



**CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 03 - in effect as of: 28 July 2006**

CONTENTS

- A. General description of project activity
- B. Application of a baseline and monitoring methodology
- C. Duration of the project activity / crediting period
- D. Environmental impacts
- E. Stakeholders' comments

Annexes

- Annex 1: Contact information on participants in the project activity
- Annex 2: Information regarding public funding
- Annex 3: Baseline information
- Annex 4: Monitoring plan
- Annex 5: South African Sustainable Development Criteria for CDM Projects

**SECTION A. General description of project activity****A.1 Title of the project activity:**

“N₂O abatement project at nitric acid plant No. 11 at African Explosives Ltd. (AEL), South Africa”

Version 1.a.

Date of completion: 4th May 2007

A.2. Description of the project activity:

The sole purpose of the proposed project activity is to significantly reduce current levels of N₂O emissions from the production of nitric acid at one of AEL’s nitric acid plants (the “No. 11 Plant”) at Modderfontein, South Africa. The 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.

AEL is the principal developer, producer and supplier of commercial explosives, initiating systems and blasting services for all mining, quarrying and construction markets in Africa.

Established in 1896, AEL is one of the world's leading suppliers of explosives and initiating systems. The nitric acid produced by AEL is mainly utilized by AEL’s own Ammonium Nitrate (“AN”) production plant which produces both porous prilled AN and dense prilled AN for commercial explosives manufacturing, mainly for mining purposes. In addition, some AN is supplied as an aqueous solution to local fertiliser manufacturers in South Africa.

To produce nitric acid, ammonia (NH₃) 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 NO₂, which is later absorbed in water to form HNO₃ – nitric acid. Simultaneously, undesired side reactions yield nitrous oxide (N₂O), nitrogen and water. N₂O is a potent greenhouse gas with a Global Warming Potential (GWP) of 310¹.

The project activity involves the installation of a new N₂O abatement technology; a pelletised catalyst that will be installed inside the ammonia oxidation reactor, underneath the precious metal gauzes. It is expected that this catalyst will reduce between 80% and 90% of current N₂O emissions.

The project transfers a new, clean technology to South Africa that is not even common industrial practice in Annex 1 countries. Also, the project will lead to an enhancement of skills as employees will be trained to operate both the N₂O abatement catalyst and the Automated Monitoring System.

AEL is an ISO 9001 and 14001 certified company. 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.

¹ IPCC Second Assessment Report (1995)



Through the sale of CERs, AEL will also be able to improve its profitability and ensure employment, contribute to economic prosperity in the region as well as invest in further clean technologies to improve its environmental performance.

AEL's shares are owned by AECI and Tiso (a "black empowerment" investment company). A share of AEL's CDM profits will go to the Tiso-AEL Community Development Trust which benefits two local communities near Modderfontein: Alexandra and Tembisa; especially an Environmental Education Project (EEP) aimed at local schoolchildren². The EEP will improve social structures and social amenities in the community.

Furthermore, the project activity may well stimulate the implementation of further CDM projects in South Africa. Compared to tertiary catalyst technology, which requires additional natural gas for its operation, the implementation of secondary catalyst technology also indirectly contributes to the South African Government's Energy Efficiency Strategy³.

In these aspects, the project will contribute to the sustainable development objectives of South Africa in accordance with the National Environmental Management Act No. 107 of 1998. The project has already received Letters of Endorsement from the Ministry of Minerals and Energy in South Africa and the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. A letter of Approval from the South African government is only obtainable once the project has been validated⁴.

A.3. 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 | African Explosives Ltd ("AEL"): AEL is the owner and operator of the No. 11 nitric acid plant in South Africa. | No |
| United Kingdom ⁵ | N.serve Environmental Services GmbH, Germany ("N.serve") is a developer and financier of CDM and JI projects. | No |

A.4. Technical description of the project activity:**A.4.1. Location of the project activity:**

² See Annex 5 for more detailed information on the Environmental Education Project.

³ See <http://www.dme.gov.za/energy/efficiency.stm>

⁴ See http://www.dme.gov.za/dna/dna_approvalprocess.stm under "mandatory submission".

⁵ The UK DNA also accepts Non-UK entities as potential project participants, if they are located in a EU member state; due to the extraordinarily high fees presently charged by the German DNA, the project participants have agreed to apply to the UK for obtaining an investor country approval.

**A.4.1.1. Host Party(ies):**

South Africa

A.4.1.2. Region/State/Province etc.:

Province of Gauteng, South Africa

A.4.1.3. City/Town/Community etc:

Modderfontein, east of the City of Johannesburg

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

AEL operates an industrial complex at Modderfontein, approximately 20 km north-east from the centre of the City of Johannesburg. The postal address is PO Modderfontein 1645. This PDD covers the larger of the two nitric acid plants – named No. 11 – operated at this location. The exact longitude and latitude of the plant's location is 26° 05' 31.00'' South and 28° 10' 16.39'' East⁶.

A regional map shows the location of Modderfontein near Johannesburg



Aerial photograph shows the location of the No. 11 plant in relation to the No. 9 plant on the site

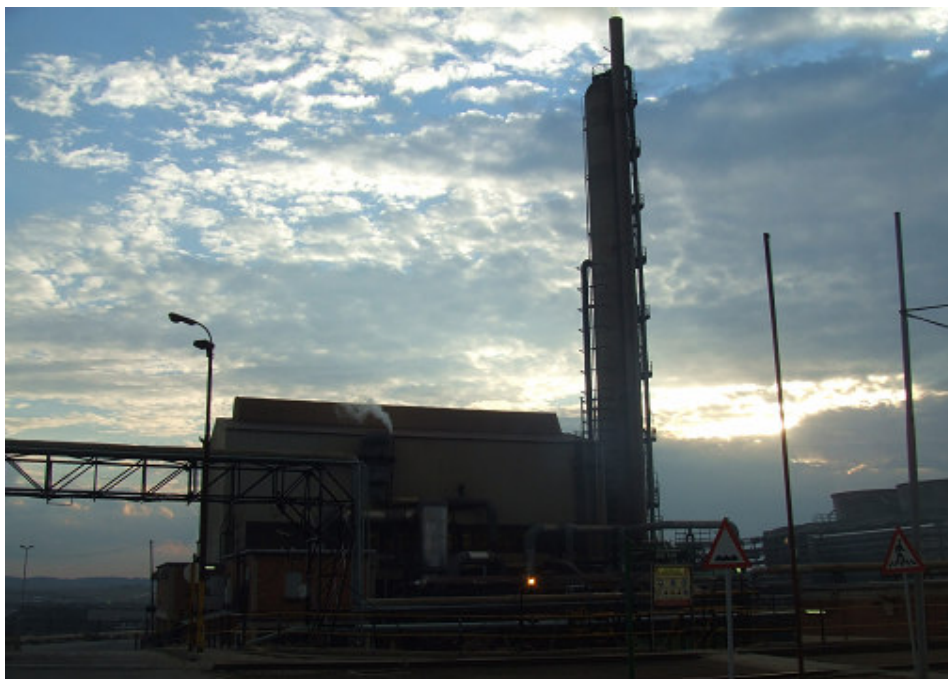
⁶ Coordinates according to Google Earth©, version 4.0.291 (beta)



No. 9 Nitric Acid Plant

No. 11 Nitric Acid Plant

Photograph of the No. 11 nitric acid plant





The No. 9 nitric acid plant operated on the AEL production site has been developed as a separate CDM project. The No. 9 PDD has been submitted to the validator for the purpose of initiating the Global Stakeholder Consultation process on the 16th December 2006 for publication on the UNFCCC web site⁷.

A.4.2. Category(ies) of project activity:

Sectoral Scope 5: Chemical Industry

A.4.3. Technology to be employed by the project activity:

The project activity entails a transfer of

- state-of-the art N₂O abatement technology which is not even commonly applied in Annex I countries.
- Specialised monitoring equipment
- Training of staff for installation, operation and maintenance of catalyst and AMS, etc.

A number of N₂O abatement technologies have become available in the past 2 years after some 10 years of research, development and industrial testing. Only now that N₂O regulation is likely to be introduced in the EU in the near future⁸ and with the incentives provided by the Kyoto Protocol nitric acid plant operators are considering adopting these technologies. N₂O abatement technology is now commercially available from a number of catalyst manufacturers, mainly from Germany and the UK. These technologies are proprietary and will be sold or leased to nitric acid plants. The financing of this technology is facilitated by the CDM. Hence, the CDM will enable nitric acid plants in non-Annex 1 countries to become the pioneers of N₂O abatement of the global nitric acid industry.

AEL will install a secondary N₂O abatement catalyst system upon successful registration as a CDM project, but has not yet finally decided on the catalyst vendor.

Technology transfer and safety issues

As mentioned before, the secondary abatement technology has been tested in several industrial trials in which it has proven to be reliable in reducing N₂O and environmentally safe. Especially, its implementation does not lead to increased NO_x emissions. Neither is the environment directly or indirectly harmed in any other way.

AEL will ensure that the chosen N₂O 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 ought to be operated by the local AEL-employees. All project participants will work together on training the AEL workers to reliably supervise the effective operation of the catalyst technology, apply the installed monitoring system to measure the emission levels and collect the data in a manner that allows a successful completion of each verification procedure.

⁷ See <http://cdm.unfccc.int/Projects/Validation/DB/OWXM15OTRAUOL7A4HIUTR6AO7VCP81/view.html>.

⁸ Responding to Article 30 of the EU ETS Directive 2003/87/EC, the Commission has submitted a report to the European Parliament and the Council considering the functioning of the Scheme. See the EU homepage under http://ec.europa.eu/environment/climat/emission/pdf/com2006_676final_en.pdf for this report which expressly considers extending the EU ETS into N₂O emissions (see page 6 therein).

**A.4.4 Estimated amount of emission reductions over the chosen crediting period:**

From the data collected during the baseline campaign an N₂O emissions factor (EF_{BL}) of 4.01 kg per tonne of 100% concentrated nitric acid has been established.

AEL's larger No. 11 nitric acid plant usually operates at full capacity throughout the year, thus providing the "base load" supply of nitric acid, whereas the No. 9 plant serves as a "swing plant" to provide "peak-load" nitric acid supply. On average, the No. 11 plant has been producing an average of 236,097 tonnes of nitric acid per year⁹ in the last 7 years, including an estimate for 2006.

Average Production Output of 100 %-concentrated nitric acid (2000 to 2006):

| Year | NAP (tHNO ₃) |
|----------------|--------------------------|
| 2000 | 219,020 |
| 2001 | 244,534 |
| 2002 | 246,495 |
| 2003 | 242,016 |
| 2004 | 226,715 |
| 2005 | 250,307 |
| 2006 | 223,595 |
| Average | 236,097 |

Assuming that the production of nitric acid in the No. 11 plant continues at the levels observed during these past years, the estimated amount of emission reductions for the purposes of this PDD will be based on an average annual production of 236,097 tHNO₃.

Multiplied by the EF_{BL} of 4.01 kg/tHNO₃, the annual baseline emissions are 293,492 tCO₂e (assuming that that emissions would stay the same without the project activity).

Assuming a 90% abatement efficiency of the N₂O abatement catalyst, the project emissions for the same production output of nitric acid would be 29,349 tCO₂e. The resulting amount of emission reductions therefore would be 264,143 tCO₂e per year.

Based on these assumptions, the estimated emission reductions generated by the project activity over a 10 year crediting period are projected in the table below:

Estimated emission reductions over a 10 year crediting period

| Years | Estimated Emission Reductions [tCO ₂ e] |
|-------|--|
| 1 | 264,143 |
| 2 | 264,143 |
| 3 | 264,143 |
| 4 | 264,143 |
| 6 | 264,143 |
| 7 | 264,143 |

⁹ All nitric acid amounts are provided in metric tonnes of 100% concentrated HNO₃, unless otherwise indicated.



| | |
|--|-----------|
| 8 | 264,143 |
| 9 | 264,143 |
| 10 | 264,143 |
| Total number of crediting years | 10 |
| Total estimated Emission Reductions | 2,64,1430 |
| Annual average over the crediting period of estimated reductions | 264,143 |

A.4.5. Public funding of the project activity:

No public funding has been or will be received in the development, implementation or operation of this project. The complete financing of the project will be borne by the Project Participants.

**SECTION B. Application of a baseline and monitoring methodology****B.1. Title and reference of the approved 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 N₂O inside the ammonia burner of nitric acid plants”.

Furthermore, the project draws on approved baseline methodology AM0028 (Version 04.1) for the baseline scenario selection and employs the “Tool for the demonstration and assessment of additionality” (Version 03).

B.2 Justification of the choice of the methodology and why it is applicable to the project activity:

The chosen baseline methodology AM0034 is applicable to project activities that install a secondary abatement catalyst inside the ammonia burner of a nitric acid plant, underneath the precious metal gauze pack. This corresponds with the proposed project activity.

