irrelevant as it only results in the formation of water vapour and nitrogen, both present in the atmosphere in abundance. Reaction (b), however, leads to the emission of N<sub>2</sub>O.

On leaving the ammonia oxidation reactor some of the N<sub>2</sub>O generated may decompose

- In the high temperature homogenous gas phase inside the ammonia oxidation reactor (especially if the heat exchanger coils are inefficient or not placed directly underneath the ammonia oxidation section)
- At platinum deposits downstream of the ammonia oxidation reactor (provided that sufficient temperature levels coincide with substantial traces of platinum and the gas flow velocity allows a sufficient contact time)
- In sections of the plant downstream of the ammonia oxidation reactor, where temperatures above 300°C allow N<sub>2</sub>O to spontaneously decompose.

An overview of all emission sources within the project boundary is provided below:

	Source	Gas	Included?	Justification / Explanation
Baseline	Nitric Acid Plant (Burner Inlet to Stack)	CO <sub>2</sub>	No	The process does not lead to any CO <sub>2</sub> or CH <sub>4</sub> emissions
		CH <sub>4</sub>	No	
		N <sub>2</sub> O	Yes	
		CO <sub>2</sub>		
		CH <sub>4</sub>		
		N <sub>2</sub> O		
		CO <sub>2</sub>		
		CH <sub>4</sub>		
		N <sub>2</sub> O		
Project Activity	Nitric Acid Plant (Burner Inlet to Stack)	CO <sub>2</sub>	No	The process does not lead to any CO <sub>2</sub> or CH <sub>4</sub> emissions
		CH <sub>4</sub>	No	
		N <sub>2</sub> O	Yes	
	Leakage emissions	CO <sub>2</sub>	No	No leakage emissions are expected.
		CH <sub>4</sub>	No	
		N <sub>2</sub> O	No	

## 5. Baseline and monitoring methodology applied to the project activity

This project is based on Approved Baseline and Monitoring methodologies AM0034 (Version 02): “Catalytic reduction of N<sub>2</sub>O inside the ammonia burner of nitric acid plants”. This version of AM0034 is applicable to the project activity, because it has been registered on 8<sup>th</sup> February 2008 when this version was valid<sup>1</sup>.

The project draws on approved baseline methodology AM0028 (Version 4.2) for the baseline scenario selection and uses the “Tool for the demonstration and assessment of additionality”.

<sup>1</sup> Subsequent revisions of AM0034 do not apply to this Project, see decision 3/CMP.1, Annex G, paragraph 39, 2<sup>nd</sup> sentence. This is a general rule for CDM projects that aims at ensuring regulatory certainty for project proponents.

### 5.1. Determination of the permitted operating conditions of the nitric acid plant to avoid overestimation of baseline emissions:

In order to avoid the possibility that the operating conditions of the nitric acid production plant are modified in such a way that increases N<sub>2</sub>O generation during the baseline campaign, the normal ranges for operating conditions were determined for the following parameters: (i) oxidation temperature; (ii) oxidation pressure; (iii) ammonia gas flow rate, and (iv) air input flow rates. The permitted range has been established using the procedures described below. Note that data for these parameters is routinely logged in the process control systems of the plant.

#### i. Oxidation temperature and pressure:

Process parameters monitored:

OT <sub>h</sub>	Oxidation temperature for each hour (°C)
OP <sub>h</sub>	Oxidation pressure for each hour (Pa)
OT <sub>normal</sub>	Normal range for oxidation temperature (°C)
OP <sub>normal</sub>	Normal range for oxidation pressure (Pa)

For the determination of the permitted operating conditions, the methodology suggests that historic operating data as logged by the process control system should be used. However, there is no requirement by South African law or by AEL management to record and store the above operating parameters of the nitric acid plants. 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 Annex 1 for details.

#### ii. Ammonia gas flow rates and ammonia to air ratio input into the ammonia oxidation reactor (AOR):

Parameters monitored:

AFR	Ammonia gas flow rate to the AOR (tNH <sub>3</sub> /h)
AFR <sub>max</sub>	Maximum ammonia gas flow rate to the AOR (tNH <sub>3</sub> /h)
AIFR	Ammonia to air ratio (%)
AIFR <sub>max</sub>	Maximum ammonia to air ratio (%)

Historic data of daily NH<sub>3</sub> 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 Nm<sup>3</sup>/hr, which was used to determine AIFR.

### 5.2. Determination of baseline emission factor: measurement procedure for N<sub>2</sub>O concentration and gas volume flow

N<sub>2</sub>O concentration and gas volume flow have been monitored throughout the baseline campaign by an Automated Monitoring System (AMS) which was installed and operated using European Norm 14181 (2004) as guidance where applicable. The AMS provides separate readings for N<sub>2</sub>O concentration (NCSG) and gas volume flow (VSG) for every two seconds of operation of the plant. Error readings (e.g.



downtime or malfunction) and extreme values are to be eliminated from the output data series.

Measurement results can be distorted before and after periods of downtime or malfunction of the monitoring system and can lead to mavericks. To eliminate such extremes and to ensure a conservative approach, the following statistical evaluation is to be applied to the complete data series of N<sub>2</sub>O concentration as well as to the data series for gas volume flow. The statistical procedure will be applied to data obtained after eliminating data measured for periods where the plant operated outside the permitted ranges:

- a) Calculate the sample mean (x)
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values (volume of stack gas (VSG) and N<sub>2</sub>O concentration of stack gas (NCSG))

The average mass of N<sub>2</sub>O emissions per hour is estimated as product of the NCSG and VSG. The N<sub>2</sub>O emissions per campaign are estimates product of N<sub>2</sub>O emission per hour and the total number of complete hours of operation of the campaign using the following equation:

$$BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC}$$

The plant specific baseline emissions factor representing the average N<sub>2</sub>O emissions per tonne of nitric acid over one full campaign has been derived by dividing the total mass of N<sub>2</sub>O emissions by the total output of 100% concentrated nitric acid for that period. The overall uncertainty of the monitoring system (*UNC*) has been determined. The N<sub>2</sub>O emission factor per tonne of nitric acid produced in the baseline period (*EF<sub>BL</sub>*) was reduced by the estimated percentage error as follows:

$$EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100)$$

In the absence of any national or regional regulations for N<sub>2</sub>O emissions in South Africa, the resulting *EF<sub>BL</sub>* has been used as the baseline emission factor.

The gauze supplier and gauze composition during the baseline campaign had been the same as used during the historic campaigns when the permitted operating conditions were established. Therefore, the *EF<sub>BL</sub>* derived is valid.

The plant was operating within the permitted range of normal operating conditions for more than 50% of the time, therefore the baseline campaign is valid and the resulting *EF<sub>BL</sub>* can be applied to calculate the resulting emission reductions of the project.

### 5.3. Campaign Length

In order to take into account the variations in campaign length and its influence on N<sub>2</sub>O emission levels, the historic campaign lengths and the baseline campaign length are to be determined and compared to the project campaign length. Campaign length

is defined as the total number of metric tonnes of nitric acid at 100% concentration produced with one set of gauzes.

The average historic campaign length ( $CL_{normal}$ ) defined as the average campaign length for the historic campaigns used to define operating condition (the previous five campaigns), has been used as a cap on the length of the baseline campaign as described in the PDD.

**If  $CL_{BL} \leq CL_{normal}$ , then** all  $N_2O$  values measured during the baseline campaign can be used for the calculation of  $EF_{BL}$  (subject to the elimination of data that was monitored during times where the plant was operating outside of the “permitted range”).

**If  $CL_{BL} > CL_{normal}$ , then**  $N_2O$  values that were measured beyond the length of  $CL_{normal}$  during the production of the quantity of nitric acid (i.e. the final tonnes produced) are to be eliminated from the calculation of  $EF_{BL}$ .

#### 5.4. Leakage

As per methodology AM0034, no leakage emission calculation is required since no leakage emissions have occurred as a result of the project activity nor are any expected in future.

#### 5.5. Project Emissions

Over the duration of the project activity,  $N_2O$  concentration and gas volume flow in the stack of the nitric acid plant as well as the temperature and pressure of ammonia gas flow and ammonia-to-air ratio will be measured continuously.

The same statistical evaluation that was applied to the baseline data series is applied to the project data series of NCSG and VSG:

- a) Calculate the sample mean ( $\bar{x}$ )
- b) Calculate the sample standard deviation ( $s$ )
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values

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

In order to take into account possible long-term emissions trends over the duration of the project activity and to take a conservative approach a moving average emission factor shall be estimated as follows:

*Step1:* estimate campaign specific emissions factor for each campaign during the project’s crediting period by dividing the total mass of  $N_2O$  emissions during that campaign by the total production of 100% concentrated nitric acid during that same

campaign. For example, for campaign  $n$  the campaign specific emission factor would be:

$$EF_n = PE_n / NAP_n$$

*Step 2:* A moving average emissions factor be calculated at the end of a campaign  $n$  as follows:

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

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

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

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

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

## 5.6. Minimum Project Emissions Factor

$N_2O$  emissions that may result from a potential built up of platinum deposits. After the first ten campaigns of the crediting period of the project, the lowest  $EF_n$  observed during those campaigns will be adopted as a minimum ( $EF_{min}$ ).  $EF_{min}$  is equal to the lowest  $EF_n$  observed during the first 10 campaigns of the project crediting period ( $N_2O/tHNO_3$ ). 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  $EF_n$ .

## 5.7. Project Campaign Length

If the length of each individual project campaign  $CL_n$  is longer than or equal to the average historic campaign length  $CL_{normal}$ , 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 Ammonia/Air analysis, see above). 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  $EF_n$ .

## 5.8. Emission Reductions

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

$$ER = (EF_{BL} - EF_P) * NAP * GWP_{N_2O}$$

According to AM0034, the value for Nitric acid production (NAP) during the project campaign shall not exceed the design capacity of the nitric acid plant.

The existing production capacity is 282,875 metric tonnes of 100% concentrated nitric acid per year (based on 365<sup>2</sup> operating days per year and a daily nameplate capacity of 775 tHNO<sub>3</sub>). Therefore, the AEL No. 11 nitric acid plant shall not be eligible to earn CERs for any tonnes of nitric acid produced exceeding 282,875 in any one year.

#### **5.9. Data and parameters for calculation of Baseline campaign emissions**

See Annex 1

#### **5.10. Data and parameters for calculation of Project campaign emissions**

See Annex 2

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<sup>2</sup> As per AM0034 page 11.