The use of the chosen methodology is applicable as

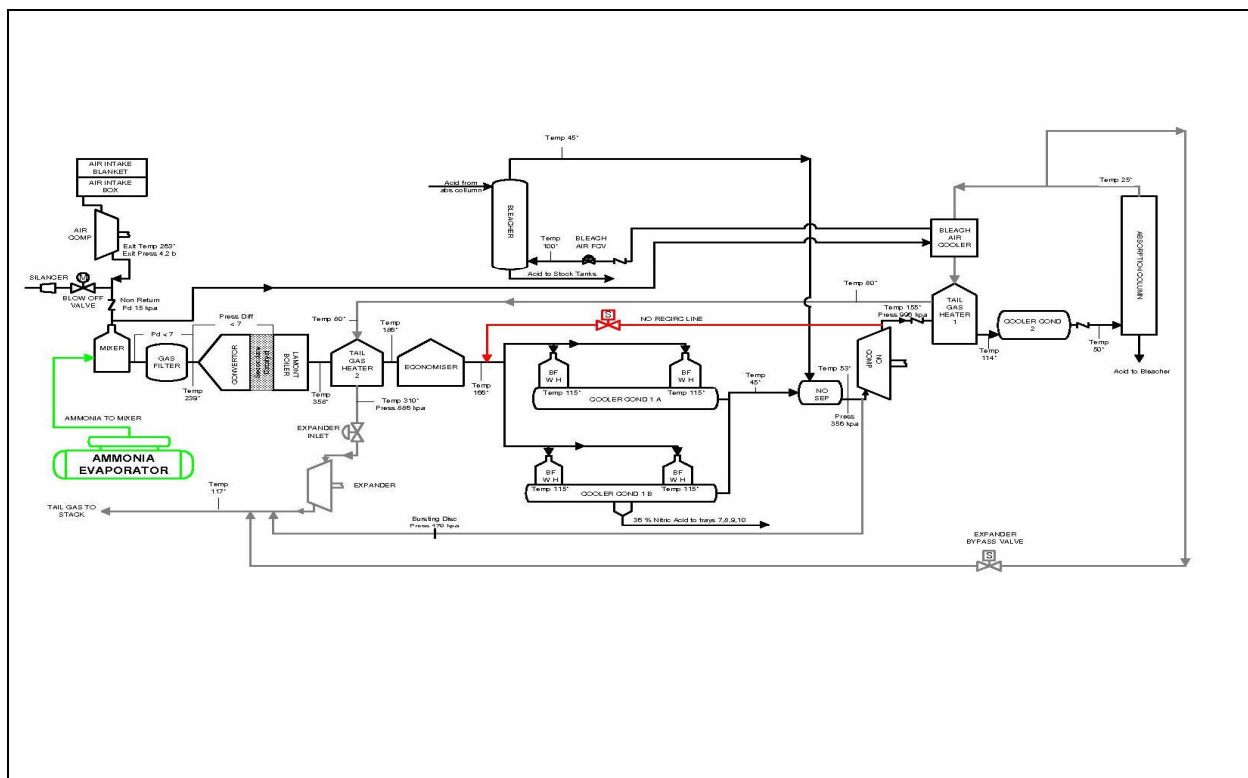
1. The proposed project activity will be applied to an existing production facility installed prior to the 31st December 2005. The plant has been commissioned and is in operation since 1968. The existing nameplate production capacity is 282,875 metric tonnes of 100% concentrated nitric acid per year (based on 365¹⁰ operating days per year and a daily nameplate capacity of 775 t/HNO₃)
2. Currently, the plant does not have any N₂O destruction or abatement facilities that could be affected by the project activity.
3. The project activity has no influence on the plant’s nitric acid production levels.
4. The host country does not have any legal requirements to reduce N₂O emissions from nitric acid plants.
5. Presently, no N₂O abatement technology is installed in the plant.
6. The project activity will not increase NO_x emissions.
7. There is no NSCR De NO_x-unit installed in the plant.
8. The installation of the secondary N₂O abatement catalyst will not lead to any additional direct or indirect GHG emissions within the project boundary.
9. A complete Automated Monitoring System (AMS) comprised of an N₂O analyser and a volume flow meter, has been installed in the appropriate location as per AM0034. The AMS has been continuously operated since January 2006 to collect the baseline data and will continue to measure concentration and total gas volume flow in the stack during the plant’s operation throughout the crediting period of the project activity.

B.3. Description of the sources and gases included in the project boundary

¹⁰ As per AM0034 page 11.



The following flow chart displays the No. 11 nitric acid plant on which the project activity is to be applied¹¹. The boundary of the project activity includes the complete process equipment of the No. 11 nitric acid plant as shown on the flow chart below.



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 about 900°C and 4.5 bar (gauge) at the precious metal gauzes inside the plant's ammonia oxidation reactor.

The main product of this reaction is NO created by oxidising ammonia (NH₃) with atmospheric oxygen (O₂) (reaction 1). NO readily oxidises further to form NO₂ (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 NO₂ (reaction 2).

These intended chemical reactions (main reactions) are the following:

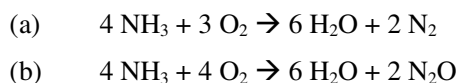
- (1) $4 \text{ NH}_3 + 5 \text{ O}_2 \rightarrow 4 \text{ NO} + 6 \text{ H}_2\text{O}$
- (2) $2 \text{ NO} + \text{O}_2 \rightarrow 2 \text{ NO}_2$
- (3) $2 \text{ NO}_2 + \text{H}_2\text{O} \rightarrow \text{HNO}_3 + \text{HNO}_2$
- (4) $3 \text{ HNO}_2 \rightarrow \text{HNO}_3 + \text{NO} + \text{H}_2\text{O}$

¹¹ A more legible hard copy version of the flow chart will be made available to the validator during the on-site validation. Upon request, it can also be sent to the CDM EB.



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 N₂O.

On leaving the ammonia oxidation reactor some of the N₂O 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 may allow N₂O to spontaneously decompose.

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

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

B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:

The approved baseline methodology AM0034 (Version 02) refers to AM0028 with regard to the identification of the baseline scenario. The following steps are taken from this methodology's version 4.01, adapted to the project activity in question and applied in a four-step-procedure: after the identification of all principally viable alternatives to the proposed project activity – combining technical solutions for N₂O- (step 1a) and NO_x- (step 1b) abatement for reasons explained in the second next paragraph below –



, those that would not comply with applicable legal standards are eliminated (step 2). After conducting a barrier analysis (step 3a), it is shown that at least one of the remaining scenario alternatives (which is not the project activity) is viable in spite of the identified barriers (step 3b). It will be demonstrated below that only one scenario alternative meets these criteria. This is the most likely “business as usual” scenario, the assumed baseline scenario.

Step 1: Identification of all realistic, credible and technically feasible baseline scenario alternatives to the project alternative.

The AM0028-procedure suggests assessing N₂O and NO_x abatement scenarios separately (steps 1a and b). This is omitted, because NO_x abatement options are only relevant if the NO_x regulations in South Africa would require an amendment of the plant. However, AEL is in compliance with South Africa’s NO_x regulations without any such technical amendment.

Currently the regulator NO_x emissions limit for AEL’s No. 11 nitric acid plant is 200 ppmv. AEL does not normally exceed this limit and is therefore in full compliance of the prevailing NO_x regulations in South Africa.

The baseline scenario alternatives should include all possible options that are technically feasible to handle N₂O emissions. For the No. 11 plant, the principally debatable options are:

- 1) Status quo: The continuation of the current situation, without installing any N₂O abatement technology in the plant
- 2) Switch to alternative production method not involving ammonia oxidation process
- 3) Alternative use of N₂O such as:
 - a) recycling of N₂O as feedstock for the plant;
 - b) The use of N₂O for external purposes.
- 4) Installation of a Non-Selective Catalytic Reduction (NSCR) De NO_x-unit¹²
- 5) Installation of an N₂O abatement or reduction technology
 - a) Primary or tertiary measures to prevent the formation or reduce N₂O
 - b) A secondary facility to reduce N₂O (like proposed project activity without registration as CDM project activity)

These options should also include the CDM project activity not implemented as CDM project. The last baseline scenario alternative provides for this.

The following options are technically not feasible:

Baseline scenario alternative 2) is not an option, because there is no other commercially viable alternative for producing nitric acid. In history, there have been other methods for producing nitric acid:

The *Birkland & Eyde* method applied electrical discharge on air to produce small quantities of NO₂ that could be reacted with water for equally small amounts of nitric acid. This procedure requires large

¹² Non-Selective Catalytic Reduction (NSCR): As a NSCR DeNO_x-unit would reduce N₂O emissions as a side reaction to the NO_x-reduction, a new NSCR installation can be regarded as an alternative N₂O reduction technology.



amounts of electricity. It was applied for industrial production in Norway between 1902 and 1930. This method did not prevail as it entails significant production costs.

The same is to be said for nitric acid production according to the *Glauber* methodology. This was the main procedure used before now predominant *Ostwald* process was introduced. It entailed reacting salt-petre with sulphuric acid and required large amounts of both to match current production levels.

Even if one considered these methods as viable options, amending an existent nitric acid production facility to operate using another process would not be possible. Thus, AEL could not switch to an alternative production method without building a completely new plant.

The use of N_2O as a feedstock for the AEL plant – as suggested by scenario 3) a) – is technically not practicable as it is not possible to produce nitric acid from N_2O . The recovery of N_2O for the sake of gaining feedstock for the production process is not practiced in any known nitric acid plant.

Scenario 3) b), the use of N_2O for external purposes, is economically not viable as the quantity of exhaust gas to be filtered would be enormous compared to the amount of nitrous oxide that could be recovered at the prevailing N_2O concentrations in the tail gas of AEL's No. 11 plant.

Therefore, the baseline alternatives 2) as well as 3) a) and b) can be excluded from further assessment.

Step 2: Elimination of all baseline scenario alternatives that are not in compliance with applicable legal or regulatory requirements. This step may also include laws and regulations that have another objective than GHG reduction, such as national or local NO_x regulations.

There is no legal national, provincial or local government requirement for AEL to reduce NO_x emissions, neither under the National Environmental Management Air Quality Act (No.39 of 2004), nor under the Atmospheric Pollution Prevention Act, Act No. 45 of 1965.

Neither of AEL's nitric acid plants has NO_x abatement systems installed. AEL uses cooling water for heat removal in the NO_2 absorption process.

Currently, the NO_x emissions statutory limit for AEL's No. 11 nitric acid plants is 200 ppmv, and the average NO_x emission for this plant is 156 (2006 average) ppmv. AEL's nitric acid plants both have an atmospheric emissions certificate issued under the Atmospheric Pollution Prevention Act, Act No. 45 of 1965 that certifies that emission levels are in compliance with environmental standards¹³.

Therefore, it can be concluded that the continuation of the current situation or status quo is in full compliance with the current regulations.

The secondary abatement catalysts on the market have not shown to lead to any change in the levels of NO_x emissions of the nitric acid plants where they were tested. Therefore, it can safely be assumed that AEL's NO_x emissions will remain constant and in compliance after the installation of the secondary catalyst. In any case, NO_x emissions are currently monitored by an NDIR analyser using extractive gas technology as installed for monitoring N_2O concentration. Therefore, any change in NO_x emission levels could easily be detected and investigated.

The above scenarios are in compliance with all applicable laws and regulatory requirements. Currently, there are no laws or regulations in place that would prohibit implementing any of the remaining scenario alternatives.

¹³ Department of Environmental Affairs and Tourism, Registration in terms of the Atmospheric Pollution Prevention Act, 1965 (Act 45 of 1965), Registration Certificate No. 135/22.



Therefore, this step does not lead to the exclusion of any of the aforementioned baseline scenario alternatives.

Step 3: Identification of those baseline scenario alternatives that face prohibitive barriers (step 3a) and naming of the most likely scenario alternative (step 3b).

In Step 3a of the baseline identification process, all baseline scenario alternatives that face prohibitive barriers (investment related, technical or incompatibility with the prevailing practice) are to be eliminated.

Investment barriers (economic/financial)

Scenario 4), the installation of a Non-Selective Catalytic Reduction (NSCR) De NO_x unit is not economically viable since AEL is already operating a (much more economical and equally effective) Selective Catalytic Reduction (SCR) NO_x abatement catalyst and is in full compliance with the prevailing NO_x regulations in South Africa.

Should these NO_x regulations change in a way that would require AEL to install a NO_x abatement unit, the installation of an outdated technology (NSCR) cannot be conceived as a viable alternative to installing a state-of-the-art Selective Catalytic Reduction (SCR) NO_x abatement unit. NSCR units require additional natural gas or ammonia to achieve sufficient tail gas temperatures and/or the right reducing environment inside the catalyst leading to comparably high operational costs. By being led through the absorption tower the gas mix has been cooled down to a temperature level below what is required for N₂O abatement catalysts to function¹⁴. Because of this, a stack-mounted catalyst abatement system would only work if the stack gas mix is re-heated. This is been done by combustion of additionally added natural gas.

The necessity to purchase additional gas would significantly contribute to overall operational expenses. Moreover, fitting NSCR units would halt production for a significant time, because tail gas heating systems needed to be installed in the stack¹⁵. Therefore, baseline scenario alternative 4) faces significant investment barriers.

Also, none of the N₂O destruction technology options – scenarios 5 a) and b) – would require considerable additional investment without generating any financial or economic benefits to compensate for this. The only option for gaining additional revenues would require a registration as CDM project activity.

There is no other revenue potential in implementing such technologies other than CDM related income. Their operation does not create any marketable products or by-products. However, any operator willing to install and thereafter operate such technology faces significant investment and additional operating costs. The legislative and regulatory environment in South Africa does not require any investment in N₂O abatement technology. Thus, any investment would be entirely voluntary.

It is unlikely that any plant operator would install such technologies on a voluntary basis without the incentive of any regulatory requirements (emissions caps) or financial benefits (such as revenues from the sale of CERs).

¹⁴ N₂O abatement catalysts require a minimum gas mix temperature of at least 550°C in order to operate effectively; see the booklet no. 2 of the European Fertilizer Manufacturers Association (EFMA), published in the internet under <http://www.efma.org/Publications/BAT%202000/Bat02/booklet2.pdf> (page 17 therein) for further information.

¹⁵ For other disadvantages of NSCR technology see an EFMA-booklet (also footnote 14) published in the internet under <http://www.efma.org/Publications/BAT%202000/Bat02/booklet2.pdf> (page 18 therein).



Therefore, any baseline scenario alternatives that include the implementation of N₂O abatement catalysts will entail considerable investment barriers. Thus, scenario alternatives 4), 5) a) and b) all are hampered by significant investment barriers.

Technical barriers

Any of the available N₂O abatement technologies are integrated in the nitric acid plant. Primary and secondary abatement technologies are installed inside the ammonia oxidation reactor where they may, if not correctly designed and installed, interfere with the nitric acid production process by causing a deterioration of product quality or a loss of production output. Tertiary measures require the installation of a complete catalyst container between the absorption column and the stack which may cause significant downtime of the plant during construction and commissioning.

Therefore, these circumstances also constitute considerable technical barriers.

Barriers due to prevailing practice

The installation of N₂O abatement technology currently is neither industrial practice in South Africa nor anywhere else in Africa or even the industrialised parts of the world. However, currently all nitric acid producers in South Africa are pursuing the implementation of N₂O abatement technologies in order to participate in the CDM. Thus, it can be assumed that these activities would not take place in the absence of CDM related revenues.

Step 3b demonstrates that the identified barriers would not prevent the implementation of at least one of the remaining alternatives (which is not the proposed project activity).

Under step 3a it was demonstrated that those baseline scenario alternatives entailing the installation of N₂O abatement catalysts face considerable barriers.

The only baseline alternative that is not prevented by any one of the barriers and that is in full compliance with the prevailing laws and regulations in South Africa is baseline scenario 1): the continuation of the current situation without installing any N₂O abatement technology in the plant. Therefore, this is identified as the applicable baseline scenario for the proposed project activity.

All other alternatives are eliminated and Step 4 (Identify the economically most attractive baseline alternative) can therefore be omitted.

The table below summarises the findings of section B.4.:

| | Baseline Scenario Alternative | Legal / Technical preclusion | Identified barriers | | | Probability |
|-----|---|------------------------------|---------------------|------------|-------------------------|-------------|
| | | | Investment related | Technical | Common practice related | |
| 1 | Continued plant operation without change | No | No | No | No | Likely |
| 2 | Switch to alternative HNO ₃ production methodology | Yes | Irrelevant | Irrelevant | Irrelevant | Excluded |
| 3 a | External use of N ₂ O | Yes (Technical) | Irrelevant | Irrelevant | Irrelevant | Excluded |



| | | | | | | |
|-------|--|-----------------|------------|------------|------------|----------|
| 3 b | N ₂ O re-cycling as feedstock for production | Yes (Technical) | Irrelevant | Irrelevant | Irrelevant | Excluded |
| 4 | Installation of a NSCR DeNO _x unit | No | Yes | Yes | Yes | Very Low |
| 5 a/b | Catalytic N ₂ O abatement technology without CDM registration | No | Yes | No | Yes | Very Low |

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality):

This section employs the “Tool for the demonstration and assessment of additionality” (Version 03) as agreed by the CDM Executive Board and published in February 2007 (“Additionality Tool”).