## 6. Monitoring plan:

### 6.1. General description of the monitoring plan

The emission reductions achieved by the project activity are monitored based on the approved monitoring methodology AM0034 (Version 2) as prepared by N.serve Environmental Services GmbH. It is the appropriate monitoring methodology to be used in conjunction with the baseline methodology AM0034, "Catalytic reduction of 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 Norm EN14181 (2004) "*Stationary source emissions - Quality assurance of automated measuring systems*"<sup>3</sup> as a guidance<sup>4</sup> for installing and operating the Automated Monitoring System (AMS) in the nitric acid plants for the monitoring of N<sub>2</sub>O emissions.

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 a ABB AO2000 Uras 14 NDIR analyser in 2007. Because of some technical difficulties with the Environnement MIR9000 analyser on the No. 9 plant, AEL has decided to install two completely new analysers (ABB Uras 14) in both the No. 9 and the No. 11 plant in mid 2007.

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.

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<sup>3</sup> This standard describes the quality assurance procedures needed to assure that an Automated Measuring System (AMS) installed to measure emissions to air are capable of meeting the uncertainty requirements on measured values given by legislation, e.g. EU Directives, or national legislation, and more generally by competent authorities.

<sup>4</sup> See page 8, last paragraph of AM0034 version 2: "The monitoring system is to be installed using the guidance document EN 14181 ..."

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.

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

In the following, it is described how the procedures given in EN14181 for QAL1, 2 and 3 have been practically applied at AEL No. 9 plant.

### QAL 1

In accordance with EN14181 an AMS shall have been proven suitable for its measuring task (composition of the flue gas) by use of the QAL1 procedure as specified by EN ISO 14956. Using this standard, it shall be proven that the total uncertainty of the results obtained from the AMS meets the specification for uncertainty stated in the applicable regulations. Such suitability testing has to be carried out under specific conditions by an independent third party on a specific testing site. A test institute shall perform all relevant tests on two identical AMS. These two AMS have to be tested in the laboratory and field.

At the time of purchasing of the AMS by AEL, no AMS vendors had yet conducted the QAL 1 suitability testing for N<sub>2</sub>O and it was not known if any vendors were in the process of obtaining this. The chosen gas analyser MIR9000 from Environnement however, has passed the QAL1 suitability for measurements of NO<sub>x</sub> and other gaseous emissions. In addition QAL1 laboratory 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. MIR9000 analyser was used during the baseline campaign. Before start of the first project campaign it was replaced by a ABB AO2000 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>5</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>6</sup> for the follow-up model of this analyser module within the same analyser series (ABB AO2000 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)

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<sup>5</sup> TÜV Süddeutschland Bau und Betrieb GmbH (Report number 170 608), March 2003

<sup>6</sup> TÜV Süd Industrie Service GmbH, München (Report number 821029) June 2006

QAL2 is a procedure for the determination of the calibration function and its variability, and a test of the variability of the measured values of the AMS compared with the uncertainty given by legislation. The QAL2 tests are performed on suitable AMS that have been correctly installed and commissioned on-site (as opposed to QAL 1 which is conducted off-site). QAL 2 tests are to be performed at least every 3 years according to EN 14181 but also after major changes to the plant or changes or repairs to the AMS, which will influence the results obtained significantly.

A calibration function is established from the results of a number of parallel measurements performed with a Standard Reference Method (SRM). The variability of the measured values obtained with the AMS is then evaluated against the required uncertainty. According to EN14181, both the QAL 2 procedures and the SRM need to be conducted by an independent “testing house” or laboratory which has to be accredited to EN ISO/IEC 17025.

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) 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  $EF_{BL}$  and  $EF_n$ .

In June 2009 an Annual Surveillance Tests (AST) has been successfully performed by an accredited testing house. The test was performed in accordance with EN14181. The AST is a series of measurements that need to be conducted by independent measurement equipment in parallel to the existing AMS.

### **6.3. 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

Zero and span calibrations are conducted regularly. 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 device which will not have drift. Therefore, it is sufficient to regularly inspect the physical condition of the Annubar. Therefore, the Annubar is taken out of the stack once per year for physical inspection.

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

### 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.

### QAL 3

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

This is achieved by conducting periodic zero and span checks on the AMS and then evaluating the results obtained using control charts. Zero and span adjustments or maintenance of the AMS, may be necessary depending on the results of this evaluation. In addition, Annual Surveillance Tests (AST) should be conducted in accordance with EN14181, these are a series of measurements that need to be conducted by independent measurement equipment in parallel to the existing AMS.

## **6.4. Data acquisition system**

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 discdrive. 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).

#### **6.5. Description of the 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 a 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.

At N.serve the received data is stored at the N.serve fileserver in a special section for the storage of monitoring data separately for each project. The files are protected against manipulation by a password. Martin Stilkenbäumer at N.serve is responsible for the correct data handling and processing.

To ensure that the correct data is used in the N.DBMS calculation and to ensure that the calculations are done correctly, plausibility checks are done by N.serve using manual EXCEL calculations on the received data from the plant. For example the average values for the different parameters are calculated by EXCEL and compared to the results of Query 1 of the N.DBMS calculation.

After this plausibility check, the data is transferred from the received excel files into the N.DBMS in Microsoft Access for the analysis in accordance with AM0034. The results of this analysis are then exported into excel again where the final calculations are undertaken to derive EFBL and EFP which will then be used in the Monitoring Reports prepared by N.serve.

#### **6.6. Monitoring Procedures for parameters other than NCSG and VSG**

Throughout the crediting period of the project the following parameters shall be monitored and recorded as described in Annex 1 and Annex 2:  $OT_h$ ,  $OP_h$ , AFR, AIFR, NAP, GS, GC, CL, incoming  $N_2O$  regulation and changes in the  $NO_x$  regulations.

All of the data obtained and used as part of the baseline and during the crediting period of the project will be archived electronically at least 2 years longer than the entire crediting period of the project in at least 2 different locations.

## 7. GHG Calculations

The results of the N.DBMS data analysis are exported to EXCEL spreadsheets for further analysis and presentation

### 7.1. Analysis of Historical campaign data

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 Annex 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  $\text{Nm}^3/\text{hr}$ , 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
Maximim ammonia to air ratio:	0,115 or 11,5 %

This permitted range is then applied in the baseline evaluation in Query 5 below.

The analysis of the historical campaigns is now complete. Next, the analysis of the baseline data can be conducted applying the results of the analysis of the historical data.

### 7.2. Analysis of Baseline campaign data

As the baseline campaign for AEL No11 the campaign AEL No 11 C16 was used the baseline campaign was in operation in the period 20.07.2006 – 18.02.2007.

#### **Baseline Query 1 (Raw data): Analysis of the raw baseline data without any operating limits applied**

In a first step, a number of statistical calculations are carried out for the historical and baseline data using Query 1:

- Number of data sets
- Minimum value
- Maximum value
- Mean value and/or sum (depending on the character of the parameter)

- Standard deviation
- 95% confidence interval

The resulting Access table is shown below:

AEL No 11:

**Query 1: Without parameter limits**

ProjId	CampType	Count(DT)	Count(AFR)	Min(AFR)	Max(AFR)	Max(AIFR)	Min(Oph)	Max(Oph)	Min(OTh)	Max(OTh)	Sum(NAP)
7 B		5.128,00	5.120,00	0,01	8,58	0,99	139,00	425.428,00	800,48	901,94	134.699,80

For convenience of handling, the data from this Access table is exported into Excel for further analysis. The result of this export is shown below:

N.DBMS		AEL No. 11 Johannesburg, South Africa								
Baseline campaign		Query 1: Without parameter limits								
Parameter	Unit	OH	AFR	AIFR	Oph	OTh	NCSG	VSG	NAP	
		h	t NH3 / h	ratio	Pa	°C	mg N2O / Nm3	Nm3 / h	t HNO3	
Count		5.128	5.120	5.120	5.120	5.120	5.120	5.120		
Minimum			0,01	0,000	139	800	4	0		
Maximum			8,58	0,993	425.428	902	3.122	84.962		
Mean			7,37	0,107	380.683	896	1.550	70.156		
Standard deviation			1,40	0,037	69.337	18	314	13.859		
Sum		5.128								134.700
<b>Baseline emissions</b>	<b>BE</b>	$= VSG * NCSG * OH$						t N2O		<b>557,5</b>
<b>Emission factor</b>	<b>EF</b>	$= BE / NAP$						kg N2O / t HNO3		<b>4,14</b>

This table gives the raw results for NAP, OH, NCSG, VSG and EF<sub>BL</sub>.

According to this Query 1, the NAP value of the baseline campaign is 134,700 tonnes.

### **Baseline 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. During the project, the following “trip conditions” are used:

Since the design plant operating temperature is between 820°C and 905°C, by definition the plant is offline if the temperature recorded is at or below 800°C. For practical purposes, each hour for which the ammonia oxidation temperature (OTh) was recorded to be below 820°C is excluded from the determination of operating hours and all NCSG and VSG data is excluded from the further analysis if the temperature is below 820 °C.

N.DBMS		AEL No. 11 Johannesburg, South Africa							
Baseline campaign		Query 2: With limits on historical data							
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	4.943	4.943	4.943	4.943	4.943	4.943	4.943		
Remaining share of data set	96%	97%	97%	97%	97%	97%			
Minimum		1,50	0,095	84.380	822	4	14.343		
Maximum		8,58	0,108	425.428	902	2.470	84.962		
Mean		7,62	0,103	393.332	899	1.595	72.570		
Standard deviation		0,37	0,001	17.070	3	190	5.437		
95% confidence level		0,72	0,002	33.457	6	373	10.657		
Sum	4.943								134.700
<i>Limits acc. to consistency check</i>									
Lower limit					820				
Upper limit									

According to this Query 2, the OH value of the baseline campaign is 4,943 hours.

### **Baseline Query 5: Applying the permitted operating range from historical data**

After conducting Queries 2 and 5 which effect the elimination of

- all invalid (i.e. obviously inconsistent) baseline data sets
- all baseline data sets registered while the plant was operating outside the historic operational parameters

94% of all original data sets remain.

The remaining data sets are those recorded when the plant was operating normal.

N.DBMS		AEL No. 11 Johannesburg, South Africa							
Baseline campaign		Query 5: Permitted range from hist. campaigns applied to BL data, invalid data sets excluded, CL cut							
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	4.635	4.635	4.635	4.635	4.635	4.635	4.635		
Remaining share of data set	94%	94%	94%	94%	94%	94%	94%		
Minimum		7,04	0,099	365.143,0	894	6	64.035		
Maximum		8,58	0,108	425.428,0	902	1.909	84.962		
Mean		7,64	0,103	394.566	899	1.588	72.783		
Standard deviation		0,31	0,001	13.439,5	1	193	5.144		
95% Confidence Interval		0,60	0,002	26.341,4	2	377	10.082		
Sum	4.943								134.699,8
<i>Limits acc. to consistency check</i>									
Lower limit			0	365.000	820				
Upper limit		9,094	0,115	450.000	905				
<b>Baseline emissions</b>	<b>BE</b>	$= VSG * NCSG * OH$					t N2O		<b>571,1</b>
<b>Emission factor</b>	<b>EF</b>	$= BE / NAP$					kg N2O / t HNO3		<b>4,24</b>

This query excludes those NCSG and VSG data from the calculation of BE that were taken during times when the plant was operating outside of the permitted operating range during the baseline campaign. Only those VSG and NCSG values were taken into account for which a matching AFR, AIFR, OPh and OTh value was available.

CL<sub>normal</sub> for AEL No. 11 is: 127,302.4 tonnes of HNO<sub>3</sub>

CL<sub>BL</sub> for AEL No. 11 is: 134.699.8 tonnes of HNO<sub>3</sub>

Therefore  $CL_{BL} > CL_{normal}$  and all NCSG and VSG datasets were excluded from that operating hour onwards when the nitric acid production during the baseline campaign exceeded the  $CL_{normal}$  value.

The remaining share of the operating data after Query 5 is 94% of the raw data and therefore meets the criterion set by AM0034 that the plant must be operating within the permitted range at least 50% of the time during the baseline campaign.

### **Query 6 a + b: Application of 95% confidence interval, AMS UNC and calculation of EFBL**

The 95% confidence level of NCSG and VSG values is derived, thereby excluding outliers and determining the mean values that are to be applied to the calculation of BE. Also the correction factors for NCSG and VSG that are determined during QAL2 test are applied.

N.DBMS		AEL No. 11 Johannesburg, South Africa							
Baseline campaign		Query 6a+b: Confidence levels for NCSG and VSG							
Parameter	OH	AFR	AIFR	Oph	OTh	NCSG	VSG	NAP	
Unit	h	t NH <sub>3</sub> / h	ratio	Pa	°C	mg N <sub>2</sub> O / Nm <sup>3</sup>	Nm <sup>3</sup> / h	t HNO <sub>3</sub>	
Count						4.317	4.557		
Minimum		7,036	0,099	365.143,0	894	1.210	64.035		
Maximum		8,584	0,108	425.428,0	902	1.909	82.850		
Mean		7,639	0,103	394.565,8	899	1.630	72.600		
Standard deviation						110	4.992		
95% Confidence Interval									
Sum		4.943,0							134.700
<i>Limits acc. to consistency check</i>									
Lower limit			0	365.000	820	1.210,1	62.700		
Upper limit		9,094	0,115	450.000	905	1.965,0	82.865		
Correction factors resulting from QAL2						1,104	1,010		
Baseline emissions	BE	= VSG * NCSG * OH					t N <sub>2</sub> O		652,3
Emission factor	EF	= BE / NAP * (1 - UNC/100)					kg N <sub>2</sub> O / t HNO <sub>3</sub>		4,649
Uncertainty	UNC								3,99

### **Resulting EFBL**

The EFBL derived from this analysis of historic and baseline data is 4.649 kg N<sub>2</sub>O/tHNO<sub>3</sub>.

### 7.3. 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 the complete project campaign.

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 18 12.09.07 - 19.03.08									
Project campaign 1 Query 1: Without parameter limits									
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	4.552	4.550	4.550	4.550	4.550	4.550	4.550		
Minimum		0,00	0,00	141,00	800	0,00	0		
Maximum		9,28	0,9	427.079,0	902	1.421	89.024		
Mean		8,26	0,11	380.928,9	892	381	74.546		
Standard deviation		1,892	0,05	82.022,49	21	127	16.921		
95% confidence level (1.96 * Std.dev.)		3,71	0,09	160.764,07	41	250	33.165		
Sum	4.552								128.190
Limits acc. to consistency check									
Lower limit									
Upper limit									
Correction factors resulting from QAL2						0,970	1,010		
Campaign emissions	PE	= VSG * NCSG * Oh					t N2O	126,8	
Emission factor	EF_P	= PE / NAP					kg N2O / t HNO3	0,99	

According to this Query 1, the NAP value of the project campaign 1 is 128,190 tonnes HNO<sub>3</sub>.

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 19 20.03.08 - 28.09.08									
Project campaign 2 Query 1: Without parameter limits									
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	4.629	4.614	4.614	4.614	4.614	4.614	4.614		
Minimum		0,01	0,00	146,00	801	0,00	0		
Maximum		8,55	0,7	427.631,0	900	1.641	83.660		
Mean		7,73	0,11	385.466,7	892	328	74.476		
Standard deviation		1,759	0,08	85.878,58	21	97	16.857		
95% confidence level (1.96 * Std.dev.)		3,45	0,15	168.322,01	41	190	33.040		
Sum	4.629								131.941
Limits acc. to consistency check									
Lower limit									
Upper limit									
Correction factors resulting from QAL2						0,970	1,010		
Campaign emissions	PE	= VSG * NCSG * Oh					t N2O	110,6	
Emission factor	EF_P	= PE / NAP					kg N2O / t HNO3	0,84	

According to this Query 1, the NAP value of the project campaign 2 is 131,941 tonnes HNO<sub>3</sub>.

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa Campaign: C 20 04.10.08 - 23.05.09									
Project campaign 3 Query 1: Without parameter limits 48									
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	5.555	5.516	5.516	5.516	5.516	5.516	5.516		
Minimum		0,01	0,00	45,00	801	0,35	0		
Maximum		8,42	0,7	417.033,0	904	779	81.075		
Mean		7,01	0,10	346.199,6	887	386	65.818		
Standard deviation		2,509	0,04	122.717,63	31	157	23.621		
95% confidence level (1.96 * Std.dev.)		4,92	0,08	240.526,56	60	309	46.298		
Sum	5.555								138.917
Limits acc. to consistency check									
Lower limit									
Upper limit									
Correction factors resulting from QAL2						0,970	1,010		
Campaign emissions	PE	$= VSG * NCSG * Oh$					t N2O		138,3
Emission factor	EF_P	$= PE / NAP$					kg N2O / t HNO3		1,00

According to this Query 1, the NAP value of the project campaign 3 is 138,917 tonnes HNO<sub>3</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 18 12.09.07 - 19.03.08									
Project campaign 1 Query 2: With operational limits 12									
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	4.339	4.339	4.339	4.339	4.339	4.339	4.339		
Remaining share of data sets	95%	95%	95%	95%	95%	95%	95%		
Minimum		1,74	0,07	90.321,00	820	0	15.985		
Maximum		9,28	0,11	427.079,0	902	1.421	89.024		
Mean		8,64	0,10	397.768,7	896	398	78.002		
Standard deviation		0,690	0,003	27.932,836	7,8	101	6.355		
95% confidence level (1.96 * Std.dev.)		1,352	0,005	54.748,358	15,4	198	12.455		
Sum	4.339								128.190
Limits acc. to consistency check									
Lower limit					820				
Upper limit									
Correction factors resulting from QAL2						0,9700	1,0100		
Campaign emissions	PE	$= VSG * NCSG * Oh$					t N2O		132,1
Emission factor	EF_P	$= PE / NAP$					kg N2O / t HNO3		1,03

According to this Query 2, the OH value of the project campaign 1 is 4,339 hours.

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa							Campaign: C 19	20.03.08 - 28.09.08
Project campaign 2							32	
Query 2: With operational limits								
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	4.629	4.614	4.614	4.614	4.614	4.614	4.614	
Remaining share of data sets	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	
Minimum		0,01	0,00	146,00	801	0	0	
Maximum		8,55	0,74	427.631,0	900	1.641	83.660	
Mean		7,73	0,11	385.466,7	892	328	74.476	
Standard deviation		1,759	0,078	85.878,579	20,8	97	16.857	
95% confidence level (1.96 * Std.dev.)		3,448	0,153	168.322,015	40,7	190	33.040	
Sum	4.629							131.941
Limits acc. to consistency check								
Lower limit					820			
Upper limit								
Correction factors resulting from QAL2						0,9700	1,0100	
Campaign emissions	PE	$= VSG * NCSG * Oh$					t N2O	110,6
Emission factor	EF_P	$= PE / NAP$					kg N2O / t HNO3	0,84

According to this Query 2, the OH value of the project campaign 2 is 4,629 hours.

N.DBMS Project Campaign Calculation Project: AEL No. 11, Johannesburg, South Africa							Campaign: C 20	04.10.08 - 23.05.09
Project campaign 3							52	
Query 2: With operational limits								
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	4.887	4.887	4.887	4.887	4.887	4.887	4.887	
Remaining share of data sets	88,0%	88,6%	88,6%	88,6%	88,6%	88,6%	88,6%	
Minimum		2,66	0,10	151.187,00	836	178	28.174	
Maximum		8,42	0,10	417.033,0	904	733	81.075	
Mean		7,91	0,10	390.020,7	898	435	74.257	
Standard deviation		0,155	0,001	8.838,829	2,3	83	2.177	
95% confidence level (1.96 * Std.dev.)		0,304	0,002	17.324,104	4,5	162	4.267	
Sum	4.887							138.917,2
Limits acc. to consistency check								
Lower limit					820			
Upper limit								
Correction factors resulting from QAL2						0,9700	1,0100	
Campaign emissions	PE	$= VSG * NCSG * Oh$					t N2O	154,6
Emission factor	EF_P	$= PE / NAP$					kg N2O / t HNO3	1,11

According to this Query 2, the OH value of the project campaign 3 is 4,887 hours.

### Query 6: application of confidence intervall 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 Calculator Project: AEL No. 11, Johannesburg, South Africa							Campaign: C 18	12.09.07 - 19.03.08
Project campaign 1							16	20
Q6: Q2 + confidence levels							12	12
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						4.199	4.269	
Remaining share of data sets								
Minimum		1,741	0,07	90.321,00	820	204	65.978	
Maximum		9,28	0,11	427.079,0	902	582	89.024	
Mean		8,64	0,10	397.768,7	896	398	78.691	
Standard deviation		0,690	0,003	27.932,836	7,8	82	2.920	
95% confidence level (1.96 * Std.dev.)		1,352	0,005	54.748,358	15,4	160	5.724	
Sum	4.339							128.190
Limits acc. to consistency check								
Lower limit					820	200	65.547	
Upper limit						597	90.457	
Correction factors resulting from QAL2						0,9900	1,0100	
= VSG * NCSG * Oh							t N2O	136,0
= PE / NAP							kg N2O / t HNO3	1,06
Campaign emissions	PE							
Emission factor	EF_P							

The result of this query is the Emission factor for the project campaign of 1.06 kg N<sub>2</sub>O/ t HNO<sub>3</sub> for project campaign 1 (PC1).