Step 1: As suggested by AM0034 (Version 02), step 1 of procedure proposed by the Additionality Tool has been omitted. The identification of scenarios in alternative to the project activity has been conducted within the baseline scenario identification process (see B.4. above).

Steps 2 and 3: To establish additionality, the Additionality Tool requires an investment or a barrier analysis, focussing on the comparison of the proposed project activity with the identified baseline scenario. Alternatively project applicants can select to do both.

Here, an investment analysis is chosen to carry out this part of the procedure. This corresponds with step 2 of the Additionality Tool; thus, step 3 (comprising the option of a barrier analysis) is omitted.

Step 2: Investment Analysis

Step 2a: At first, the appropriate investment evaluation methodology has to be chosen to conduct the comparative investment analysis between the identified baseline scenario and the proposed project activity.

As demonstrated above (B.4.), none of the two alternatives generates any additional financial or economic benefits besides those obtainable from the sale of CERs, which implies the applicability of a simple cost analysis. This evaluation method is chosen here.

Step 2b – Option I. Simple Cost Analysis:

The proposed project activity will lead to significant investment and operating costs for the engineering, construction, shipping, installation and commissioning of the secondary N₂O abatement catalyst and any necessary modifications of the basket currently holding the rashig rings. In addition, AEL will have to pay a regular lease fee for the continued operation and regular replacement of the secondary N₂O abatement catalyst. The investment and operating costs for the Automated Monitoring System (AMS) amount to approximately EUR 80,000 (AMS purchasing price, plus costs for maintenance and replacement parts, excluding any labour costs) throughout the crediting period.



The estimated costs of the project amount to EUR 2.73m of which an estimated EUR 1.4m are for the N₂O abatement catalyst, approximately EUR 1.08m for the purchasing of the AMS and the operation of the project by AEL staff and EUR 0.25m for validations and verifications¹⁶.

The identified baseline scenario alternative – the continuation of the current situation, operating the nitric acid plant without an N₂O abatement catalyst – does not incur any additional costs.

Therefore, the proposed project activity is financially and economically less attractive than the baseline scenario.

(Step 3, Barrier Analysis is omitted, see above)

Step 4 Common Practice Analysis

Step 4 assesses the common industrial practice in the area, where the project activity is to be implemented and thus allows verifying the results obtained in the previous steps. If the technology that is to be installed is the common industrial practice in the region already, this would indicate that the project activity is financially and economically more attractive than the baseline scenario alternative and / or that there are no considerable barriers for its implementation.

Market studies (e.g. by EFMA, EU IPPC, US EPA, IPCC) show that N₂O abatement technologies have not yet spread out into the nitric acid industry even in Annex 1 countries, apart from occasional industrial testing. The main reason for this is a lack of regulation / incentive to reduce N₂O emissions.

The research and development work done so far have been driven by a general expectation that industrialised countries – especially the EU, USA, Japan and Canada – may eventually introduce N₂O emission caps. EU legislation initiating such a limit is under way already and will probably enter into force in 2007.

The proposed project activity would lead to a first time installation of N₂O abatement technology for nitric acid plants in the region. Up until today, the common practice in the area is to operate such facilities without any N₂O abatement technology. This situation is changing now, since other nitric acid plant operators are also planning to implement N₂O abatement technologies as a CDM project activity.

Therefore, the analysis of the common industrial practice indicates that the proposed project activity is additional to the baseline scenario.

Conclusion:

Currently, there are no national regulations or legal obligations in South Africa concerning N₂O emissions. It is unlikely that any such limits on N₂O emissions will be imposed in the near future.

AEL is in no need to invest in any N₂O destruction or abatement technology. Neither are there any national incentives to promote similar project activities. Without the sale of the CER's generated by the project activity no revenue would be generated and the technology would not be installed. No income from any kind of potential product or by-product except CERs are able to pay back investment costs as well as running costs for the installation of the proposed project activity as no marketable product or by product exists. The proposed CDM project activity is undoubtedly additional, since it passes all the steps of the "Tool for demonstration and assessment of additionality".

¹⁶ More detailed, confidential information on investment and operation costs can be disclosed to the DOE and the CDM EB upon request



The registration of the project activity as a CDM Project and the resulting expected CER revenues are the single source of project revenues. CDM registration is therefore the decisive factor for the realization of the proposed project activity.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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 N₂O generation during the baseline campaign, the normal ranges for operating conditions shall be 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 shall be 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 to be monitored are the following:

OT_h Oxidation temperature for each hour (°C)

OP_h Oxidation pressure for each hour (Pa)

OT_{normal} Normal range for oxidation temperature (°C)

OP_{normal} 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 ranges¹⁷. See section B.6.2, B.16, 17, 18 and 19 for details.

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

Parameters to be monitored

AFR Ammonia gas flow rate to the AOR (tNH₃/h)

AFR_{max} Maximum ammonia gas flow rate to the AOR (tNH₃/h)

AIFR_ Ammonia to air ratio (%)

AIFR_{max}_ Maximum ammonia to air ratio (%)

Historic data of daily NH₃ consumption was used to obtain determine the range of AFR for the five historic campaigns (excluding abnormal campaigns). Due to an inappropriately adjusted monitoring range of the data acquisition system installed at the plant, the measured values had to be adjusted by factoring the obtained results; this procedure and the underlying reasons are explained below¹⁸.

¹⁷ See AM0034: Baseline Emissions, 1.i.b)

¹⁸ See section B.6.2 (tables B.10 AFR, B.11 AFR_{max}, B.12 AIFR and B.15 AIFR_{max}) for further information.



2. Determination of baseline emission factor: measurement procedure for N₂O concentration and gas volume flow

N₂O concentration and gas volume flow are to be monitored throughout the baseline campaign by an Automated Monitoring System (AMS) which is to be installed and operated using European Norm 14181 (2004) as guidance where applicable. The AMS provides separate readings for N₂O concentration (NCSG) and gas volume flow (VSG) for every two seconds of operation of the plant.

Error readings (e.g. downtime or malfunction) are indicated by the digital alarm conditions of the analyser.

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 N₂O 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 (\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 (volume of stack gas (VSG) and N₂O concentration of stack gas (NCSG))

The average mass of N₂O emissions per hour is estimated as product of the NCSG and VSG. The N₂O emissions per campaign are estimates product of N₂O 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 N₂O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N₂O emissions by the total output of 100% concentrated nitric acid for that period. The overall uncertainty of the monitoring system shall also be determined and the measurement error will be expressed as a percentage (*UNC*). The N₂O emission factor per tonne of nitric acid produced in the baseline period (EF_{BL}) shall then be 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 N₂O emissions in South Africa, the resulting EF_{BL} will be used as the baseline emission factor.

The gauze supplier and gauze composition during the baseline campaign is the same as during the historic campaigns used to establish the permitted operating conditions. Therefore, the EF_{BL} 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_{BL} can be applied to calculate the resulting emission reductions of the project.

Campaign Length

In order to take into account the variations in campaign length and its influence on N₂O 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), will be used as a cap on the length of the baseline campaign.

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} .

Statistical Tests comparing Baseline Campaign with “normal” operating conditions

In accordance with AM0034, statistical tests should be performed to compare the average values of the permitted operating conditions with the average values obtained during the baseline campaign.

Since no specific statistical tests for comparing the baseline campaign with “normal” operating conditions are prescribed in AM0034, the project proponents used the statistical tests that are already being used in AM0034 to ensure a consistent approach.

If the mean values for OT_h , OP_h , AFR and AIFR obtained during the baseline campaign fall within the 95% confidence interval (1.96 times the standard deviation) of the normal operating conditions, then the baseline campaign is considered to be representative of a normal campaign.

The result of these tests was that the baseline campaign is representative of a normal campaign because all four mean values obtained during the baseline campaign fall within the 95% confidence interval of the normal operating conditions.

Leakage

As per methodology AM0034, no leakage emission calculation is required since no leakage emissions are expected to occur as a result of the project activity.

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:

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



Step 1: estimate campaign specific emissions factor for each campaign during the project's crediting period by dividing the total mass of N₂O 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: estimate 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:

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

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

Minimum Project Emissions Factor

N₂O 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 (N₂O/tHNO₃). 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 .

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 N₂O 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 N₂O 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 .

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 N₂O:

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

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 365¹⁹ operating days per year and a daily nameplate capacity of 775 t/HNO₃). Therefore, the

¹⁹ As per AM0034 page 11.



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.

The No 11 nitric acid plant was commissioned in 1977. The basis of the plant design was to guarantee a production of 650 metric tons of 100% acid per day. In 1996 trials were carried out to up rate the capacity of the plant. The limiting factor identified was the airflow through the plant. Trials involved the installation of a dedicated air compressor to supply the bleach airflow. This was not successful due to the failure of this air compressor. Subsequent investigations into the compressor train revealed that the plant can be operated up to 775 tHNO₃/day acid by speeding up the compressor train, without having to run a secondary compressor. This is the current mode of operation. Currently plant output is however restricted as a result of a high pressure drop through a number of vessels. These vessels are going to be replaced in the shutdown to be carried out in August 2007, with the intention of returning the plant to the abovementioned higher production rates at best. However, the plant has been operated according to maximum and even beyond²⁰ daily design capacity for short periods of time in the past.

Therefore, the currently valid value of 775 tHNO₃ per day provides an adequate basis for deriving the maximum annual nitric acid production output (NAP) for which CERs may be earned.

N.serve Database Management System (N.DBMS)

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

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

A detailed description of the N.DBMS and its application to AM0034 and this project in particular is contained in Annex 3: Baseline information.

²⁰ AEL has on occasion produced more than 775 tHNO₃ per day; for example on 14th June 2002 AEL produced 781 tHNO₃.

**B.6.2. Data and parameters that are available at validation:**

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

| | |
|---|--|
| Data / Parameter: | B.1 / NCSG_{BC} |
| Data unit: | ppmv |
| Description: | N ₂ O concentration in the stack gas during the baseline campaign. |
| Source of data used: | NDIR N ₂ O gas analyser (Environnement S.A. MIR 9000) |
| Value applied: | 829.07 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | AM0034 requires the determination of the concentration of N ₂ O in the stack gas. NCSG is continuously monitored with an NDIR gas analyser ²¹ and monitoring results are taken and recorded for every two seconds of plant operation. Hourly means for NCSG are derived by the SCADA data acquisition system. NCSG data taken during times when the plant was operating outside the permitted operating range were eliminated. The remaining hourly average values were subjected to the following statistical analysis: a) Calculate the sample mean (x) b) Calculate the sample standard deviation (s) c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation) d) Eliminate all data that lie outside the 95% confidence interval e) Calculate the new sample mean from the remaining NCSG values |
| Any comment: | After significant difficulties with the N ₂ O analyser on the No. 9 nitric acid plant, AEL has decided in February 2007 to replace the existing Environnement MIR9000 analysers in both the No. 9 and No. 11 plant with new ABB Uras 14 analysers. For the No. 11 plant, this substitution will take place after the Environnement analyser has been QAL2-tested in order to ensure the validity of the data sets recorded during the baseline campaign. |

| | |
|--------------------------|--|
| Data / Parameter: | B.2 VSG_{BC} |
| Data unit: | Nm ³ /h |
| Description: | Normal gas volume flow rate of the stack gas during the baseline campaign. |

²¹ 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, NO₂, SO₂ and various other gasses. 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 N₂O.



| | |
|---|--|
| Source of data used: | Gas Volume Flow meter, Emerson Rosemount Annubar® Model 485 |
| Value applied: | 70,803 |
| 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 SCADA data acquisition system. VSG data taken during times when the plant was operating outside the permitted operating range were eliminated.</p> <p>The flow meter is ranged to a maximum flow of 150,000 m³/h (corresponding to normal m³ at a stack temperature of 113°C and stack pressure of 85.6 kPa (absolute) or 856 mbar) and a maximum differential pressure of 1.898 kPa (gauge). The flow meter was not re-ranged during the baseline campaign in order to avoid a confusion of the baseline date. Therefore, the measured VSG data have to be multiplied with a standard factor of 0.9594 in order to give the normal flow for the above assumed conditions.</p> <p>This factor will be readjusted in the QAL2-testing process that the AMS installed at the No. 11 plant will be subject to.</p> <p>For the project campaigns, the flow meter will be readjusted to the appropriate range so that this factoring of the measured value is no longer necessary.</p> <p>Also, the corrected measured data need to be compensated for the actual prevailing temperature and pressure in the stack through the following calculation:</p> $\frac{P_s * V_s}{T_s} = \frac{P_a * V_a}{T_a}$ <p>Where:</p> <p>P refers to the Pressure (mbar) [conversion from kPa to mbar is a factor of 10] V the volumetric flow rate (m³/hr) T the temperature in Kelvin (Note 1 K = T (°C) + 273). Subscript “s” refers to the actual stack values Subscript “a” refers to the assumed stack conditions.</p> <p>This simplifies to:</p> $V_s = V_a * \frac{P_a}{T_a} * \frac{T_s}{P_s}$ <p>As an example</p> <p>The assumed stack temperature and pressure values are 113°C and 846 mbar. The measured values are: 115.16 °C and 842.59 mbar. Using a flow from the acquisition system of 73,165.32 and the conversion of 0.9594 gives a final flow of 70,873.28 Nm³/hr.</p> $73165.32 * 0.9594 * \frac{846 * (115.16 + 273)}{(273 + 113) * 842.59} = 70873.28$ <p>The resulting hourly average VSG values are now expressed in Nm³/h as re-</p> |



| | |
|--------------|--|
| | <p>quired by AM0034 and where subsequently subjected to the following statistical analysis:</p> <ul style="list-style-type: none"> 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 a) e) Calculate the new sample mean from the remaining VSG values |
| Any comment: | None |

| | |
|---|---|
| Data / Parameter: | B.3 BE_{BC} |
| Data unit: | tN ₂ O |
| Description: | Total N ₂ O gas flow for baseline campaign |
| Source of data used: | Calculation from measured data. |
| Value applied: | 521.35 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | <p>The total mass N₂O emissions during the baseline campaign are determined as a product of NSCG, VSG and the total hours of operation during that baseline campaign:</p> $BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC}$ |
| Any comment: | None |

| | |
|---|--|
| Data / Parameter: | B.4 OH_{BC} |
| Data unit: | hours |
| Description: | Operating hours |
| Source of data used: | Process Control System. |
| Value applied: | 4,521 |
| 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 N₂O 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 (OT_h) was recorded to be below 830°C is excluded from the determination of OH_{BC}.</p> |
| Any comment: | None |



| | |
|---|--|
| Data / Parameter: | B.5 NAP_{BC} |
| Data unit: | tHNO ₃ |
| Description: | Metric tonnes of 100% concentrated nitric acid produced during the baseline campaign. |
| Source of data used: | Mass balance calculation |
| Value applied: | 136,476 |
| 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 (EF_{BL}) per tonne of 100% concentrated nitric acid produced during that baseline campaign. NAP is determined by a mass balance calculation according to the following procedures:</p> <p>The opening and closing stock are determined by tank level measurements of the plant operator for each production day and recorded in the production logs.</p> <p>Currently roughly 5% of the nitric acid production is delivered to consumers outside of AEL. A pipeline delivers nitric acid to external consumers based on the same site as the No. 11 nitric acid plant. The delivery volumes are measured by flow meters. Deliveries of nitric acid to consumers by tanker truck are checked and recorded on a weighbridge.</p> <p>The majority of nitric acid produced (approximately 95%) is supplied to AEL's own Ammonium Nitrate (AN) plants on the same site via pipeline. The transferred volumes of nitric acid are determined by tank level measurements before and after the transfer. Normally there is no nitric acid production supplied into the tanks during times of transfer to on-site consumers. Should that be the case, the tank levels at the receiving plant are checked for received nitric acid volumes instead to determine the delivered nitric acid volumes.</p> <p>The total nitric acid delivered is then calculated by a mass balance calculation.</p> <p>Using all these figures the total mass of nitric acid produced is calculated to derive the <u>Calculated Production</u>. Because both of AEL's nitric acid plants on site (No. 11 and No. 9) produce into the same storage tank, the Calculated Production is a combined result for both plants.</p> <p>There is also a coriolis flow meter installed, which continuously measures the production output of nitric acid into the storage tank. However, this flow meter is quite unreliable and because of this AEL uses the calculated values for its financial planning and reporting and uses the flow meter results only for plausibility checks.</p> <p>The value of NAP has to be adjusted in accordance with the results of a comparison between CL_{BL} and CL_{normal}. In the case of AEL No. 11, the baseline campaign was longer than the normal historic campaign length. Therefore, NAP_{BC} as stated herein is not used for the calculation of EF_{BL}, but rather CL_{normal} is applied. The same adjustment will be applied to the value of operational hours (OH).</p> |
| Any comment: | None |





| | |
|---|--|
| Data / Parameter: | B.6 TSG |
| Data unit: | °C |
| Description: | Temperature in the stack gas |
| Source of data used: | Stack temperature probe situated next to the volume flow meter. |
| Value applied: | Not applicable |
| 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 |

| | |
|---|--|
| Data / Parameter: | B.7 PSG |
| Data unit: | mbar (absolute) |
| Description: | Pressure in the stack |
| Source of data used: | Stack pressure probe situated directly next to the volume flow meter. |
| Value applied: | Not applicable |
| 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 |

| | |
|---|--|
| Data / Parameter: | B.8 EF_{BL} |
| Data unit: | tN ₂ O / tHNO ₃ |
| Description: | Emissions factor for baseline period |
| Source of data used: | Calculated from measured data (tons of nitric acid produced / tons of N ₂ O emitted) |
| Value applied: | 0.00406 |
| 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 ₂ O emissions per tonne of nitric acid during the baseline campaign is derived by dividing the total mass of N ₂ O emissions by the total output of 100% concentrated nitric acid during the baseline campaign. The overall uncertainty of the monitoring system shall also be determined and the measurement error will be expressed as a percentage (<i>UNC</i>). The N ₂ O emission factor per tonne of nitric acid produced in the baseline period (EF _{BL}) shall then be reduced by the percentage uncertainty as follows: $EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100) (tN_2O/tHNO_3)$ The given value is based on the preliminary assumption that the UNC value |



| | |
|--------------|--|
| | equals 5%. This estimate will be substituted by the accurate value based on the QAL2-test yet to be conducted. |
| Any comment: | None |

| | |
|---|--|
| Data / Parameter: | B.9 UNC |
| Data unit: | % |
| 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: | 5 (estimated value; will be substituted by obtained value from QAL2 test as soon as this is available) |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | <p>In accordance with AM0034 the overall measurement uncertainty of the AMS is applied in the calculation of the baseline emissions factor (EF_{BL}).</p> <p>No uncertainty data was available from the analyser vendor. Therefore, Calibration data from the analyser vendor was used to calculate the expected uncertainty.</p> <p>The calculated values provided by the vendors of the flow meter (Rosemount engineering report), stack temperature (uncertainty according to SABS standard specifications) and pressure probes (Rosemount data sheet), the flow meter DP cell (Rosemount engineering report), the temperature transducer (calculation calibration data), the analogue input card as well as the rounding errors resulting in the data acquisition system (SCADA) were used to calculate the overall uncertainty of the AMS by taking the square root of the sum of the squares of these values.</p> |
| Any comment: | None. |

| | |
|---|---|
| Data / Parameter: | B.10 AFR |
| Data unit: | tNH ₃ /h |
| Description: | Mean Ammonia gas flow rate to the ammonia oxidation reactor |
| Source of data used: | Orifice plate |
| Value applied: | Not applicable, monitored data of AFR will be used to determine if plant was operating outside of AFR_{max} . |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | <p>The monitoring of AFR is required by AM0034 in order to determine AFR_{max} based on the historic campaigns. AFR_{max} is then used to determine those periods during the baseline and the subsequent project campaigns where the plant is operating outside of the permitted operating conditions.</p> <p>AEL has chosen two different approaches to determining the AFR values.</p> <p>Direct <u>historic</u> data on gaseous ammonia flow to the plant's converter – as required by AM0034 – is unavailable, because this had not been monitored during the historic campaigns. Instead, AEL recorded daily NH₃ consumption which has been used to calculate the maximum AFR for the five historic campaigns.</p> <p>Table: Maximum NH₃ gas flow to the AOR per day</p> |



| Campaign No. | Start Date | End date | Total NH ₃ consumed | Maximum NH ₃ consumed per day |
|-------------------|------------|-----------|--------------------------------|--|
| | | | tonnes | tonnes |
| C10 | 29 May 03 | 24 Nov 03 | 34,914 | 219 |
| C12 ²² | 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 |

The maximum daily flow rate was 218²³ tNH₃. This corresponds to an hourly maximum flow rate of 9.094 tNH₃/h.

For measuring AFR values during the baseline campaign, the installed AMS has been used. However, when setting up the data acquisition system for the baseline campaign, it was wrongly assumed that the data control system (“DCS”) indicates the ammonia flow in m³/h. In order to obtain the values required by AM0034, the measured results need to be converted to tNH₃/h.

Thus, the following formula is used for converting kg/h into m³/h:

$$F_v = F_m * 22.41 / M_w$$

Where:

F_v – Volumetric flow rate in Nm³/hr

F_m – Mass flow rate in kg/hr

M_w – molar mass

This is based on the following assumptions:

- 1) The molar mass of ammonia (NH₃) is 17g/mol.
- 2) The molar mass of air is 28.84 g/mol.
- 3) The volume of 1 mol of ideal gas at standard temperature and pressure (“STP”) is 22.41 l/mol.
- 4) For the example calculation below, the ammonia flow to the converter is 5,774 kg/h.

The illustration below on how the adjustment is applied to the data sets obtained from the DCS, is based on the following reference values:

To acquire the correct volumetric flow for the ammonia flow in the example value, the following adjustment has to be made:



| | |
|--------------|--|
| | $F_v = F_m * \left(\frac{22.41}{M_w} \right)^2$ <p>Using the sample values for ammonia:</p> $F_v = 5774 * \left(\frac{22.41}{17} \right)^2 = 10034 m^3 / hr$ <p>Along these lines, all the data obtained from the DCS is converted in order to obtain the correct units.</p> |
| Any comment: | None |

| | |
|---|---|
| Data / Parameter: | B.11 AFR_{max} |
| Data unit: | tNH ₃ /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 : | AFR _{max} has been determined according to the description in table B.10 above. It is based on the maximum daily consumption of ammonia. Maximum AFR values based on daily (rather than hourly) values are more conservative in nature, because composite values are on average lower than single hourly peak values would be. |
| Any comment: | None |

| | |
|---|---|
| Data / Parameter: | B.12 AIFR |
| 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: | 8.3 to 11.5 (AIFR will be used to determine AIFR _{max}). |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | <p>The monitoring of AIFR is required by AM0034 in order to determine AIFR_{max}.</p> <p>Again, AEL applies a different approach for determining the historic AIFR values from what the procedure has been like for the baseline campaign and will be for the subsequent project campaigns.</p> <p>For the <u>historic</u> campaigns the allowable NH₃ to Air ratio is taken from the controller data sheet (No 11 Technical Manual, TM4, p255, June 1977), since no data on this value has been recorded prior to the installation of the AMS. The range as specified in the manual is 8.3% v/v - 11.5% v/v; therefore the maximum ammonia to air ratio is 11.5% v/v.</p> <p>In the <u>baseline</u> AIFR has been calculated based on AFR (as described in table B.10 above) and by relating these known ammonia flow values to air flow values. The latter are converted to the required unit according to the same pro-</p> |



| | |
|--------------|---|
| | <p>cedure as the ammonia values.</p> <p>Calculations are based on the following assumptions:</p> <ol style="list-style-type: none">1) The molar mass of air is 28.84 g/mol.2) The volume of 1 mol of ideal gas at standard temperature and pressure (“STP”) is 22.41 l/mol.3) For purposes of an example calculation, the air flow into the converter is 113,723 kg/h. <p>Based on these assumptions, the correct value for the example amount can be calculated as follows:</p> $F_v = F_m * \left(\frac{22.41}{M_w} \right)^2$ <p>Using the sample values above for air gives:</p> $F_v = 113723 * \left(\frac{22.41}{28.84} \right) = 88368 m^3 / hr$ <p>Along these lines, all data collected by the DCS are converted into the correct value unit.</p> |
| Any comment: | None |



| | |
|---|--|
| Data / Parameter: | B.15 AIFR_{max} |
| Data unit: | % v/v |
| Description: | Maximum Ammonia to air ratio into the ammonia oxidation reactor. |
| Source of data used: | Plant operating manual |
| Value applied: | 11.5 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | <p>In accordance with AM0034 AIFR_{max} is used to determine those periods where the plant may be operating outside of the permitted operating conditions.</p> <p>The upper limits for ammonia flow and ammonia to air ratio shall be determined using one of the following three options, in preferential order:</p> <ol style="list-style-type: none"> 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, 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 If information for (b) above is not available, based on a relevant technical literature source. <p>Since no historical data were recorded and available, the allowable NH₃ to Air ratio is taken from the controller data sheet (No 11 Technical Manual, TM4, p255, June 1977). The range is 8.3% v/v - 11.5% v/v, therefore the maximum ammonia to air ratio is 11.5% v/v.</p> |
| Any comment: | None |

| | |
|---|--|
| Data / Parameter: | B.13 CL_{BL} |
| Data unit: | tHNO ₃ |
| Description: | Length of the baseline campaign measured in metric tonnes of 100% concentrated nitric acid produced during that baseline campaign. |
| Source of data used: | NAP _{BC} |
| Value applied: | 136,476 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | <p>In accordance with AM0034 the baseline campaign length (CL_{BL}) has to be compared to the established average historic campaign length (CL_{normal}); and</p> <p>If $CL_{BL} \leq CL_{normal}$, then all N₂O values measured during the baseline campaign can be used for the calculation of EF_{BL} (subject to the elimination of data that was monitored during times where the plant was operating outside of the “permitted range”).</p> <p>If $CL_{BL} > CL_{normal}$, then N₂O values that were measured beyond the length of CL_{normal} during the production of the quantity of nitric acid (i.e. the final tonnes produced) are to be eliminated from the calculation of EF_{BL}.</p> <p>For No. 11 the average historic campaign production was 123,578 tHNO₃, see</p> |



| | |
|--------------|--|
| | table B.14 below. Thus, for the calculation of EF_{BL} , only those values below this margin are to be taken into account. |
| Any comment: | None |

| Data / Parameter: | B.14 CL _{normal} | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|-------------|------------|---------------------------------|---------------------------------|--|--|--|------|-----|-----------|-----------|---------|-------------------|-----------|-----------|---------|-----|-----------|-----------|---------|-----|-----------|-----------|---------|-----|-----------|-----------|---------|---------|--|--|---------|
| Data unit: | tHNO ₃ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 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: | Mass Balance calculations as described in NAP. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Value applied: | 123,578 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | In accordance with AM0034 the average historic campaign length (CL _{normal}) is defined as the average campaign length for the historic campaigns that were used to define operating condition. CL _{normal} presents the cap on the length of the baseline campaign from which the baseline emissions factor will be derived. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | During the five historic campaigns, the following amounts of metric tonnes of 100% concentrated nitric acid have been produced: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | <table><tr><th>Campaign No</th><th>Start Date</th><th>End Date</th><th>Total HNO₃ produced</th></tr><tr><td></td><td></td><td></td><td>tons</td></tr><tr><td>C10</td><td>29-May-03</td><td>24-Nov-03</td><td>124,030</td></tr><tr><td>C12²⁴</td><td>27-May-04</td><td>12-Dec-04</td><td>133,266</td></tr><tr><td>C13</td><td>15-Dec-04</td><td>24-Jul-05</td><td>138,908</td></tr><tr><td>C14</td><td>27-Jul-05</td><td>28-Jan-06</td><td>119,797</td></tr><tr><td>C15</td><td>03-Feb-06</td><td>31-Jul-06</td><td>101,888</td></tr><tr><td>Average</td><td></td><td></td><td>123,578</td></tr></table> | Campaign No | Start Date | End Date | Total HNO ₃ produced | | | | tons | C10 | 29-May-03 | 24-Nov-03 | 124,030 | C12 ²⁴ | 27-May-04 | 12-Dec-04 | 133,266 | C13 | 15-Dec-04 | 24-Jul-05 | 138,908 | C14 | 27-Jul-05 | 28-Jan-06 | 119,797 | C15 | 03-Feb-06 | 31-Jul-06 | 101,888 | Average | | | 123,578 |
| | Campaign No | Start Date | End Date | Total HNO ₃ produced | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | tons | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | C10 | 29-May-03 | 24-Nov-03 | 124,030 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | C12 ²⁴ | 27-May-04 | 12-Dec-04 | 133,266 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | C13 | 15-Dec-04 | 24-Jul-05 | 138,908 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | C14 | 27-Jul-05 | 28-Jan-06 | 119,797 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | C15 | 03-Feb-06 | 31-Jul-06 | 101,888 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Average | | | 123,578 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Therefore, the average historic campaign length (CL _{normal}) is 123,578 tonnes of 100% concentrated nitric acid. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Any comment: | None. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | |
|--------------------------|--|
| Data / Parameter: | B.16 OT_h |
| Data unit: | °C |
| Description: | Oxidation temperature for each hour during the baseline campaign |