N.DBMS Project Campaign Calculator Project: AEL No. 11, Johannesburg, South Africa							Campaign: C 19	20.03.08 - 28.09.08
Project campaign 2							36	40
Q6: Q2 + confidence levels							32	32
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						4.356	4.382	
Remaining share of data sets								
Minimum		0,010	0,00	146,00	801	150	42.063	
Maximum		8,55	0,74	427.631,0	900	505	83.660	
Mean		7,73	0,11	385.466,7	892	344	78.318	
Standard deviation		1,759	0,078	85.878,579	20,8	49	1.909	
95% confidence level (1.96 * Std.dev.)		3,448	0,153	168.322,015	40,7	95	3.741	
Sum	4.629							131.941
Limits acc. to consistency check								
Lower limit					820	138	41.436	
Upper limit						517	107.515	
Correction factors resulting from QAL2						0,9900	1,0100	
= VSG * NCSG * Oh							t N2O	124,7
= PE / NAP							kg N2O / t HNO3	0,95
Campaign emissions	PE							
Emission factor	EF_P							

The result of this query is the Emission factor for the project campaign of 0.95kg N<sub>2</sub>O/ t HNO<sub>3</sub> for project campaign 2 (PC2).

N.DBMS Project Campaign Calculator Project: AEL No. 11, Johannesburg, South Africa							Campaign: C 20	04.10.08 - 23.05.09
Project campaign 3							56	60
Q6: Q2 + confidence levels							52	52
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						4.781	4.736	
Remaining share of data sets								
Minimum		2,661	0,10	151.187,00	836	274	69.991	
Maximum		8,42	0,10	417.033,0	904	597	78.510	
Mean		7,91	0,10	390.020,7	898	436	74.185	
Standard deviation		0,155	0,001	8.838,829	2,3	78	1.652	
95% confidence level (1.96 * Std.dev.)		0,304	0,002	17.324,104	4,5	153	3.238	
Sum	4.887							138.917
Limits acc. to consistency check								
Lower limit					820	273	69.990	
Upper limit						597	78.524	
Correction factors resulting from QAL2						0,9900	1,0100	
= VSG * NCSG * Oh							t N2O	158,0
= PE / NAP							kg N2O / t HNO3	1,14
Campaign emissions	PE							
Emission factor	EF_P							

The result of this query is the Emission factor for the project campaign of 1.14 kg N<sub>2</sub>O/ t HNO<sub>3</sub> for project campaign 3 (PC3).

### **Project Campaign Length**

If the length of each individual project campaign  $CL_n$  is longer than or equal to the average historic campaign length  $CL_{normal}$ , 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 Ammonia/Air analysis, see above). 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  $EF_n$ .

**For all three project campaigns the  $CL_n$  is longer than  $CL_{normal}$ , therefore no adjustment of the Baseline emissions factor  $EF_{BL}$  is necessary.**

### **Adjustment of Baseline emissions factor due to $EF_{reg}$**

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

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

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

#### **Variable Definition**

$EF_{BL}$  Baseline emissions factor ( $tN_2O/tHNO_3$ )

$EF_{reg}$  Emissions level set by newly introduced policies or regulations ( $tN_2O/tHNO_3$ ).

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

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

### **Emission reductions**

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

$$ER = (EF_{BL} - EF_P) * NAP * GWP_{N_2O} (tCO_2e)$$

Where:

ER Emission reductions of the project for the specific campaign ( $tCO_2e$ )

NAP Nitric acid production for the project campaign ( $tHNO_3$ ). The maximum value of NAP shall not exceed the design capacity.

EF<sub>BL</sub> Baseline emissions factor (tN<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>)

N.DBMS Project Campaign Calculation		Project: AEL No. 11, Johannesburg, South Africa	Campaign: C 18	12.09.07 - 19.03.08
<b>Project campaign 1</b>			31	24
Emission factor Baseline	EF <sub>BL</sub>		kg N2O / t HNO3	4,65
Emission factor Project Campaign	EF <sub>P</sub>		kg N2O / t HNO3	1,06
NAP before registration (08.02.2008)	NAP			100.141
NAP after registration (08.02.2008)	NAP		t HNO3	28.050
Greenhouse warming potential N2O	GWP			310
<b>Emission reduction</b>	<b>ER</b>		<b>t CO2e</b>	<b>31.199</b>

N.DBMS Project Campaign Calculation		Project: AEL No. 11, Johannesburg, South Africa	Campaign: C 19	20.03.08 - 28.09.08
<b>Project campaign 2</b>				
Emission factor Baseline	EF <sub>BL</sub>		kg N2O / t HNO3	4,65
Emission factor nth Campaign	EF <sub>n</sub>		kg N2O / t HNO3	0,95
Moving average emission factor	EF <sub>ma,n</sub>		kg N2O / t HNO3	1,00
Emission factor Project Campaign	EF <sub>P</sub>		kg N2O / t HNO3	1,00
NAP	NAP		t HNO3	131.941
Greenhouse warming potential N2O	GWP			310
<b>Emission reduction</b>	<b>ER</b>		<b>t CO2e</b>	<b>149.125</b>

N.DBMS Project Campaign Calculation		Project: AEL No. 11, Johannesburg, South Africa	Campaign: C 20	04.10.08 - 23.05.09
<b>Project campaign 3</b>				
Emission factor Baseline	EF <sub>BL</sub>		kg N2O / t HNO3	4,65
Emission factor nth Campaign	EF <sub>n</sub>		kg N2O / t HNO3	1,14
Moving average emission factor	EF <sub>ma,n</sub>		kg N2O / t HNO3	1,05
Emission factor Project Campaign	EF <sub>P</sub>		kg N2O / t HNO3	1,14
NAP	NAP		t HNO3	138.917
Greenhouse warming potential N2O	GWP			310
<b>Emission reduction</b>	<b>ER</b>		<b>t CO2e</b>	<b>151.220</b>

The total amount of emission reductions for the project activity of the “N<sub>2</sub>O abatement project at nitric acid plant No. 11 at African Explosives Ltd. (AEL), South Africa” during the 1<sup>st</sup> monitoring period is: 331,554 tCO<sub>2</sub>e.

### Comparison of achieved ER to estimated in registered PDD

The monitoring period covered by this report is from 08 February 2008 to 23 May 2009 (470 days). The estimated amount of emission reductions according to the registered PDD is 265,460 tonnes CO<sub>2</sub>e per year i. e. 341,825 tonnes CO<sub>2</sub>e for a period of 470 days.

The achieved amount of emission reductions during this monitoring period is 331,554 tonnes of CO<sub>2</sub>e and therefore coming very close to the estimated amount as mentioned in the PDD. However, the abatement performance of the secondary catalyst was lower than expected (75 % - 79 % instead of 90 %). On the other hand the EF<sub>BL</sub> was slightly higher than the figure that was used for the assumptions in the PDD because the QAL2 correction factors were not yet available when the PDD was completed. Therefore the EF<sub>BL</sub> as mentioned in the PDD was only a provisional estimation.

## Annex 1: Data and parameters for calculation of Baseline campaign emissions

All of the monitoring equipment used to derive the data for this Monitoring Report has been made part of the ISO 9001/14001 procedures.

All of the relevant data obtained as per the monitoring plan of the registered PDD and used as part of the baseline and during the crediting period of the project will be archived electronically at least 2 years longer than the entire crediting period of the project in at least 2 different locations.

### Baseline Campaign period: July 20<sup>th</sup> 2006 – February 18<sup>th</sup>

<b>Data / Parameter:</b>	<b>B.1 / NCSG<sub>BC</sub></b>
<b>Data unit:</b>	<b>mg/Nm<sup>3</sup></b>
<b>Description:</b>	N <sub>2</sub> O concentration in the stack gas during the baseline campaign.
<b>Source of data used:</b>	NDIR N <sub>2</sub> O gas analyser (Environnement S.A. MIR 9000)
<b>Value applied:</b>	<b>1,630</b>
<b>Justification of the choice of data or description of measurement methods and procedures actually applied :</b>	<p>AM0034 requires the determination of the concentration of N<sub>2</sub>O in the stack gas. NCSG is continuously monitored with an NDIR gas analyser<sup>7</sup> 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 operating outside the permitted operating range were eliminated. The remaining hourly average values were 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 NCSG values</li> </ol> <p>During the QAL2 reference measurements it was determined that the analyser consistently underestimates 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 1.104 will have to be applied to all NCSG measurements. Therefore, the result of the above statistical analysis, i.e. the mean NCSG value will be multiplied by 1.104 before going into the calculation of BE<sub>BC</sub>.</p>
<b>Any comment:</b>	A complete QAL2 audit in accordance with EN 14181 was conducted on the AMS in 2007.

<b>Data / Parameter:</b>	<b>B.2 VSG<sub>BC</sub></b>
<b>Data unit:</b>	<b>Nm<sup>3</sup>/h</b>

<sup>7</sup> The Environnement S.A. MIR 9000 gas analyser has been certified according to ISO 14956, QAL1 procedures as suitable for stack gas concentration monitoring of NO, NO<sub>2</sub>, SO<sub>2</sub> and various other gasses. In addition QAL1 laboratory 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. At the time of installation of the AMS at AEL's No. 11 plant, no analyser was available on the market that had already passed the QAL1 suitability certification for N<sub>2</sub>O.

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 applied:	<b>72,600</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>AM0034 requires the determination of the gas volume flow (VSG) in the stack. VSG is continuously monitored with a flow meter and monitoring results are taken and recorded for every two seconds of plant operation. Hourly means for VSG are derived by the data acquisition system. VSG data taken during times when the plant was operating outside the permitted operating range 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>e) Calculate the new sample mean from the remaining VSG values</li> </ol> <p>During the QAL2 reference measurements it was determined that the flow meter consistently underestimates the total gas volume flow in the stack. As a result from the QAL2 calibration curve, it was determined that a correction factor of 1.01 will have to be applied to all VSG measurements. Therefore, the result of the above statistical analysis, i.e. the mean VSG value will be multiplied by 1.01 before going into the calculation of BE<sub>BC</sub>.</p>
Any comment:	The QAL2 test as well as the AST test, performed by an independent 3rd party laboratory with EN ISO/IEC 17025 accreditation, include the test of the correct measurement of stack gas temperature and stack gas pressure by comparison of the AMS results of these parameters with the results of the reference measurement instruments of the testing laboratory. Moreover during the QAL2 and AST tests the correct normalization of the stack gas flow (VSG) to standard conditions is verified by comparison of the AMS results for normalized flow with the reference measurement results for normalized flow.