| | |
|---|--|
| Source of data used: | Monitoring results of a composite thermocouple inside the ammonia oxidation reactor and recorded by SCADA. |
| Value applied: | Not applicable |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | <p>In accordance with AM0034 the oxidation temperature in the ammonia oxidation reactor (OT_h) has to be monitored and compared to the Normal range for oxidation temperature (OT_{normal}). VSG and NCSG data obtained during times when OT_h was above or below OT_{normal} has to be eliminated from the calculation of EF_{BL}.</p> <p>Oxidation temperature is set and is never actively changed during operation. The composite thermocouple is made up of six individual temperature probes and continuously measures OT_h. OT_h is controlled by AIFR which is a controlled parameter and should stay as constant as possible. OT_h is therefore a control parameter for AIFR.</p> |
| Any comment: | None |

| | |
|---|--|
| Data / Parameter: | B.17 OT_{normal} |
| Data unit: | °C (min and max) |
| Description: | Normal range operating temperature |
| Source of data used: | Design specifications and operating manual of the No. 11 nitric acid plant (Technical Manual (TM4 June 1977, p. 250) ²⁵ . |
| Value applied: | 830°C (min.) and 905°C (max.) |
| 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 temperatures in the ammonia oxidation reactor. Since no historical data for the No. 11 plant are available, the range of operating temperature of between 800°C and 915°C, as stipulated in the operating manual was applied to derive OT_{normal}.</p> <p>The measuring range of the thermocouples determining the oxidation temperatures is set accordingly, i.e. when the plant is offline, the temperature reading will continue to show 800°C.</p> <p>For practical purposes, all VSG and NCSG values taken during times when the plant was operating at below 830°C will be excluded.</p> |
| Any comment: | None |

| | |
|---|---|
| Data / Parameter: | B.18 OP_h |
| Data unit: | kPa (gauge) |
| Description: | Oxidation Pressure for each hour |
| Source of data used: | Design specifications and operating manual of the No. 11 nitric acid plant (Drawing No. D31 113-4, Sheet 2, December 1977; Operating Instructions No. M69.0300.2008, 1978; No 11 Plant Understanding, p. 10). |
| Value applied: | Not applicable. |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | In accordance with AM0034 the oxidation pressure in the ammonia oxidation reactor (OP_h) has to be monitored and compared to the Normal range for oxidation temperature (OP_{normal}). VSG and NCSG data obtained during times when |



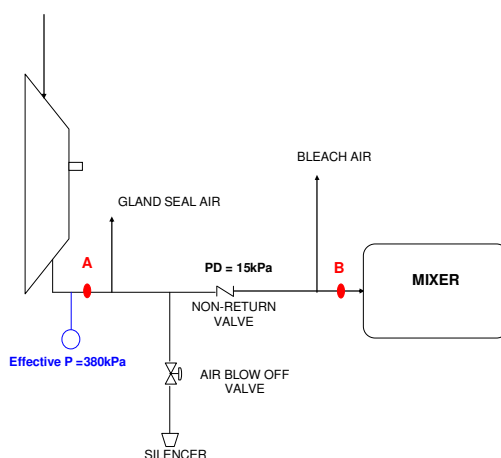
ment methods and procedures actually applied :

OP_h was above or below OP_{normal} has to be eliminated from the calculation of EF_{BL} .

AM0034 prescribes the monitoring and recording of the Oxidation Pressure for each hour (OP_h) during the baseline campaign. This would imply the measurement of pressure inside the Ammonia Oxidation Reactor. AEL has no such measurement equipment installed at that point; instead the available measurements for air pressure before the ammonia-air-mixer are used to determine OP_h .

The pressure for the oxidation reactor is taken as the pressure at point **B** (air to mixer pressure). The permitted range for the oxidation pressure is inferred from the values given for point **A** (HP compressor discharge pressure range).

Figure: Pressure points for No. 11



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.

Any comment:

None

| | |
|--------------------------|---|
| Data / Parameter: | B.19 OP_{normal} |
| Data unit: | kPa (gauge) |
| Description: | Normal operating pressure of the ammonia oxidation reactor. |
| Source of data used: | Plant operating manual. |
| Value applied: | 365 – 450 |
| Justification of the | AM0034 requires the establishment of the normal range of operating pressure |



| | |
|--|---|
| choice of data or description of measurement methods and procedures actually applied : | <p>in the ammonia oxidation reactor. Since no historical data for the No. 11 plant are available, the range of temperature stipulated in the operating manual was applied to derive OP_{normal}.</p> <p>The upper limit is 450 kPa. The lower limit is inferred from the effective discharge set point pressure, 380 kPa (Operating Instructions No. M69.0300.2008, 1978) and the pressure drop across the non-return valve (No 11 HNO_3 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_3-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, 6th Ed, Vol. 23, p3).</p> |
| Any comment: | None |

| | |
|---|---|
| Data / Parameter: | B.20 GS_{normal} |
| Data unit: | Name of Supplier |
| Description: | Gauze supplier for the operating condition campaigns |
| Source of data used: | Monitored / Invoices |
| Value applied: | W.C. Heraeus |
| 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_2O 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 |

| | |
|--|---|
| Data / Parameter: | B.21 GS_{BL} |
| Data unit: | Name of Supplier |
| Description: | Gauze supplier for the operating condition campaigns |
| Source of data used: | Monitored / Invoices |
| Value applied: | W.C. Heraeus |
| Justification of the choice of data or description of measurement methods and pro- | 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. |



| | |
|----------------------------|------|
| cedures actually applied : | |
| Any comment: | None |

| Data / Parameter: | B.23 GC _{normal} | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|--|----------|----------------|-------------------|--|--|--------|--------|--------|-----|---------|------|-----|------|-----|---------|------|-----|------|-----|---------|------|-----|------|-----|---------|------|-----|------|-----|---------|------|-----|------|---------|--|------|-----|------|
| Data unit: | % | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 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: | Platinum (Pt) 56.5% Rhodium (Rh) 3.8% Palladium (Pd) 37% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 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 N₂O baseline emissions.</p> <p>Record of Gauze compositions installed during the historic campaigns²⁶:</p> <table><tr><th rowspan="2">Campaign</th><th rowspan="2">Gauze Supplier</th><th colspan="3">Gauze Composition</th></tr><tr><th>Pt (%)</th><th>Rh (%)</th><th>Pd (%)</th></tr><tr><td>C10</td><td>Heraeus</td><td>58.3</td><td>3.9</td><td>37.9</td></tr><tr><td>C12</td><td>Heraeus</td><td>56.1</td><td>3.8</td><td>40.1</td></tr><tr><td>C13</td><td>Heraeus</td><td>56.4</td><td>3.8</td><td>39.8</td></tr><tr><td>C14</td><td>Heraeus</td><td>56.1</td><td>3.8</td><td>40.1</td></tr><tr><td>C15</td><td>Heraeus</td><td>55.4</td><td>3.8</td><td>40.8</td></tr><tr><td colspan="2">Average</td><td>56.5</td><td>3.8</td><td>39.7</td></tr></table> | Campaign | Gauze Supplier | Gauze Composition | | | Pt (%) | Rh (%) | Pd (%) | C10 | Heraeus | 58.3 | 3.9 | 37.9 | C12 | Heraeus | 56.1 | 3.8 | 40.1 | C13 | Heraeus | 56.4 | 3.8 | 39.8 | C14 | Heraeus | 56.1 | 3.8 | 40.1 | C15 | Heraeus | 55.4 | 3.8 | 40.8 | Average | | 56.5 | 3.8 | 39.7 |
| Campaign | Gauze Supplier | | | Gauze Composition | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Pt (%) | Rh (%) | Pd (%) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| C10 | Heraeus | 58.3 | 3.9 | 37.9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| C12 | Heraeus | 56.1 | 3.8 | 40.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| C13 | Heraeus | 56.4 | 3.8 | 39.8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| C14 | Heraeus | 56.1 | 3.8 | 40.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| C15 | Heraeus | 55.4 | 3.8 | 40.8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Average | | 56.5 | 3.8 | 39.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Any comment: | None | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | |
|--------------------------|---|
| Data / Parameter: | B.24 GC_{BL} |
| 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: | Platinum (Pt) 56.0% Rhodium (Rh) 3.8% Palladium (Pd) 40.2% |
| Justification of the | A change in the composition of the ammonia oxidation catalyst in the baseline |



| | |
|--|--|
| choice of data or description of measurement methods and procedures actually applied : | <p>campaign to a composition other than that used in the previous five campaigns, is permissible without any limitation on the N₂O baseline emissions if the following conditions are met</p> <p>(i) The baseline catalyst composition is considered as common practice in the industry, or</p> <p>(ii) The change in catalyst composition is justified by its availability, performance, relevant literature etc.</p> <p>Otherwise, the baseline emission factor shall be set to the conservative IPCC default emission factor for N₂O from nitric acid plants which have not installed N₂O destruction measures (4.5 kgN₂O/tHNO₃).</p> <p>GC_{BL} at AEL's No. 11 nitric acid plant is the same as GC_{normal}; therefore, the results of the baseline campaign are fully valid and applicable.</p> |
| Any comment: | None |

| | |
|---|---|
| Data / Parameter: | B.26 EF_{reg} |
| Data unit: | tN ₂ O/tHNO ₃ |
| Description: | Emissions cap for N ₂ O from nitric acid production set by government regulation |
| Source of data used: | Department of Environmental Affairs and Tourism |
| Value applied: | None |
| 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 ₂ O from nitric acid production. |
| Any comment: | |

**B.6.3 Ex-ante calculation of emission reductions:****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.

Relation DBMS organize all data in tables. N.DBMS mainly consists of three such tables, labelled PROJECTS, CAMPAIGNS, and DATA_CROSS.

The first table, PROJECTS, serves as an anchor for all data stored. Each CDM project must be defined here, before any related data can be stored. Table PROJECTS provides a unique identifier and a short name for each project. In addition, project specific data such as owner and location may be stored.

Structure of table PROJECTS

| Field Name | Field Type | Comment |
|-------------|------------|--|
| ProjId | Integer | Unique identifier for the project |
| ProjName | Text | Short name of the project |
| ProjOwner | Text | Operator of the installation |
| ProjLoc | Text | Location of the installation (City) |
| ProjCountry | Text | Location of the installation (Country) |

Sample content of table PROJECTS

| Projects | | | | |
|----------|----------|--------------------|---------------|--------------|
| ProjId | ProjName | ProjOwner | ProjLoc | ProjCountry |
| 1 | No. 11 | African Explosives | Modderfontein | South Africa |
| 2 | | | | |
| 3 | | | | |

Table CAMPAIGNS defines the individual production campaigns and contains data which describe the campaign as a whole, such as date and time of start and stop and the physical units in which the data are stored. Each campaign must be defined here, before time series of related data can be stored.

Structure of table CAMPAIGNS



| FieldName | FieldType | Comment |
|------------|-----------|--|
| ProjId | Integer | Identifier of the project, to which the campaign belongs |
| CampId | Integer | Identifier of the campaign |
| CampName | Text | Campaign name defined by owner |
| CampType | Text | Type of campaign: H (historical), B (baseline), I (Intermediate, between BL and CDM registration), P (Project) |
| DateStart | Date | Starting day of the campaign |
| TimeStart | Date | Starting time of the campaign |
| DateStop | Date | Stopping day of the campaign |
| TimeStop | Date | Stopping time of the campaign |
| Period | Text | Length of measurement period: hours, minutes, seconds |
| CampLength | Number | Length of campaign (measured in tons of nitric acid produced) |
| AFR_Unit | Text | Physical unit of AFR data |
| AIFR_Unit | Text | Physical unit of AIFR data |
| NAP_Unit | Text | Physical unit of NAP data |
| NCSG_Unit | Text | Physical unit of NCSG data |
| Oph_Unit | Text | Physical unit of OPh data |
| OTh_Unit | Text | Physical unit of OTh data |
| VSG_Unit | Text | Physical unit of VSG data |

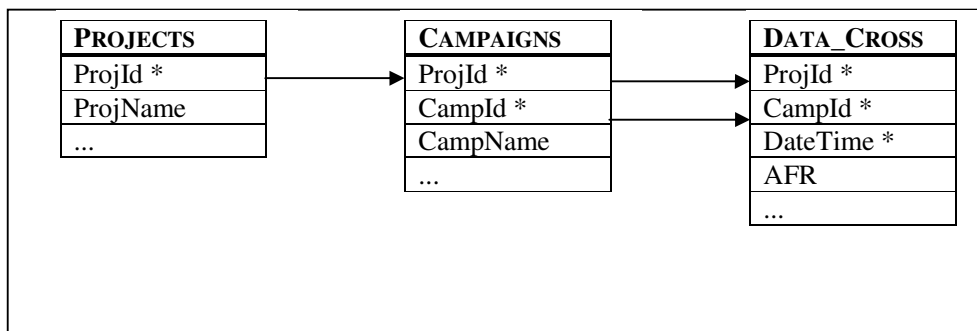
Finally, the times series of the parameter values listed above are stored in table DATA_CROSS. Each set of values for the different parameters is identified by the ProjId, CampId and a date/time-stamp.

Structure of table DATA_CROSS

| FieldName | FieldType | Comment |
|-----------|-----------|--|
| ProjId | Integer | Identifier of the project, to which the campaign belongs |
| CampId | Integer | Identifier of the campaign to which the data belong |
| DateTime | Date | Date and time stamp |
| AFR | Number | AFR value |
| AIFR | Number | AIFR value |
| NAP | Number | NAP value |
| NCSG | Number | NCSG value |
| Oph | Number | Oph value |
| OTh | Number | OTh value |
| VSG | Number | VSG value |

The tables PROJECTS, CAMPAIGNS, and DATA_CROSS are linked by so-called 1:n relationships. That is, for each project, there may be n campaigns and for each campaign, m sets of data may be stored, where n and m indicated the number of campaign and data sets, respectively. Other than in Excel, for the purpose of the calculations required by the methodology, there is no practical limit for n and m when using a DBMS such as Access.

Data model



Stars (*) indicate the primary keys of the three tables, which make sure, that data sets are unique.

Using the database structure outlined above, it is now possible to analyse the data stored in many different ways using the database query mechanisms provided by Access. All statistical analyses and exclusions of parameter sets required by AM0034 will be carried out by appropriately designed database queries, which will be described in detail below.

Calibration using historical campaigns and calculation of the baseline emissions factor with N.DBMS

The database would normally first be applied to conduct a “calibration” of N.DBMS in accordance with the historic data obtained from the previous 5 campaigns. In the case of AEL No. 11, no such historical data are available and therefore, this calibration is not carried out.

Queries from N.DBMS to determine EF_{BL}

Query 1²⁷: Results from Raw Data for exact campaign duration

The table below illustrates the N.DBMS table after query 1 which contains the raw data sets as taken from the data acquisition system on-site after adapting them to the requirements of the N.DBMS format.

| N.DBMS Baseline Calculation | | Project: African Explosives No. 11, Johannesburg, South Africa | | | | | | | | |
|-----------------------------|------|--|------------|-------|--------|-------|-------|--------------|-----------------|---------|
| Baseline campaign | | Query 1: Without parameter limits, invalid data sets excluded | | | | | | | | |
| Parameter | Unit | OH | AFR | AIFR | Oph | OTh | NCSG | VSG | NAP | |
| | | h | kg NH3 / h | 1 | kPa-g | oC | ppm | mg N2O / Nm3 | Nm3 / h | tHNO3 |
| Count | | 5,002 | 5,002 | 5,002 | 5,002 | 5,002 | 5,002 | | 5,002 | |
| Minimum | | | 7 | 0.00 | 0.14 | 801 | 1.7 | 3.4 | | 0 |
| Maximum | | | 7,933 | 0.99 | 846.44 | 903 | 1,581 | 3,106 | 81,671 | |
| Mean | | | 5,563 | 0.11 | 378.67 | 895 | 784 | 1,540 | 67,870 | |
| Standard deviation | | | 1,160 | 0.05 | 77.03 | 19 | 174 | 342 | 14,537 | |
| Sum | | 4,987 | | | | | | | | 136,476 |
| (-> Sheet NAP_BL) | | | | | | | | | | |
| Baseline emissions | BE | = VSG * NCSG * Oh | | | | | | | t N2O | 521 |
| Emission factor | EF | = BE / NAP | | | | | | | kg N2O / t HNO3 | 3.82 |

The campaign started on 17th July 2006 and ran until 18th February 2007. Any data in the database before or after those dates were excluded.

Query 2: Determination of NAP and OH



Since the baseline campaign (NAP_{BC}) was longer than the historic normal campaign length (CL_{normal}), the NAP value for the baseline campaign had to be adjusted. This was done by excluding as many of the final days of the baseline campaign as needed in order for the NAP value to be equivalent to CL_{normal} .

Because NAP is only determined for each whole day of production, CL_{normal} as contained in the N.DBMS is slightly lower than CL_{normal} as calculated based on the total campaign productions (123,469 instead of 123,578), see below.

Query 3: Application of limits from “permitted operating range”

In the next step, the limits provided by the permitted operating range, derived from the plant operating manual, were applied.

AM0034 monitoring methodology actually suggests that in the event that the monitoring system is down, the lowest between the conservative IPCC (4.5 kgN₂O/tHNO₃) or the last measured value will be valid and applied for the downtime period for the baseline emissions factor.

To fulfil this criterion, it would be necessary to convert the last measured value into the equivalent of kgN₂O/tHNO₃ in order to check if it is lower or higher than 4.5 kgN₂O/tHNO₃. It is impossible to determine this for a 2-second value because the volume of nitric acid produced is not attributable to this specific instant.

Therefore, it is appropriate to exclude the measured values from the calculation of the NCSG mean rather than trying to guess whether to apply the last measured value or the 4.5 kg value.

Query 4: Confidence Intervals and determination of BE and EF

| N.DBMS Baseline Calculation Project: African Explosives No. 11, Johannesburg, South Africa | | | | | | | | | | |
|--|-------------------|------------------------|-------|-------|-------|-------|---------------------------------------|--|-------------------|--|
| Baseline campaign Query 5: Permitted range from operating manual, CL cut | | | | | | | | | | |
| Parameter | OH | AFR | AIFR | Oph | OTh | NCSG | VSG | | NAP | |
| Unit | h | kg NH ₃ / h | 1 | kPa-g | oC | ppm | mg N ₂ O / Nm ³ | Nm ³ / h | tHNO ₃ | |
| Count | 4,369 | 4,369 | 4,369 | 4,369 | 4,369 | 4,369 | | 4,369 | | |
| Remaining share of data sets | 87% | 87% | 87% | 87% | 87% | 87% | | 87% | | |
| Minimum | | 5,337 | 0.10 | 365 | 892 | 447 | 877 | 63,221 | | |
| Maximum | | 6,512 | 0.11 | 425 | 903 | 993 | 1,950 | 81,671 | | |
| Mean | | 5,804 | 0.10 | 395 | 899 | 808 | 1,587 | 70,948 | | |
| Standard deviation | | 236 | 0.00 | 13.5 | 1 | 95 | 186 | 4,614 | | |
| 95% confidence level (1.96 * Std.dev.) | | 463 | 0 | 26.5 | 2 | 185 | 364 | 9,043 | | |
| Sum | 4,521 | | | | | | | | 123,469 | |
| Limits acc. to consistency check | <30.1.2007 | | | | | | | | | |
| Lower limit | | ? | 0.083 | 365 | 830 | | | | | |
| Upper limit | | ? | 0.12 | 450 | 905 | | | | | |
| | (-> Sheet NAP_BL) | | | | | | | | | |
| Baseline emissions | BE | = VSG * NCSG * Oh | | | | | | t N ₂ O | 509 | |
| Emission factor | EF | = BE / NAP | | | | | | kg N ₂ O / t HNO ₃ | 4.12 | |

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:

- $Mean_{Q5}(NCSG) - StdDev_{Q5}(NCSG) < NCSG < Mean_{Q5}(NCSG) + StdDev_{Q5}(NCSG)$
- $Mean_{Q5}(VSG) - StdDev_{Q5}(VSG) < VSG < Mean_{Q5}(VSG) + StdDev_{Q5}(VSG)$



CDM – Executive Board

page 44

The line “Remaining share of data sets” in the excel table indicates how many data sets remain after application of the queries. Since this value is well above the 50% required by AM0034, the baseline is valid.

Also, the determined uncertainty for the AMS will be applied to the EF calculation. Currently, a preliminary value of 5% is taken.

| N.DBMS Baseline Calculation | | Project: African Explosives No. 11, Johannesburg, South Africa | | | | | | | | |
|--|------|--|------------|--------|-------|-------|---|--------------|-----------------|---------|
| Baseline campaign | | Query 6a: Q5 + confidence levels applied to NCSG | | | | | Query 6b: Q5 + confidence levels applied to VSG | | | |
| Parameter | Unit | OH | AFR | AIFR | Oph | OTh | NCSG | NCSG | VSG | NAP |
| | Unit | h | kg NH3 / h | 1 | kPa-g | oC | ppm | mg N2O / Nm3 | Nm3 / h | tHNO3 |
| Count | | 4,369 | 4,369 | 4,369 | 4,369 | 4,369 | 4,068 | | 4,304 | |
| Remaining share of data sets | | 87% | 87% | 87% | 87% | 87% | 81% | | 86% | |
| Minimum | | 0 | 5,337 | 0.10 | 365 | 892 | 623 | 1,224 | 63,221 | |
| Maximum | | 0 | 6,512 | 0.11 | 425 | 903 | 993 | 1,950 | 79,970 | |
| Mean | | 0 | 5,804 | 0.10 | 395 | 899 | 829 | 1,629 | 70,803 | |
| Standard deviation | | 0 | 236 | 0.00 | 14 | 1 | 55 | 109 | 4,493 | |
| 95% confidence level (1.96 * Std.dev.) | | | | | | | | | | |
| Sum | | 4,521 | | | | | | | | 123,469 |
| Limits acc. to consistency check | | <30.1.2007 | | | | | | | not blank | |
| Lower limit | | | ? | 0.083 | 365 | 830 | 623 | | 61,906 | |
| Upper limit | | | ? | 0.1150 | 450 | 905 | 993 | | 79,991 | |
| (-> Sheet NAP_BL) | | | | | | | | | | |
| Baseline emissions | BE | = VSG * NCSG * Oh | | | | | | | t N2O | 521 |
| Emission factor | EF | = BE / NAP * (1 - UNC/100) | | | | | | | kg N2O / t HNO3 | 4.01 |
| Uncertainty | UNC | | | | | | | | | 5.00 |

The resulting baseline emissions factor is 4.01 kgN₂O/tHNO₃.

During the EF_p and ER_n calculation, the same procedures will be applied in the N.DBMS as described in this section in accordance with AM0034.

Ex-ante calculation of Emission Reductions

Several of the parameters necessary to calculate the emission reductions expected from the project activity will only be established during the operation of the project.

Therefore, certain assumptions had to be made for the calculations (see section A.4.4 above for details), such as:

- Production output of nitric acid (NAP) per year being 236,097 tHNO₃ (based on the average production during the past four years and the present year forecast)
- Emissions Factor during each of the project campaigns (EF_p) which is mainly influenced by the abatement efficiency of the N₂O abatement catalyst, which is assumed to be at least 80% of baseline N₂O emissions. Taking EF_{BL} of 4.01 kgN₂O/tHNO₃ and applying a realistic 90% abatement efficiency, the annual baseline emissions would be 293,492 tCO₂e and the annual emission reductions 264,143 tCO₂e.
- The crediting period will begin in August 2007
- The overall uncertainty of the AMS is 5%.

These assumptions underline in the calculations for table B.6.4 below.

**B.6.4 Summary of the ex-ante estimation of emission reductions²⁸:**

| Year | Estimation of project activity emissions (tCO ₂ e) | Estimation of baseline emissions (tCO ₂ e) | Estimation of leakage (tCO ₂ e) | Estimation of overall emission reductions (tCO ₂ e) |
|--------------------|---|---|--|--|
| 2007 ²⁹ | 12,229 | 122,288 | 0 | 110,060 |
| 2008 | 29,349 | 293,492 | 0 | 264,143 |
| 2009 | 29,349 | 293,492 | 0 | 264,143 |
| 2010 | 29,349 | 293,492 | 0 | 264,143 |
| 2011 | 29,349 | 293,492 | 0 | 264,143 |
| 2012 | 29,349 | 293,492 | 0 | 264,143 |
| 2013 | 29,349 | 293,492 | 0 | 264,143 |
| 2014 | 29,349 | 293,492 | 0 | 264,143 |
| 2015 | 29,349 | 293,492 | 0 | 264,143 |
| 2016 | 29,349 | 293,492 | 0 | 264,143 |
| 2017 | 17,120 | 171,204 | 0 | 154,083 |
| Total | 293,490 | 2,934,920 | 0 | 2,641,430 |

**B.7 Application of the monitoring methodology and description of the monitoring plan:****B.7.1 Data and parameters monitored:**

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

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

| Data / Parameter: | NCSG |
|--|--|
| Data unit: | ppmv (convertible to mgN ₂ O/m ³) |
| Description: | N ₂ O concentration in the stack gas during each project campaign. |
| Source of data to be used: | NDIR N ₂ O gas analyser (ABB Uras 14 analyser) |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | Not available yet. |
| Description of measurement methods and procedures to be applied: | <p>AM0034 requires the determination of the concentration of N₂O in the stack gas. During the crediting period, NCSG will be continuously monitored with an ABB Uras 14 NDIR gas analyser³⁰ and monitoring results will be taken and recorded for every two seconds of plant operation. Hourly means for NCSG are derived by the SCADA data acquisition system. NCSG data taken during times when the plant was operating outside the permitted operating range were eliminated. The remaining hourly average values were subjected to the following statistical analysis:</p> <ol style="list-style-type: none"> Calculate the sample mean (x) Calculate the sample standard deviation (s) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation) Eliminate all data that lie outside the 95% confidence interval Calculate the new sample mean from the remaining NCSG values |
| QA/QC procedures to be applied: | <p>Analyser Zero Calibration</p> <p>Dry oil-free instrument air with a dew point of < 50 °C or better must be used as a reference signal. This commodity is crucial to the operation of the analyser since the dry air is used as a zero gas as well as for emergency purging of the measuring cell should the sample gas contain more than a certain amount of moisture that could be harmful to the analyser. The dry air is also used to either dilute or remove moisture from the sample at the sample probe, depending on what type of sampling system is used. Dry air of a good quality must thus always</p> |



| | |
|--------------|--|
| | <p>be available and connected to both the “Zero Ref.” port on the analyser as well as to the sample probe via the designated connections.</p> <p>The zero calibration of the ABB Uras 14 is performed fully automatically and is done on programmable intervals. The analyser at No. 11 plant is set to the standard default time interval, which means that an automatic zero calibration is done every 3 hrs.</p> <p>Analyser Span calibration</p> <p>The span calibration of the analyser can only be performed manually. Calibration gas is supplied by AFROX and certified by Modderfontein Laboratory is always connected to the analyser to conduct the regular analyser span calibration. The span calibration is conducted at least twice per week (usually Tuesdays and Fridays) with the calibration gas being injected into the analyser sample cell. As a result of the span calibration, the K-factors used to adjust the measured result before being sent to the DCS data acquisition system are readjusted if the span error is more than 2% (of range).</p> <p>New cal factor = <u>Concentration of the calibration gas x Old calibration factor</u> Reading of the analyser once stabilised</p> <p>Once per month the span calibration is also performed on the whole sample system where the calibration gas is manually injected at the sample probe and then passed through the sample conditioning system and the analyser.</p> |
| Any comment: | See comments under B.1 above |

| | |
|--|---|
| Data / Parameter: | VSG |
| Data unit: | Nm ³ /h |
| 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 for the purpose of calculating expected emission reductions in section B.5 | Not available yet. |
| 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 SCADA data acquisition system. VSG data taken during times when the plant was operating outside the permitted operating range are to be eliminated. The remaining VSG data series will have to be subjected to the following adjustment.</p> <p>Also, the corrected measured data need to be compensated for the actual prevailing temperature and pressure in the stack through the following calculation:</p> |



| | |
|---------------------------------|---|
| | $\frac{P_s * V_s}{T_s} = \frac{P_a * V_a}{T_a}$ <p>Where: P refers to the Pressure (mBar) [conversion from kPa to mbar is a factor of 10] V the volumetric flow rate (m³/hr) T the temperature in Kelvin (Note 1 K = T(°C) + 273). Subscript “s” refers to the actual stack values Subscript “a” refers to the assumed stack conditions.</p> <p>This simplifies to:</p> $V_s = V_a * \frac{P_a}{T_a} * \frac{T_s}{P_s}$ <p>(Going forward after the baseline campaign, this calculation will automatically be performed by the SCADA data acquisition system)</p> <p>The resulting hourly average VSG values are now expressed in Nm³/h as required by AM0034 and where subsequently subjected to the following statistical analysis:</p> <ol style="list-style-type: none"> Calculate the sample mean (x) Calculate the sample standard deviation (s) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation) Eliminate all data that lie outside the 95% confidence interval Calculate the new sample mean from the remaining VSG values <p>The inappropriate range adjustment that necessitated the application of a correction factor during the baseline campaign has been amended.</p> |
| QA/QC procedures to be applied: | <p>The flow meter is calibrated at least every 6 months between campaigns (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).</p> <p>If the deviation exceeds indicated flow by 450 m³/hr (equal to 1% of range), then the pressure transmitter is recalibrated and the previous procedure repeated.</p> <p>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.</p> <p>The results of these calibration procedures are then recorded in the Calibration Procedure log sheet.</p> |
| Any comment: | None. |
| Data / Parameter: | PE_n |