Data / Parameter:	<b>B.3 BE<sub>BC</sub></b>
Data unit:	<b>tN<sub>2</sub>O</b>
Description:	Total N <sub>2</sub> O gas flow for baseline campaign
Source of data used:	Calculation from measured data.
Value applied:	<b>652.262</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>The total mass N<sub>2</sub>O emissions during the baseline campaign are determined as a product of NSCG, VSG and the total hours of operation during that baseline campaign:</p> $BE_{BC} = VSG_{BC} * NCSG_{BC} * QAL2 \text{ correction factors} * 10^{-9} * OH_{BC}$ <p>A special adjustment factor is applied to the mean NSCG and VSG values derived. These correction factors were determined during the QAL2 test.</p>
Any 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:	Process Control System.
Value applied:	<b>4.943</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>Required by AM0034 to determine the total mass emissions of N<sub>2</sub>O during the baseline.</p> <p>Since the design plant operating temperature is between 820°C and 905°C, by definition the plant is offline if the temperature recorded is at or below 800°C. For practical purposes, each hour for which the ammonia oxidation temperature (OTh) was recorded to be below 820°C is excluded from the determination of OHBC.</p>
Any 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 flow meter
Value applied:	<b>134,700</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>Required by AM0034 to calculate the average baseline emissions factor (EFBL) per tonne of 100% concentrated nitric acid produced during that baseline campaign. NAP is determined in the following way:</p> <p>NAP is determined by a mass flow meter according to the following procedures:</p> <p>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.</p>
Any comment:	The mass flow meter is calibrated in regular intervals.

<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 applied:	<b>Not applicable</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	AM0034 requires the determination of gas volume flow at normal conditions in the stack. In order to calculate from the measured VSG values to VSG at normal conditions, the actual temperature in the stack is measured by temperature probes inserted directly next to the flow meter inside the stack. The resulting measurements are applied to each hourly mean VSG value for calculation of normal volume flow.
Any comment:	None

<b>Data / Parameter:</b>	<b>B.7 PSG</b>
Data unit:	<b>Pa</b>
Description:	Pressure in the stack
Source of data used:	Stack pressure probe situated directly next to the volume flow meter.



Value applied:	<b>Not applicable</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	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.
Any comment:	None

<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 nitric acid produced / tons of N <sub>2</sub> O emitted)
Value applied:	<b>0,00465</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	As required by AM0034 the plant specific baseline emissions factor representing the average N <sub>2</sub> O emissions per tonne of nitric acid during the baseline campaign is derived by dividing the total mass of N <sub>2</sub> O emissions by the total output of 100% concentrated nitric acid during the baseline campaign. The overall uncertainty of the monitoring system shall also be determined and the measurement error will be expressed as a percentage ( <i>UNC</i> ). The N <sub>2</sub> O emission factor per tonne of nitric acid produced in the baseline period (EF <sub>BL</sub> ) is then reduced by the percentage uncertainty as follows:  $EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100) (tN_2O/tHNO_3)$
Any comment:	None

<b>Data / Parameter:</b>	<b>B.9 UNC</b>
Data unit:	<b>%</b>
Description:	Calculated uncertainty of the overall Automated Monitoring System (AMS)
Source of data used:	Engineering reports and calculations conducted by the manufacturer of the components of the AMS.
Value applied:	<b>3,99</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	In accordance with AM0034 the overall measurement uncertainty of the AMS is applied in the calculation of the baseline emissions factor (EF <sub>BL</sub> ).  The overall total uncertainty of the AMS has been determined by an accredited ISO 17025 testing house during the on-site QAL2 audit. The QAL2 audit report and the uncertainty calculation are available to the DOE on request.
Any comment:	None.

<b>Data / Parameter:</b>	<b>B.10 AFR</b>
Data unit:	<b>tNH<sub>3</sub>/h</b>
Description:	Mean Ammonia gas flow rate to the ammonia oxidation reactor
Source of data used:	Orifice plate
Value applied:	<b>Not applicable, monitored data of AFR will be used to determine if plant was operating outside of AFR<sub>max</sub>.</b>

Justification of the choice of data or description of measurement methods and procedures actually applied :	The monitoring of AFR is required by AM0034 in order to determine AFR <sub>max</sub> .
Any comment:	None

Data / Parameter:	B.11 AFR <sub>max</sub>																																			
Data unit:	tNH3/h																																			
Description:	Maximum Ammonia gas flow rate to the ammonia oxidation reactor																																			
Source of data used:	AFR data																																			
Value applied:	9.094																																			
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>AFR<sub>max</sub> is used to determine those periods where the plant may be operating outside of the permitted operating conditions.</p> <p>Historic data of daily NH<sub>3</sub> consumption was used to obtain determine the range of AFR for the five historic campaigns.</p> <p>Table: Maximum NH<sub>3</sub> gas flow to the AOR</p> <table><tr><th>Campaign No.</th><th>Start Date</th><th>End date</th><th>Total NH<sub>3</sub> consumed</th><th>Maximum NH<sub>3</sub> consumed per day</th></tr><tr><td></td><td></td><td></td><td>tonnes</td><td>tonnes</td></tr><tr><td>C10</td><td>29 May 03</td><td>24 Nov 03</td><td>34,914</td><td>219</td></tr><tr><td>C12<sup>8</sup></td><td>27 May 04</td><td>12 Dec 04</td><td>38,492</td><td>211</td></tr><tr><td>C13</td><td>15 Dec 04</td><td>24 Jul 05</td><td>43,187</td><td>206</td></tr><tr><td>C14</td><td>27 Jul 05</td><td>28 Jan 06</td><td>34,623</td><td>206</td></tr><tr><td>C15</td><td>03 Feb 06</td><td>31 Jul 06</td><td>28,824</td><td>198</td></tr></table> <p>After removing the top 2.5 percentile values the maximum daily flow rate was 218<sup>9</sup> tNH<sub>3</sub>. This corresponds to an hourly maximum flow rate of 9,094 kgNH<sub>3</sub>/h.</p>	Campaign No.	Start Date	End date	Total NH <sub>3</sub> consumed	Maximum NH <sub>3</sub> consumed per day				tonnes	tonnes	C10	29 May 03	24 Nov 03	34,914	219	C12 <sup>8</sup>	27 May 04	12 Dec 04	38,492	211	C13	15 Dec 04	24 Jul 05	43,187	206	C14	27 Jul 05	28 Jan 06	34,623	206	C15	03 Feb 06	31 Jul 06	28,824	198
Campaign No.	Start Date	End date	Total NH <sub>3</sub> consumed	Maximum NH <sub>3</sub> consumed per day																																
			tonnes	tonnes																																
C10	29 May 03	24 Nov 03	34,914	219																																
C12 <sup>8</sup>	27 May 04	12 Dec 04	38,492	211																																
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C14	27 Jul 05	28 Jan 06	34,623	206																																
C15	03 Feb 06	31 Jul 06	28,824	198																																
Any 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 applied:	<b>8.3 to 11.5 (AIFR will be used to determine AIFR<sub>max</sub>).</b>
Justification of the	The monitoring of AIFR is required by AM0034 in order to determine AIFR <sub>max</sub> .

<sup>8</sup> AEL does a statutory shutdown every 3 years. These shutdowns usually take place during a time that AEL predicts low customer demand. The last statutory shutdown was done during May 2004. Because of the timing of this shutdown, the campaign before the shutdown (C11) had to be made shorter. Since this shorter campaign was not representative of normal operation, it was excluded from the analysis.

<sup>9</sup> This value corresponds to the C10 value provided in the table, after the top 2.5 percentile data sets have been eliminated.



choice of data or description of measurement methods and procedures actually applied :	The allowable NH <sub>3</sub> to Air ratio is taken from the controller data sheet (No. 11 Technical Manual, TM4, p250, June 1977). The range is 8.3 % v/v - 11.5 % v/v.
Any comment:	None

<b>Data / Parameter:</b>	<b>B.15 AIFR<sub>max</sub></b>
Data unit:	% v/v
Description:	Maximum Ammonia to air ratio into the ammonia oxidation reactor during the baseline campaign.
Source of data used:	Plant operating manual
Value applied:	<b>11.5</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>In accordance with AM0034 AIFR<sub>max</sub> is used to determine those periods where the plant may be operating outside of the permitted operating conditions.</p> <p>The upper limits for ammonia flow and ammonia to air ratio shall be determined using one of the following three options, in preferential order:</p> <ol style="list-style-type: none"> <li>Historical maximum operating data for hourly ammonia gas and ammonia to air ratio for the previous five campaigns (or fewer, if the plant has not been operating for five campaigns; excluding abnormal campaigns; or,</li> <li>If no data is available, calculation of the maximum permitted ammonia gas flow rates and ammonia to air ratio as specified by the ammonia oxidation catalyst manufacturer or for typical catalyst loadings; or</li> <li>If information for (b) above is not available, based on a relevant technical literature source.</li> </ol> <p>Since no historical data were recorded and available, the allowable NH<sub>3</sub> to Air ratio is taken from the controller data sheet (No. 11 Technical Manual, TM4, p250, June 1977). The range is 8.3 % v/v - 11.5 % v/v, therefore the maximum ammonia to air ratio is 11.5%.</p>
Any comment:	None

<b>Data / Parameter:</b>	<b>B.13 CL<sub>BL</sub></b>
Data unit:	tHNO <sub>3</sub>
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 applied:	<b>134,700</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>CL<sub>BL</sub> is comprised of each and every tonne of nitric acid produced during the baseline campaign, regardless of whether the measured NCSG and VSG data were excluded from the relevant period.</p> <p>In accordance with AM0034 the respective baseline campaign length for each plant (CL<sub>BL</sub>) has to be compared to the established average historic campaign length (CL<sub>normal</sub>); and</p> <p>If CL<sub>BL</sub> ≤ CL<sub>normal</sub>, then all N<sub>2</sub>O values measured during the baseline campaign can be used for the calculation of EF<sub>BL</sub> (subject to the elimination of data that</p>

	<p>was monitored during times where the plant was operating outside of the “permitted range”).</p> <p>If <math>CL_{BL} &gt; CL_{normal}</math>, then <math>N_2O</math> values that were measured beyond the length of <math>CL_{normal}</math> during the production of the quantity of nitric acid (i.e. the final tonnes produced) are to be eliminated from the calculation of <math>EF_{BL}</math>.</p> <p><math>CL_{normal}</math> for AEL No. 11 is:            127,302.4 tonnes of <math>HNO_3</math>  <math>CL_{BL}</math> for AEL No. 11 is:                134.700 tonnes of <math>HNO_3</math></p> <p>Therefore <math>CL_{BL} &gt; CL_{normal}</math> and all NCSG and VSG datasets were excluded from that operating hour onwards when the nitric acid production during the baseline campaign exceeded the <math>CL_{normal}</math> value.</p>
Any comment:	None