CDM – Executive Board

page 49

| | |
|--|--|
| Data unit: | tN ₂ O |
| Description: | Total mass N ₂ O emissions in each project campaign. |
| Source of data to be used: | Calculated from the measurements from measured data. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | Not available yet. |
| Description of measurement methods and procedures to be applied: | Not applicable, calculated value as per the following formula: $PE_n = VSG * NCSG * 10^{-9} * OH$ |
| QA/QC procedures to be applied: | Not applicable. Calculated value. |
| Any comment: | None. |

| | |
|--|--|
| Data / Parameter: | OH_n |
| Data unit: | hours |
| Description: | Total operating hours during each project campaign |
| Source of data to be used: | Process Control System. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | Not available yet. |
| Description of measurement methods and procedures to be applied: | Required by AM0034 to determine the total mass emissions of N ₂ O during the baseline. Each hour for which the ammonia oxidation temperature (OT _h) was recorded to be 830°C or above is included. 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 830°C. |
| QA/QC procedures to be applied: | Subject to SABS ISO 9001/14001 procedures. |
| Any comment: | None. |

| | |
|---|--|
| Data / Parameter: | NAP_n |
| Data unit: | tHNO ₃ |
| Description: | Metric tonnes of 100% concentrated nitric acid during each project campaign. |
| Source of data to be used: | Mass balance calculation and flow measurements at the No. 11 plant. |
| Value of data applied for the purpose of calculating expected | Not available yet. |



| | |
|--|--|
| emission reductions in section B.5 | |
| Description of measurement methods and procedures to be applied: | <p>Required by AM0034 to calculate the project emissions factor (EF_n) per tonne of 100% concentrated nitric acid produced during that baseline campaign. NAP is determined by a mass balance calculation according to the following procedures:</p> <p>The opening and closing stock are determined by tank level measurements of the plant operator for each production day and recorded in the production logs.</p> <p>Currently roughly 5% of the nitric acid production is delivered to consumers outside of AEL. A pipeline delivers nitric acid to external consumers based on the same site as the No. 11 nitric acid plant. The delivery volumes are measured by flow meters. Deliveries of nitric acid to consumers by tanker truck are checked and recorded on a weighbridge.</p> <p>The majority of nitric acid produced (approximately 95%) is supplied to AEL's own Ammonium Nitrate (AN) plants on the same site via pipeline. The transferred volumes of nitric acid are determined by tank level measurements before and after the transfer. Normally there is no nitric acid production supplied into the tanks during times of transfer to on-site consumers. Should that be the case, the tank levels at the receiving plant are checked for received nitric acid volumes instead to determine the delivered nitric acid volumes.</p> <p>The total nitric acid delivered is then calculated by a mass balance calculation.</p> <p>Using all these figures the total mass of nitric acid produced is calculated to derive the <u>Calculated Production</u>. Because both of AEL's nitric acid plants on site (No. 11 and No. 9) produce into the same storage tank, the Calculated Production is a combined result for both plants.</p> <p>There is also a coriolis flow meter installed, which continuously measures the production output of nitric acid into the storage tank. However, this flow meter is quite unreliable and because of this AEL uses the calculated values for its financial planning and reporting and uses the flow meter results only for plausibility checks.</p> |
| QA/QC procedures to be applied: | <p>The procedures for determining NAP will be exactly the same during the project campaigns as they were during the baseline campaign (and the historic campaigns). Therefore, any uncertainty of NAP determination by this procedure will affect project NAP (used for calculating the EF_n) in exactly the same way as baseline NAP and therefore the uncertainties would cancel each other out and can be ignored.</p> <p>The flow meter measurements can from time be used to conduct plausibility checks of the calculated NAP values.</p> |
| Any comment: | None. |

| | |
|--------------------------|------------------------------|
| Data / Parameter: | TSG |
| Data unit: | °C |
| Description: | Temperature in the stack gas |



| | |
|--|---|
| Source of data to be used: | Stack temperature probe situated next to the volume flow meter. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | Not applicable |
| 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: | Subjected to complete SABS testing loops as part of the ISO 9001/14001 procedures. The temperature probe is taken out and replaced by a new, calibrated temperature probes at each gauze change between the campaigns. |
| Any comment: | None. |

| | |
|--|---|
| Data / Parameter: | PSG |
| Data unit: | mbar (absolute) |
| 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 for the purpose of calculating expected emission reductions in section B.5 | Not applicable. |
| 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: | Subjected to complete SABS testing loops as part of the ISO 9001/14001 procedures. The pressure probe is taken out and replaced by a new, calibrated temperature probes at each gauze change between the campaigns. 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). |
| Any comment: | None. |

| | |
|----------------------------|---|
| Data / Parameter: | EF_n |
| Data unit: | tN ₂ O/tHNO ₃ |
| Description: | Emissions factor for campaign n. |
| Source of data to be used: | Calculation from total mass N ₂ O emissions of campaign n (PE _n) and total nitric acid production (NAP _n). |



| | |
|--|--|
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | Not available yet. |
| 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 ₂ 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: $EF_n = PE_n / NAP_n$ |
| QA/QC procedures to be applied: | Not applicable. |
| Any comment: | None |

| | |
|--|--|
| Data / Parameter: | EF_{ma,n} |
| Data unit: | tN ₂ O/tHNO ₃ |
| 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 _n . |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | Not available yet. |
| Description of measurement methods and procedures to be applied: | 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: $EF_{ma,n} = (EF_1 + EF_2 + \dots + EF_n) / n$ This process is repeated for each campaign such that a moving average, EF _{ma,n} is established over time, becoming more representative and precise with each additional campaign. |
| QA/QC procedures to be applied: | Not applicable. |
| Any comment: | None |

| | |
|----------------------------|---|
| Data / Parameter: | CL_n |
| Data unit: | tHNO ₃ |
| 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 for the purpose of calculating expected emission reductions in section B.5 | Not available yet. |
| Description of measurement methods and procedures to be applied: | <p>In accordance with AM0034 the project length (CL_n) has to be compared to the established average historic campaign length (CL_{normal}); and</p> <p>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).</p> <p>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.</p> |
| QA/QC procedures to be applied: | See comments for NAP. |
| Any comment: | None. |

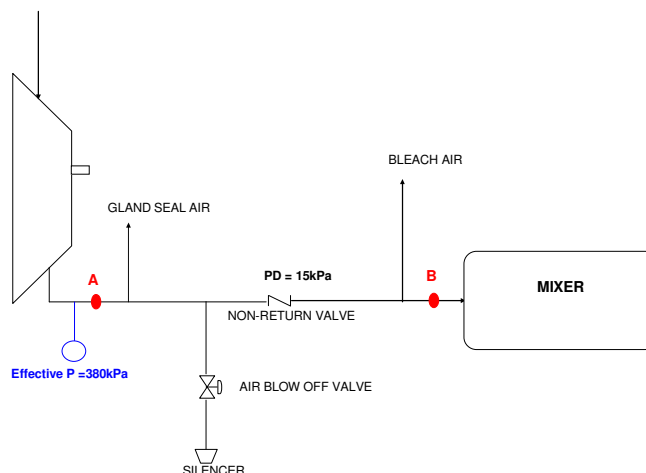
| | |
|--|---|
| Data / Parameter: | P.13 EF_p |
| Data unit: | $tN_2O/tHNO_3$ |
| Description: | Emissions factor used for the specific campaign n to determine the emission reductions of that campaign |
| Source of data to be used: | Calculation of EF_n and $EF_{ma,n}$. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | Not available yet. |
| 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 $EF_{ma,n}$ 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:</p> <p>If $EF_{ma,n} > EF_n$ then $EF_p = EF_{ma,n}$</p> <p>If $EF_{ma,n} < EF_n$ then $EF_p = EF_n$</p> |
| QA/QC procedures to be applied: | Not applicable. |
| Any comment: | None |

| | |
|----------------------------|--|
| Data / Parameter: | P.14 EF_{min} |
| Data unit: | $tN_2O/tHNO_3$ |
| Description: | EF_{min} is equal to the lowest EF_n observed during the first 10 campaigns of the project crediting period. |
| Source of data to be used: | Calculations of $EF_{ma,n}$. |



| | |
|--|--|
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | Not available yet. |
| Description of measurement methods and procedures to be applied: | A campaign-specific emissions factor shall be used to cap any potential long-term trend towards decreasing N ₂ O emissions that may result from a potential built up of platinum deposits. After the first ten campaigns of the crediting period of the project, the lowest EF _n observed during those campaigns will be adopted as a minimum (EF _{min}). If any of the later project campaigns results in an EF _n that is lower than EF _{min} , the calculation of the emission reductions for that particular campaign shall use EF _{min} and not EF _n . |
| QA/QC procedures to be applied: | Not applicable. |
| Any comment: | None. |

| | |
|--|---|
| Data / Parameter: | OP_h |
| Data unit: | kPa (gauge) |
| Description: | Oxidation Pressure for each hour |
| Source of data to be used: | Pressure probe at ammonia to air mixer. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | Not applicable. Used to determine when plant is operating outside of permitted range. |
| Description of measurement methods and procedures to be applied: | <p>In accordance with AM0034 the oxidation pressure in the ammonia oxidation reactor (OP_h) has to be monitored and compared to the Normal range for oxidation temperature (OP_{normal}). VSG and NCSG data obtained during times when OP_h was above or below OP_{normal} has to be eliminated from the calculation of EF_p.</p> <p>AM0034 prescribes the monitoring and recording of the Oxidation Pressure for each hour (OP_h) during the project campaigns. This would imply the measurement of pressure inside the Ammonia Oxidation Reactor. AEL has no such measurement equipment installed at that point; instead the available measurements for air pressure before the ammonia-air-mixer are used to determine OP_h.</p> <p>The pressure for the oxidation reactor is taken as the pressure at point B (air to mixer pressure). The permitted range for the oxidation pressure is inferred from the values given for point A (HP compressor discharge pressure range).</p> <p>Figure: Pressure points for No. 11</p> |



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.

QA/QC procedures to be applied:

Subjected to complete SABS testing loops as part of the ISO 9001/14001 procedures.

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).

Any comment:

None.

| | |
|--|---|
| Data / Parameter: | OT_h |
| Data unit: | °C |
| Description: | Oxidation temperature in the ammonia oxidation reactor (AOR). |
| Source of data to be used: | Thermocouples inside the AOR. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | Not applicable. Used to determine when plant is operating outside of permitted range. |
| Description of measurement methods and procedures to be applied: | Oxidation temperature is set and is never actively changed during operation. The composite thermocouple is made up of six individual temperature probes and continuously measures OT _h . OT _h is controlled by AIFR which is a controlled parameter and should stay as constant as possible. OT _h is therefore a control pa- |



| | |
|---------------------------------|--|
| | parameter for AIFR. |
| QA/QC procedures to be applied: | Subjected to complete SABS testing loops as part of the ISO 9001/14001 procedures. The temperature probe is taken out and replaced by a new, calibrated temperature probes at each gauze change between the campaigns. |
| Any comment: | None. |

| | |
|--|--|
| Data / Parameter: | AFR |
| Data unit: | tNH ₃ /h |
| Description: | Ammonia gas flow rate to the ammonia oxidation reactor. |
| Source of data to be used: | Orifice plate |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | Not applicable, monitored data of AFR will be used to determine if plant was operating outside of AFR _{max} . |
| Description of measurement methods and procedures to be applied: | The ammonia flow is continuously measured by orifice plate. |
| QA/QC procedures to be applied: | Subjected to complete SABS testing loops as part of the ISO 9001/14001 procedures. |
| Any comment: | None. |

| | |
|--|---|
| Data / Parameter: | AIFR |
| 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 for the purpose of calculating expected emission reductions in section B.5 | Not applicable |
| Description of measurement methods and procedures to be applied: | <p>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_{max} has been established 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_{max} will be eliminated from the calculation of EF_p.</p> <p>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 Nm³/hr, which is used in the ratio calculation.</p> |
| QA/QC procedures to be applied: | Subjected to complete SABS testing loops as part of the ISO 9001/14001 procedures. |



| | |
|--------------|-------|
| Any comment: | None. |
|--------------|-------|

| | |
|---|---|
| Data / Parameter: | GS_{PC} |
| Data unit: | Name of supplier. |
| Description: | Gauze supplier for the project campaign |
| Source of data used: | Monitored / Invoices |
| Value applied: | Not available yet. |
| 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 N₂O in the ammonia oxidation process tends to be lower than with gauzes containing little or no Palladium.</p> <p>AEL intends to continue using gauzes with the same or very similar composition for the foreseeable future.</p> |
| Any comment: | None. |

| | |
|---|--|
| Data / Parameter: | GC_n |
| Data unit: | % |
| Description: | Gauze composition during each 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 / Invoices |
| Value applied: | To be obtained during the project campaigns. |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | The gauze composition during the project needs to be monitored and compared to GC _{BL} . If the operator has changed the gauze composition during a project campaign to a composition not used during the baseline campaign, the baseline campaign may have to be repeated or a conservative IPCC default emissions factor applied. |
| Any comment: | None. |

| | |
|----------------------------|---|
| Data / Parameter: | EF_{reg} |
| Data unit: | tN ₂ O/tHNO ₃ |
| Description: | Emissions factor derived from incoming regulation for N ₂ O emissions. |
| Source of data to be used: | N ₂ O regulation |
| Value of data applied | Not applicable as there is no regulation on N ₂ O emissions in South Africa. |



| | |
|--|-----------------|
| for the purpose of calculating expected emission reductions in section B.5 | |
| Description of measurement methods and procedures to be applied: | Not applicable. |
| QA/QC procedures to be applied: | Not applicable. |
| Any comment: | None |

**B.7.2 Description of the monitoring plan:**

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

AM0034 requires the use of the European Norm EN 14181 (2004) “*Stationary source emissions - Quality assurance of automated measuring systems*” as a guidance for installing and operating the Automated Monitoring System (AMS) in the nitric acid plants for the monitoring of N₂O emissions.

A complete Automated Monitoring System (AMS) to monitor the mass emissions of N₂O at the stack of AEL’s No. 11 nitric acid plant was ordered in the second half of 2005 and has been installed and operated since January 2006. As an operator of the nitric acid plants since 1932 and of the No. 11 nitric acid plant since June 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 plant manager is responsible for the ongoing operation and maintenance of the N₂O monitoring system. Operation, maintenance, calibration and service intervals are being carried out by staff from the instrumentation department according to the vendor’s specifications and under the guidance of internationally relevant environmental standards, in particular EN 14181 (2004) and EN ISO 14956 (2002).

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.

Please see Annex 4 for a detailed description of the Automated Monitoring System (AMS) installed at AEL’s No. 11 nitric acid plant as well as for background information on EN 14181 and the practical implications for using this standard for guidance in the implementation of this CDM project activity.