Data / Parameter:	B.14 CL <sub>normal</sub>																												
Data unit:	tHNO3																												
Description:	Average length of the historic campaigns measured in metric tonnes of 100% concentrated nitric acid produced during that baseline campaign.																												
Source of data used:	Coriolis flow meter as described in NAP.																												
Value applied:	127,302.4																												
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>In accordance with AM0034 the average historic campaign length (CL<sub>normal</sub>) is defined as the average campaign length for the historic campaigns that were used to define operating condition. CL<sub>normal</sub> presents the cap on the length of the baseline campaign from which the baseline emissions factor will be derived.</p> <p>During the five historic campaigns, the following amounts of metric tonnes of 100% concentrated nitric acid have been produced:</p> <table><thead><tr><th>Campaign</th><th>Start</th><th>End</th><th>Production (tHNO3)</th></tr></thead><tbody><tr><td>C10</td><td>29-May-03</td><td>24-Nov-03</td><td>125098,7</td></tr><tr><td>C12<sup>10</sup></td><td>27-May-04</td><td>04-Dec-04</td><td>136602,6</td></tr><tr><td>C13</td><td>15-Dec-04</td><td>24-Jul-05</td><td>146720,2</td></tr><tr><td>C14</td><td>27-Jul-05</td><td>28-Jan-06</td><td>124252,6</td></tr><tr><td>C15</td><td>03-Feb-06</td><td>31-Jul-06</td><td>103837,7</td></tr><tr><td>Mean</td><td></td><td></td><td>127302,4</td></tr></tbody></table> <p>Therefore, the average historic campaign length (CL<sub>normal</sub>) is 24,026.2 tonnes of 100% concentrated nitric acid.</p>	Campaign	Start	End	Production (tHNO3)	C10	29-May-03	24-Nov-03	125098,7	C12 <sup>10</sup>	27-May-04	04-Dec-04	136602,6	C13	15-Dec-04	24-Jul-05	146720,2	C14	27-Jul-05	28-Jan-06	124252,6	C15	03-Feb-06	31-Jul-06	103837,7	Mean			127302,4
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C15	03-Feb-06	31-Jul-06	103837,7																										
Mean			127302,4																										
Any comment:	None.																												

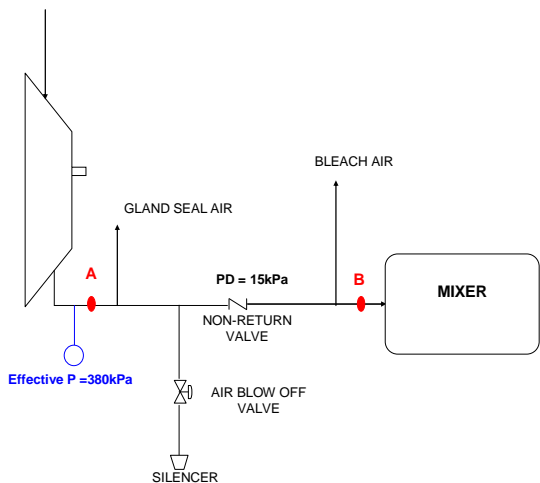
<b>Data / Parameter:</b>	<b>B.16 OT<sub>h</sub></b>
<b>Data unit:</b>	<b>°C</b>
<b>Description:</b>	Oxidation temperature for each hour during the baseline campaign
<b>Source of data used:</b>	Monitoring results of three thermocouples inside the ammonia oxidation reactor and recorded by the data acquisition system.
<b>Value applied:</b>	<b>Not applicable</b>
<b>Justification of the choice of data or description of measurement methods and procedures actually applied :</b>	<p>In accordance with AM0034 the oxidation temperature in the ammonia oxidation reactor (OT<sub>h</sub>) has to be monitored and compared to the Normal range for oxidation temperature (OT<sub>normal</sub>).</p> <p>VSG and NCSG data obtained during times when OT<sub>h</sub> was above or below OT<sub>normal</sub> has to be eliminated from the calculation of EF<sub>BL</sub>.</p>
<b>Any comment:</b>	None

<sup>10</sup> AEL does a statutory shutdown every 3 years. These shutdowns usually take place during a time that AEL predicts low customer demand. The last statutory shutdown was done during May 2004. Because of the timing of this shutdown, the campaign before the shutdown (C11) had to be made shorter. Since this shorter campaign was not representative of normal operation, it was excluded from the analysis.

<b>Data / Parameter:</b>	<b>B.17 OT<sub>normal</sub></b>
<b>Data unit:</b>	<b>°C (min and max)</b>
<b>Description:</b>	Normal range operating temperature
<b>Source of data used:</b>	Design specifications and operating manual of the No. 11 nitric acid plant (Technical Manual (TM4 June 1977, p. 250) <sup>11</sup> .
<b>Value applied:</b>	<b>820°C (min.) and 905°C (max.)</b>
<b>Justification of the choice of data or description of measurement methods and procedures actually applied :</b>	<p>AM0034 requires the establishment of the normal range of operating temperatures in the ammonia oxidation reactor. Since no historical data for the No. 11 plant are available, the range of operating temperature of between 820°C and 905°C, as stipulated in the operating manual was applied to derive OT<sub>normal</sub>.</p> <p>The measuring range of the thermocouples determining the oxidation temperatures is set accordingly, i.e. when the plant is offline, the temperature reading will continue to show 800°C.</p> <p>For practical purposes, all VSG and NCSG values taken during times when the plant was operating at below 820°C will be excluded.</p>
<b>Any comment:</b>	None

<b>Data / Parameter:</b>	<b>B.18 OP<sub>h</sub></b>
<b>Data unit:</b>	kPa (gauge)
<b>Description:</b>	Oxidation Pressure for each hour
<b>Source of data used:</b>	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).
<b>Value applied:</b>	<b>Not applicable.</b>
<b>Justification of the choice of data or description of measurement methods and procedures actually applied :</b>	<p>In accordance with AM0034 the oxidation pressure in the ammonia oxidation reactor (OP<sub>h</sub>) has to be monitored and compared to the Normal range for oxidation temperature (OP<sub>normal</sub>). VSG and NCSG data obtained during times when OP<sub>h</sub> was above or below OP<sub>normal</sub> has to be eliminated from the calculation of EF<sub>BL</sub>.</p> <p>AM0034 prescribes the monitoring and recording of the Oxidation Pressure for each hour (OP<sub>h</sub>) during the baseline campaign. This would imply the measurement of pressure inside the Ammonia Oxidation Reactor. AEL has no such measurement equipment installed at that point, instead the available measurements for air pressure before the ammonia-air-mixer are used to determine OP<sub>h</sub>.</p> <p>The pressure for the oxidation reactor is taken as the pressure at point <b>B</b> (air to mixer pressure). The permitted range for the oxidation pressure is inferred from the values given for point <b>A</b> (HP compressor discharge pressure range).</p> <p>Figure: Pressure points for No. 11</p>

<sup>11</sup> Copies of the technical plant manuals can be provided to the DOE upon request.

	 <p>During the baseline campaign (as well as for project campaigns) OP is monitored as air pressure to the ammonia to air mixer. Unlike during historic campaigns, these data will be archived and analysed as required by AM0034.</p>
Any 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:	kPa (gauge)
Description:	Normal operating pressure of the ammonia oxidation reactor.
Source of data used:	Plant operating manual.
Value applied:	<b>365 kPa – 450 kPa (gauge)</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>AM0034 requires the establishment of the normal range of operating pressure in the ammonia oxidation reactor. Since no historical data for the No. 9 plant are available, the range of temperature stipulated in the operating manual was applied to derive OP<sub>normal</sub>.</p> <p>The upper limit is 450 kPa. The lower limit is inferred from the effective discharge set point pressure, 380 kPa (Operating Instructions No. M69.0300.2008, 1978) and the pressure drop across the non-return valve (No 11 HNO<sub>3</sub> Plant Understanding, p. 10). The pressure recorded as the oxidation pressure is taken from Point A as contained in Figure 1 in table B. 18 above. The pressure drop given is 15 kPa. Since the NH<sub>3</sub>-Air mixer appears down stream of the non-return valve it is assumed that the lower pressure limit in the mixer is 365 kPa. The oxidation pressure is measured in kPa.</p> <p>For dual-pressure processes, the pressure range suggested is 400 - 600 kPa (Ullmann's Encyclopedia of Industrial Chemistry, 6<sup>th</sup> Ed, Vol. 23, p3).</p>
Any 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 campaigns
Source of data used:	Monitored / Invoices
Value applied:	<b>W.C. Heraeus</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>AM0034 requires the monitoring of the supplier of the ammonia oxidation catalyst gauze. The recorded information is not further processed in the methodology but it is used as a plausibility check against the information for GC.</p> <p>AEL has been using ammonia oxidation catalyst gauzes ("FTCplus") supplied by Heraeus for the past several years. The Heraeus FTCplus gauze contains significant levels of Palladium (approximately one third). The main motivation for this is that it leads to a weight reduction of the (more expensive) Platinum. A side effect of this gauze type is that the generation of N<sub>2</sub>O in the ammonia oxidation process tends to be lower than with gauzes containing little or no Palladium.</p> <p>AEL has used FTCplus gauzes supplied by Heraeus during the baseline campaign and intends to continue using the same or very similar composition of gauzes for the foreseeable future.</p>
Any 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 applied:	<b>W.C. Heraeus</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>AM0034 requires the monitoring of the supplier of the ammonia oxidation catalyst gauze. The recorded information is not further processed in the methodology but it is used as a plausibility check against the information for GC.</p>
Any comment:	None

<b>Data / Parameter:</b>	<b>B.23 GC<sub>normal</sub></b>
Data unit:	<b>%</b>
Description:	Gauze composition during the five 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 applied:	<b>Platinum (Pt) 56.5%</b> <b>Rhodium (Rh) 3.8%</b> <b>Palladium (Pd) 37%</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>In accordance with AM0034, if the composition of the ammonia oxidation catalyst used for the baseline campaign and after the implementation of the project are identical to that used in the campaign for setting the operating conditions (previous five campaigns), then there shall be no limitations on N<sub>2</sub>O baseline emissions.</p> <p>Record of Gauze compositions installed during the historic campaigns<sup>12</sup>:</p>

	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	
Any comment:	None					

Data / Parameter:	<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 applied:	<b>Platinum (Pt) 56.0%</b> <b>Rhodium (Rh) 3.8%</b> <b>Palladium (Pd) 40.2%</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	<p>A change in the composition of the ammonia oxidation catalyst in the baseline campaign to a composition other than that used in the previous five campaigns, is permissible without any limitation on the N<sub>2</sub>O baseline emissions if the following conditions are met</p> <p>(i) The baseline catalyst composition is considered as common practice in the industry, or</p> <p>(ii) The change in catalyst composition is justified by its availability, performance, relevant literature etc.</p> <p>Otherwise, the baseline emission factor shall be set to the conservative IPCC default emission factor for N<sub>2</sub>O from nitric acid plants which have not installed N<sub>2</sub>O destruction measures (4.5 kg-N<sub>2</sub>O / t HNO<sub>3</sub>).</p> <p>GC<sub>BL</sub> at AEL's No. 11 nitric acid plant is the same as GC<sub>normal</sub>, therefore, the results of the baseline campaign are fully valid and applicable.</p>
Any comment:	None

Data / Parameter:	<b>B.26 EF<sub>reg</sub></b>
Data unit:	<b>tN<sub>2</sub>O/tHNO<sub>3</sub></b>
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 applied:	<b>None</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	There is currently no regulation in South Africa that limits the emissions of N <sub>2</sub> O from nitric acid production.
Any comment:	None.



## Annex 2: Data and parameters for calculation of Project campaign emissions

All of the monitoring equipment used to derive the data for this Monitoring Report has been made part of the ISO 9001/14001 procedures.

All of the relevant data obtained as per the monitoring plan of the registered PDD and used as part of the baseline and during the crediting period of the project will be archived electronically at least 2 years longer than the entire crediting period of the project in at least 2 different locations.

<b>Data / Parameter:</b>	<b>P.1 NCSG</b>		
<b>Data unit:</b>	<b>mg / m<sup>3</sup></b>		
<b>Description:</b>	N <sub>2</sub> O concentration in the stack gas during each project campaign.		
<b>Source of data to be used:</b>	NDIR N <sub>2</sub> O gas analyser (ABB AO2040 Uras-14)		
<b>Value of data applied</b>			<b>NCSG</b>
			<b>mg/m<sup>3</sup></b>
	<b>Project Campaign</b>	<b>PC1</b>	<b>398</b>
	<b>Project Campaign</b>	<b>PC2</b>	<b>344</b>
	<b>Project Campaign</b>	<b>PC3</b>	<b>436</b>
<b>Description of measurement methods and procedures to be applied:</b>	<p>AM0034 requires the determination of the concentration of N<sub>2</sub>O in the stack gas. NCSG is continuously monitored with an NDIR gas analyser and monitoring results are taken and recorded for every two seconds of plant operation. Hourly means for NCSG are derived by the 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>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 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 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 PE<sub>n</sub>.</p>		
<b>QA/QC procedures to be applied:</b>	Manual zero and span calibrations are carried out regularly by the instrumentation department of AEL.		
<b>Any comment:</b>	None		

<b>Data / Parameter:</b>	<b>P.2 VSG</b>
<b>Data unit:</b>	<b>Nm<sup>3</sup>/h</b>



Description:	Normal gas volume flow rate of the stack gas during each project campaign.		
Source of data to be used:	Gas Volume Flow meter, Emerson Rosemount Annubar® Model 485		
Value of data applied		<b>VSG</b> <b>m³/h</b>	
	<b>Project Campaign</b>	<b>PC1</b>	<b>78.691</b>
	<b>Project Campaign</b>	<b>PC2</b>	<b>78.318</b>
	<b>Project Campaign</b>	<b>PC3</b>	<b>74.185</b>
Description of measurement methods and procedures to be applied:	<p>AM0034 requires the determination of the gas volume flow (VSG) in the stack. VSG is continuously monitored with a flow meter and monitoring results are taken and recorded for every two seconds of plant operation. Hourly means for VSG are derived by the data acquisition system. Temperature and pressure is also continuously measured in the stack and the VSG values subsequently adjusted to derive the VSG at normal conditions (i.e. standard pressure and temperature).</p> <p>VSG data taken during times when the plant was out of operation were eliminated.</p> <p>The resulting hourly average VSG values are now expressed in Nm³/h as required by AM0034 and where subsequently subjected to the following statistical analysis:</p> <ol style="list-style-type: none"> <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 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>		
QA/QC procedures to be applied:	The flow meter is calibrated at least annually. See Monitoring Plan for more details.		
Any comment:	None.		

<b>Data / Parameter:</b>	<b>P.3 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.		
Source of data to be used:	Calculated from the measurements from measured data.		
Value of data applied		<b>PE<sub>n</sub></b> <b>t N<sub>2</sub>O</b>	
	<b>Project Campaign</b>	<b>PC1</b>	<b>136,03</b>
	<b>Project Campaign</b>	<b>PC2</b>	<b>124,72</b>
	<b>Project Campaign</b>	<b>PC3</b>	<b>158,04</b>
Description of measurement methods	Not applicable, calculated value as per the following formula:		

and procedures to be applied:	$PE_n = VSG * NCSG * QAL2 \text{ correction factors} * 10^{-9} * OH$ A special adjustment factor is applied to the mean NCSG and VSG values derived. These correction factors were determined during the QAL2 test.
QA/QC procedures to be applied:	Not applicable. Calculated value.
Any comment:	None.

Data / Parameter:	P.4 OH <sub>n</sub>			
Data unit:	hours			
Description:	Total operating hours during each project campaign			
Source of data to be used:	Process Control System.			
Value of data applied			OH <sub>n</sub>	
			h	
	Project Campaign	PC1	4.339	
	Project Campaign	PC2	4.629	
	Project Campaign	PC3	4.887	
Description of measurement methods and procedures to be applied:	Required by AM0034 to determine the total mass emissions of N <sub>2</sub> O during the project campaign.  Since the design plant operating temperature is between 820°C and 905°C, by definition the plant is offline if the temperature recorded is at or below 800°C. For practical purposes, each hour for which the ammonia oxidation temperature (OTh) was recorded to be below 820°C is excluded from the determination of OHBC.			
QA/QC procedures to be applied:	Subject to ISO 9001/14001 procedures.			
Any comment:	None.			

Data / Parameter:	P.5 NAP																	
Data unit:	tHNO <sub>3</sub>																	
Description:	Metric tonnes of 100% concentrated nitric acid during each project campaign.																	
Source of data to be used:	Coriolis flow meter.																	
Value of data applied	<table><tr><td colspan="2" rowspan="2"></td><td>NAP</td><td rowspan="5"></td></tr><tr><td>t HNO<sub>3</sub></td></tr><tr><td>Project Campaign</td><td>PC1</td><td>128.190</td></tr><tr><td>Project Campaign</td><td>PC2</td><td>131.941</td></tr><tr><td>Project Campaign</td><td>PC3</td><td>138.917</td></tr></table>						NAP		t HNO <sub>3</sub>	Project Campaign	PC1	128.190	Project Campaign	PC2	131.941	Project Campaign	PC3	138.917
		NAP																
		t HNO <sub>3</sub>																
Project Campaign	PC1	128.190																
Project Campaign	PC2	131.941																
Project Campaign	PC3	138.917																
Description of measurement methods and procedures to be applied:	<p>NAP is determined in the following way:</p> <p>NAP is determined by a mass flow meter according to the following procedures:</p> <p>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.</p>																	
QA/QC procedures to be applied:	Subjected to complete SABS testing loops as part of the ISO 9001/14001 procedures. The mass flow meter is calibrated in regular intervals.																	

Any comment:	The total nitric acid production for project campaign 1 is 128,190 tonnes of HNO <sub>3</sub> . The Amount of nitric acid produced after registration of the project is 28.050 tonnes of HNO <sub>3</sub>
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<b>Data / Parameter:</b>	<b>P.6 TSG</b>
Data unit:	°C
Description:	Temperature in the stack gas
Source of data to be used:	Stack temperature probe situated directly next to the volume flow meter.
Value of data applied	<b>Not applicable</b>
Description of measurement methods and procedures to be applied:	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 directly next to the flow meter.
QA/QC procedures to be applied:	ISO9001/14001 procedures and documented in the applicable ISO handbooks.
Any comment:	None.

<b>Data / Parameter:</b>	<b>P.7 PSG</b>
Data unit:	<b>bar</b>
Description:	Pressure in the stack
Source of data to be used:	Stack pressure probe situated directly next to the volume flow meter.
Value of data applied	<b>Not applicable.</b>
Description of measurement methods and procedures to be applied:	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 to be applied:	ISO9001/14001 procedures and documented in the applicable ISO handbooks.
Any comment:	None.

Data / Parameter:	P.8 EF <sub>n</sub>																		
Data unit:	tN <sub>2</sub> O/tHNO <sub>3</sub>																		
Description:	Emissions factor for campaign n.																		
Source of data to be used:	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 of data applied	<table><tr><td colspan="2"></td><td>EF<sub>n</sub></td><td rowspan="5"></td></tr><tr><td colspan="2"></td><td>t N2O/ t HNO3</td></tr><tr><td>Project Campaign</td><td>PC1</td><td>0,0011</td></tr><tr><td>Project Campaign</td><td>PC2</td><td>0,0009</td></tr><tr><td>Project Campaign</td><td>PC3</td><td>0,0011</td></tr></table>					EF <sub>n</sub>				t N2O/ t HNO3	Project Campaign	PC1	0,0011	Project Campaign	PC2	0,0009	Project Campaign	PC3	0,0011
		EF <sub>n</sub>																	
		t N2O/ t HNO3																	
Project Campaign	PC1	0,0011																	
Project Campaign	PC2	0,0009																	
Project Campaign	PC3	0,0011																	
Description of measurement methods and procedures to be applied:	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 n the campaign specific emission factor would be:  EF <sub>n</sub> = PE <sub>n</sub> / NAP <sub>n</sub>																		

QA/QC procedures to be applied:	Not applicable.
Any comment:	None

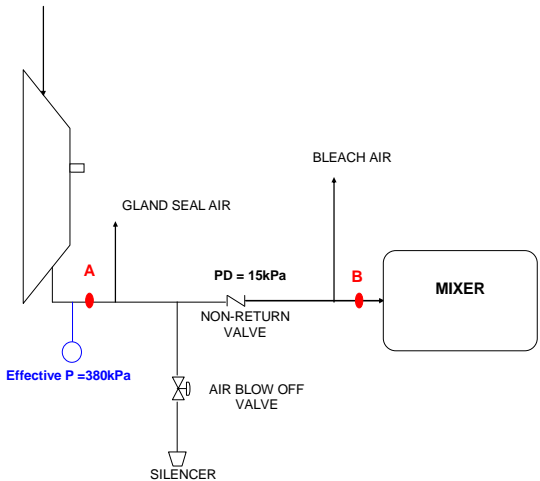
Data / Parameter:	P.9 EF <sub>ma,n</sub>																		
Data unit:	tN <sub>2</sub> O/tHNO <sub>3</sub>																		
Description:	Moving average emissions factor derived over time from campaign specific emissions factors.																		
Source of data to be used:	Calculation from campaign specific emissions factors EF <sub>n</sub> .																		
Value of data applied	<table><tr><td colspan="2"></td><td>EF<sub>ma,n</sub></td><td rowspan="5"></td></tr><tr><td colspan="2"></td><td>t N<sub>2</sub>O/ t HNO<sub>3</sub></td></tr><tr><td>Project Campaign</td><td>PC1</td><td>0,0011</td></tr><tr><td>Project Campaign</td><td>PC2</td><td>0,0010</td></tr><tr><td>Project Campaign</td><td>PC3</td><td>0,0010</td></tr></table>					EF <sub>ma,n</sub>				t N <sub>2</sub> O/ t HNO <sub>3</sub>	Project Campaign	PC1	0,0011	Project Campaign	PC2	0,0010	Project Campaign	PC3	0,0010
		EF <sub>ma,n</sub>																	
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Project Campaign	PC3	0,0010																	
Description of measurement methods and procedures to be applied:	<p>In order to take into account possible long-term emissions trends over the duration of the project activity and to take a conservative approach a moving average emission factor shall be estimated as follows:</p> $EF_{ma,n} = (EF_1 + EF_2 + \dots + EF_n) / n$ <p>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.</p>																		
QA/QC procedures to be applied:	Not applicable.																		
Any comment:	None																		

Data / Parameter:	P.12 CL <sub>n</sub>																				
Data unit:	tHNO <sub>3</sub>																				
Description:	Length of each project campaign measured in metric tonnes of 100% concentrated nitric acid produced during that campaign.																				
Source of data to be used:	NAP																				
Value of data applied	<table><tr><td colspan="2"></td><td>CL<sub>n</sub></td></tr><tr><td colspan="2"></td><td>t HNO<sub>3</sub></td></tr><tr><td>Project Campaign</td><td>PC1</td><td>28.050</td></tr><tr><td>Project Campaign</td><td>PC2</td><td>(after registration of the project)</td></tr><tr><td>Project Campaign</td><td>PC2</td><td>131.941</td></tr><tr><td>Project Campaign</td><td>PC3</td><td>138.917</td></tr></table>					CL <sub>n</sub>			t HNO <sub>3</sub>	Project Campaign	PC1	28.050	Project Campaign	PC2	(after registration of the project)	Project Campaign	PC2	131.941	Project Campaign	PC3	138.917
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Description of measurement methods and procedures to be applied:	<p>In accordance with AM0034 the project length (CL<sub>n</sub>) has to be compared to the established average historic campaign length (CL<sub>normal</sub>); and</p> <p>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>, 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 Ammonia/Air analysis).</p> <p>If CL<sub>n</sub> &lt; CL<sub>normal</sub>, recalculate EF<sub>BL</sub> by eliminating those N<sub>2</sub>O values that were obtained during the production of tonnes of nitric acid beyond the CL<sub>n</sub> (i.e. the last tonnes produced) from the calculation of EF<sub>n</sub>.</p>																				

QA/QC procedures to be applied:	See comments for NAP.
Any comment:	The total nitric acid production for project campaign 1 is 128,190 tonnes of HNO <sub>3</sub> . The Amount of nitric acid produced after registration of the project is 28.050 tonnes of HNO <sub>3</sub>

<b>Data / Parameter:</b>	<b>P.13 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		
Source of data to be used:	Calculation of EF <sub>n</sub> and EF <sub>ma,n</sub> .		
Value of data applied			<b>EF<sub>p</sub></b>
			<b>t N<sub>2</sub>O/ t HNO<sub>3</sub></b>
	<b>Project Campaign</b>	<b>PC1</b>	<b>0,0011</b>
	<b>Project Campaign</b>	<b>PC2</b>	<b>0,0010</b>
	<b>Project Campaign</b>	<b>PC3</b>	<b>0,0011</b>
Description of measurement methods and procedures to be applied:	<p>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:</p> <p>If EF<sub>ma,n</sub> &gt; EF<sub>n</sub> then EF<sub>P</sub> = EF<sub>ma,n</sub></p> <p>If EF<sub>ma,n</sub> &lt; EF<sub>n</sub> then EF<sub>P</sub> = EF<sub>n</sub></p>		
QA/QC procedures to be applied:	Not applicable.		
Any comment:	None		

<b>Data / Parameter:</b>	<b>P.14 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.		
Source of data to be used:	Calculations of EF <sub>ma,n</sub> .		
Value of data applied			<b>EFmin</b>
			<b>t N<sub>2</sub>O/ t HNO<sub>3</sub></b>
	<b>Project Campaign</b>	<b>PC1</b>	<b>0,0011</b>
	<b>Project Campaign</b>	<b>PC2</b>	<b>0,0009</b>
	<b>Project Campaign</b>	<b>PC3</b>	<b>0,0009</b>
Description of measurement methods and procedures to be applied:	<p>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<sub>n</sub> observed during those campaigns will be adopted as a minimum (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 used EF<sub>min</sub> and not EF<sub>n</sub>.</p>		
QA/QC procedures to be applied:	Not applicable.		
Any comment:	None.		

Data / Parameter:	OP <sub>h</sub>
Data unit:	bar
Description:	Oxidation Pressure for each hour
Source of data to be used:	Discharge of the air compressor before the ammonia to air mixer
Value of data applied	<b>Not applicable. Used to determine when plant is operating outside of permitted range during baseline campaign</b>
Description of measurement methods and procedures to be applied:	<p>In accordance with AM0034 the oxidation pressure in the ammonia oxidation reactor (OP<sub>h</sub>) has to be monitored and compared to the Normal range for oxidation temperature (OP<sub>normal</sub>). VSG and NCSG data obtained during times when OP<sub>h</sub> was above or below OP<sub>normal</sub> has to be eliminated from the calculation of EF<sub>BL</sub>.</p> <p>AM0034 prescribes the monitoring and recording of the Oxidation Pressure for each hour (OP<sub>h</sub>) during the baseline campaign. This would imply the measurement of pressure inside the Ammonia Oxidation Reactor. AEL has no such measurement equipment installed at that point, instead the available measurements for air pressure before the ammonia-air-mixer are used to determine OP<sub>h</sub>.</p> <p>The pressure for the oxidation reactor is taken as the pressure at point <b>B</b> (air to mixer pressure). The permitted range for the oxidation pressure is inferred from the values given for point <b>A</b> (HP compressor discharge pressure range).</p> <p>Figure: Pressure points for No. 11</p>  <p>During the project campaigns OP is monitored as air pressure to the ammonia to air mixer. Unlike during historic campaigns, these data will be archived and analysed as required by AM0034.</p>
QA/QC procedures to be applied:	Subject to ISO 9001/14001 procedures.
Any comment:	None.

<b>Data / Parameter:</b>	<b>OT<sub>h</sub></b>
Data unit:	°C
Description:	Oxidation temperature in the ammonia oxidation reactor (AOR).
Source of data to be used:	Monitoring results of three thermocouples inside the ammonia oxidation reactor and recorded by the data acquisition system.
Value of data applied	<b>Not applicable. Used to determine when plant is operating outside of permitted range during baseline campaign.</b>
Description of measurement methods and procedures to be applied:	In accordance with AM0034 the oxidation temperature in the ammonia oxidation reactor (OT <sub>h</sub> ) has to be monitored and compared to the Normal range for oxidation temperature (OT <sub>normal</sub> ).  VSG and NCSG data obtained during times when OT <sub>h</sub> was above or below OT <sub>normal</sub> has to be eliminated from the calculation of EF <sub>BL</sub> .  In case of a project campaign the OT <sub>h</sub> is used to define if the plant is in operation or not. If OT <sub>h</sub> is below 820° the plant is defined to be out of operation. In that case all date series when OT <sub>h</sub> is below 820°C are eliminated from further calculations.
QA/QC procedures to be applied:	Subject to ISO 9001/14001 procedures.
Any comment:	None.

<b>Data / Parameter:</b>	<b>AFR</b>
Data unit:	tNH <sub>3</sub> /h
Description:	Ammonia gas flow rate to the ammonia oxidation reactor.
Source of data to be used:	Orifice plate
Value of data applied	<b>Not applicable, monitored data of AFR will be used to determine if plant was operating outside of AFR<sub>max</sub> during baseline campaign.</b>
Description of measurement methods and procedures to be applied:	The ammonia flow is continuously measured by orifice plate.
QA/QC procedures to be applied:	Subject to ISO 9001/14001 procedures.
Any comment:	None.

<b>Data / Parameter:</b>	<b>AIFR</b>
Data unit:	% v/v
Description:	Ammonia to air ratio into the ammonia oxidation reactor
Source of data to be used:	Calculation for each hour of plant operation based on measurements of AFR and primary air flow rates.
Value of data applied	<b>Not applicable, monitored data of AIFR will be used to determine if plant was operating outside of AIFR<sub>max</sub> during baseline campaign.</b>
Description of measurement methods and procedures to be applied:	The monitoring of AIFR is required by AM0034 in order to determine whether the plant was operating within the permitted operating range. In the baseline procedures AIFR <sub>max</sub> was determined to be 11.5% v/v. During the analysis of the measured data, any of the NCSG and VSG data obtained from an hour during which the AIFR was above AIFR <sub>max</sub> will be eliminated from the calculation of EF <sub>BL</sub> .



	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/hr and is then converted to Nm <sup>3</sup> /h, which is used in the ratio calculation
QA/QC procedures to be applied:	Subject to ISO 9001/14001 procedures.
Any comment:	None.

<b>Data / Parameter:</b>	<b>GS<sub>project</sub></b>
Data unit:	<b>Name of Supplier</b>
Description:	Gauze supplier for the project campaign
Source of data used:	Monitored / Invoices
Value applied:	<b>W.C. Heraeus</b>
Justification of the choice of data or description of measurement methods and procedures actually applied :	AM0034 requires the monitoring of the supplier of the ammonia oxidation catalyst gauze. The recorded information is not further processed in the methodology but it is used as a plausibility check against the information for GC.
Any comment:	None

<b>Data / Parameter:</b>	<b>GC<sub>project</sub></b>
Data unit:	<b>%</b>
Description:	Gauze composition during the project 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 applied:	
Justification of the choice of data or description of measurement methods and procedures actually applied :	The gauze composition during the baseline and historic campaigns is the same as during the project campaign. Therefore the results of the baseline campaign and the project campaign are fully valid and applicable.
Any comment:	None