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

QAL 1

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

At the time of purchasing of the AMS by AEL, no AMS vendors had yet conducted the QAL 1 suitability testing for N₂O and it was not known if any vendors were in the process of obtaining this. The chosen gas analyser MIR9000 from Environnement however, has passed the QAL1 suitability for measurements of NO_x and other gaseous emissions.

The new analyser to be installed and integrated into the No. 11 AMS – an ABB Uras 14 analyser – is QAL1-tested according to EN 14181.



The AMS was calibrated by the vendor, Environnement S.A. prior to shipment and installation in the nitric acid plant³¹, the calibration report also contains information about the cross sensitivities of the analyser.

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. The new analyser type has been suitability tested for N₂O under QAL1.

Pre-validation of the AMS by a DOE

While this is not explicitly required by either AM0034 or EN 14181, a pre-validation of the AMS installation and operation was conducted on site in June 2006 by TÜV SÜD to help ensure that the AMS output and the monitoring procedures implemented in the plant are going to be acceptable to the DOE upon validation of the project.

QAL2

QAL2 is a procedure for the determination of the calibration function and its variability, and a test of the variability of the measured values of the AMS compared with the uncertainty given by legislation. The QAL2 tests are performed on suitable AMS that have been correctly installed and commissioned on-site (as opposed to QAL1 which is conducted off-site). QAL2 tests are to be performed at least every 5 years according to EN 14181 but also after major changes to the plant or changes or repairs to the AMS, which will influence the results obtained significantly.

A calibration function is established from the results of a number of parallel measurements performed with a Standard Reference Method (SRM). The variability of the measured values obtained with the AMS is then evaluated against the required uncertainty.

According to EN 14181, both the QAL2 procedures and the SRM need to be conducted by an independent “testing house” or laboratory which has to be accredited to ISO 17025.

The QAL2 tests on the No. 11 AMS were conducted by TÜV SÜD on XXX 2007³². All parts of the AMS were found to be in compliance with EN 14181³³. TÜV SÜD is accredited under ISO 17025 for conducting such tests.

Standard Reference Method (SRM)

In order to provide an additional source for verifying the ongoing functionality of the AMS, gas samples from the stack were taken at intervals and over a time period as described for the reference measurements under EN 14181. These samples were then sent for analysis to Modderfontein Laboratory Services (Pty) Ltd., which is an independent chemical analysis laboratory which is certified by the South African Bureau of Standards (SABS).

An N₂O standard gas sample with a known concentration is injected first and its area and height are recorded. Then the sample is injected and its area and height are also recorded. The concentration of the sample is obtained using the equation below³⁴.

$$C_{sample} = \frac{\frac{Area_{sample}}{Height_{sample}}}{\frac{Area_{standard}}{Height_{standard}}} \cdot 0.2$$



Modderfontein lab independently takes two samples from the plant three times per week (normally on Mondays, Wednesdays and Fridays). One sample is taken from the exit of the analyser and one is taken from the sampling point before the SEC sample conditioning system. The analyser readings shown at that particular time are also recorded.

The two samples are then analysed in the Modderfontein Lab by a gas chromatograph (GC). The GC is calibrated with standard calibration gas with a certified N₂O calibration (the balance being N₂) before two GC measurements are done on each of the two samples.

The results are compared to the plant results to check if there is a significant difference between the two figures using the t-test. Ideally, when there are significant differences between the laboratory results and plant results, the laboratory analysis should be re-done. If there are still some differences, then another span calibration is performed on the analyser and the analyser calibration factors are checked.

The series of lab sample measurements are set against the corresponding analyser results recorded at the time of sampling. An accredited ISO 17025 testing house has conducted the necessary QAL2 SRM procedures on these data series to derive the calibration curve for the analyser and to determine the total uncertainty of the analyser measurements.

In order to ensure compliance with EN 14181, the full QAL2 procedures will be repeated on site by an accredited testing house, once the new ABB Uras 14 analyser has been commissioned.

AMS calibration and QA/QC procedures

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

Currently, an Environnement MIR 9000 multigas infra red analyser is installed on the No11 nitric acid plant to measure the N₂O emissions. Due to the unreliability of the No. 9 nitric acid plant MIR 9000 analyser, a decision was made to replace both nitric acid plant’s analysers with QAL 1 certified ABB URAS 14 analysers. The URAS 14 analyser will be installed on No11 nitric acid at the end of the current project campaign.

Zero Calibration of the Environnement MIR 9000 analyser

Dry oil-free instrument air with a dew point of < 50 °C or better must be used as a reference signal. This commodity is crucial to the operation of the analyser since the dry air is used as a zero gas as well as for emergency purging of the measuring cell should the sample gas contain more than a certain amount of moisture that could be harmful to the analyser. The dry air is also used to either dilute or remove moisture from the sample at the sample probe, depending on what type of sampling system is used. Dry air of a good quality must thus always be available and connected to both the “Zero Ref.” port on the analyser as well as to the sample probe via the designated connections.

The zero calibration of the MIR 9000 is performed fully automatically and is done on programmable intervals. The analyser at No. 11 plant is set to the standard default time interval, which means that an automatic zero calibration is done every 3 hrs.

Span calibration of the Environnement MIR 9000 analyser



The span calibration of the analyser can only be performed manually. Certified calibration gas, supplied by AFROX with a known and certified concentration is always connected to the analyser to conduct the regular analyser span calibration. The certified calibration gas used for the span calibration of the analyser is checked against another certified calibration gas by Modderfontein lab. This second cylinder of certified calibration gas has previously been checked against a standard N₂O calibration gas which was produced by Modderfontein lab for that purpose using Worstoff pumps.

The span calibration is conducted at least twice a week (normally on Tuesdays and Fridays) with the calibration gas being injected into the analyser sample cell. As a result of the span calibration, the K-factors used to adjust the measured result before being sent to the DCS data acquisition system are readjusted.

**New cal factor = Concentration of the calibration gas x Old calibration factor
Reading of the analyser once stabilised**

Once per month the span calibration is also performed on the whole sample system where the calibration gas is manually injected at the sample probe and then passed through the sample conditioning system and the analyser.

Zero Calibration of the ABB URAS 14 analyser

The zero calibration of the URAS 14 is performed fully automatically and is done on programmable intervals. The analyser at No. 11 plant is set to the standard default time interval, which means that an automatic zero calibration will be done every 3 hours.

Span calibration of the ABB URAS 14 analyser

The full scale calibration of the ABB URAS 14 is also performed fully automatically and is done on programmable intervals using gas-filled calibration cells.

QAL3 software supplied by ABB will work automatically in conjunction with the URAS 14 analyser to record all calibration checks on both zero and span checks. The software will log all characteristic values for the determination of precision of drift. Any adjustments will be carried out by the analyser itself and all values will be recorded in the software. Shewhart and CASUM Control charts will be used for displaying the precision of drift. All records will be archived and backed up on a weekly basis.

Flow meter calibration procedures

The flow meter is calibrated at least every 6 months between campaigns (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 the indicated flow by 450 m³/h (equal to 1% of range) 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.

QAL3

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

This is achieved by conducting periodic zero and span checks on the AMS and then evaluating the results obtained using control charts. Zero and span adjustments or maintenance of the AMS, may be necessary depending on the results of this evaluation. In addition, Annual Surveillance Tests (AST) should be conducted in accordance with EN 14181; these are a series of measurements that need to be conducted by independent measurement equipment in parallel to the existing AMS.

In essence, AEL staff performs QAL3 procedures through the established calibration procedures described above. However, similarly to QAL2, there is no independent, qualified and certified entity in South Africa that could conduct the QAL3 procedures and particularly the AST in accordance with EN 14181. Therefore, either a sufficiently qualified (but not certified in accordance with EN 14181) technical surveillance company or laboratory could perform the independent QAL3 procedures. Or alternatively an accredited auditor from Europe will have to be called in to conduct the QAL3 procedures.

SCADA 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 disc drive. That way there are already four copies of the original and unchanged data stored in four different locations. In addition, the hourly and daily data are sent to Nserve once per week 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.

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 section B.7.1 above: 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 for at least 2 years in at least 2 different locations.

**B.8 Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies)**4th May 2007

African Explosives Ltd.

Mr. Clive Greger

N.serve Environmental Services GmbH

Mr. Albrecht von Ruffer (Database management by Dr. Helmuth Groscurth)

SECTION C. Duration of the project activity / crediting period**C.1 Duration of the project activity:**

10 years

C.1.1. Starting date of the project activity:

Expected: August 2007

C.1.2. Expected operational lifetime of the project activity:

AEL's No. 11 nitric acid plant has a remaining operational lifetime of at least 15 years and is not expected to be decommissioned before that time.

C.2 Choice of the crediting period and related information:

The project participants have chosen a fixed term crediting period of ten years.

C.2.1. Renewable crediting period

>>

C.2.1.1. Starting date of the first crediting period:

>>

C.2.1.2. Length of the first crediting period:

>>

C.2.2. Fixed crediting period:

10 years

C.2.2.1. Starting date:

01. August 2007 (or any later date at which project is registered AND the N₂O abatement catalyst installed)

C.2.2.2. Length:

10 years

**SECTION D. Environmental impacts****D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:**

The project will reduce gaseous emissions of nitrous oxide (N₂O) from the plant tail gas and will therefore contribute to international efforts to reduce greenhouse gas emissions. The project will have no effects on local air quality.

The project will have no impact on water pollution. No additional water is required for the project activity's implementation or operation. Therefore, there is no impact on the sustainable use of water.

Also, the project does not impact on the community's access to other natural resources as it will not require any additional resources. Also, there is no impact on the efficiency of resource utilization.

The N₂O abatement catalyst will be leased from an overseas supplier. The catalyst will be replaced from time to time and the spent catalyst returned to the supplier for recycling, if possible.

There are no other positive or negative impacts on the environment.

D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

The Gauteng Department of Agriculture, Conservation and Environment has confirmed by letter dated 19th September 2006, that based on the information supplied, the project is not listed in terms of the Environmental Impact Assessment Regulations, 2006, published under the National Environmental Management Act (Act 107, 1998) as amended in Government Notice R385. Therefore, it does not legally require environmental authorisation from the Department³⁵.

SECTION E. Stakeholders' comments**E.1. Brief description³⁶ how comments by local stakeholders have been invited and compiled:**

AEL has conducted a stakeholder consultation process by hiring a local consultancy³⁷ for facilitating this process. The process was initiated in mid-August and lasted until the end of September 2006. Whilst some addressees received individual information, the essential key points were compiled in a Background Information Document (BID).

The following stakeholder groups were identified and addressed:

- authorities
- the general residential urban public in nearby towns and villages
- the commercial and industrial tenants
- national and regional NGOs
- local focussed interest groups
- AEL employees

The diversity of stakeholders that had to be informed was addressed by a corresponding broad mix of communication paths.



AEL's Environment Manager had informed environmental authorities – such as the Department of Environment, Provincial and Metro Environmental Authorities and the National Department of Environment's Regional Air Pollution control officer – prior to the actual stakeholder consultation process. Thereafter, these participants were updated by E-mail on a regular basis. Also, they received the BID.

Local residents were addressed by circulating detailed information on several local newspapers. Readers were invited to contact the AEL environment officer, whose contact details were provided as well.

Other commercial and industrial tenants on the Modderfontein industrial site as well as local, regional and national NGO's were informed either via E-mail or by letter (including BID).

AEL employees were integrated by electronic newsletter using the AEL intranet. The BID was circulated the same way. Additionally, large notices were placed at all the entry gates to the AEL site.

E.2. Summary of the comments received:

Only very few responses were obtained. One stakeholder wanted to know more about N₂O and its implications for climate change, two asked to be kept informed, two others just confirmed to have received the information. AEL provided the information requested by them.

E.3. Report on how due account was taken of any comments received:

As these comments were not aimed at influencing the implementation of the project activity in any way, it was not considered necessary to take them into account other than keeping those who asked for this informed.

AEL is committed to further societal welfare in the Modderfontein area and is involved in several community projects. It is planned to launch a new initiative which will provide experiential environmental education to large numbers of local schoolchildren. The venue for this programme will be the Modderfontein Conservation Area, which is an approximately 280 ha park which AEI plans to set aside for conservation at Modderfontein. It is intended to link this environmental education initiative to the proposed N₂O abatement project. The environmental education programme will respond to contemporary environmental education theory and practice and provide a centre that responds to environmental issues or concerns of focus such as education for sustainability.

Thus, AEL will continue to involve the local community and promote the proliferation of environmental knowledge.

**Annex 1****CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY**

| | |
|------------------|--|
| Organization: | African Explosives Ltd. |
| Street/P.O.Box: | PO Modderfontein |
| Building: | Acid House |
| City: | Modderfontein |
| State/Region: | Gauteng Province |
| Postfix/ZIP: | 1645 |
| Country: | South Africa |
| Telephone: | |
| FAX: | |
| E-Mail: | |
| URL: | www.explosives.co.za |
| Represented by: | |
| Title: | Production Manager |
| Salutation: | Mr. |
| Last Name: | Aucamp |
| Middle Name: | |
| First Name: | Leon |
| Department: | Nitrates |
| Mobile: | |
| Direct FAX: | +27 (0)11 606 2426 |
| Direct tel: | +24 (0)11 606 3287 |
| Personal E-Mail: | AucampL@ael.co.za |

| | |
|-----------------|--|
| Organization: | N.serve Environmental Services GmbH |
| Street/P.O.Box: | Grubessallee 12 |
| Building: | |
| City: | Hamburg |
| State/Region: | |
| Postfix/ZIP: | 22143 |
| Country: | Germany |
| Telephone: | |
| FAX: | |
| E-Mail: | contact@nserve.net |
| URL: | www.nserve.net |
| Represented by: | |
| Title: | Managing Director |
| Salutation: | Mr. |
| Last Name: | von Ruffer |
| Middle Name: | |
| First Name: | Albrecht |
| Department: | |



| | |
|------------------|--|
| Mobile: | +49 177 65 15 964 |
| Direct FAX: | +49 40 788 937 10 |
| Direct tel: | +49 40 788 937 08 |
| Personal E-Mail: | ruffer@nserve.net |

Annex 2**INFORMATION REGARDING PUBLIC FUNDING**

No public funding was received by the project participants for the development, implementation and operation of the project.

**Annex 3****BASELINE INFORMATION**

Example of the SCADA data acquisition system output, extracted as a .csv file and then imported into the N.DBMS:

➔ insert excerpt from data to be received from AEL.

| StackPres | BoilerTemp | BoilerPres | AmmoniaF | AirFlow | NOConc | N2OConc | NO2Conc | NoxConc | StackFlowI |
|-----------|------------|------------|----------|----------|---------|----------|---------|----------|------------|
| 839.12 | 899.595 | 406.076 | 5873.753 | 112695.4 | 355.439 | 1716.489 | 297.495 | 1383.889 | 106.452 |
| 839.12 | 899.595 | 406.424 | 5873.753 | 112784.7 | 355.439 | 1716.489 | 297.495 | 1383.889 | 107.957 |
| 839.12 | 899.595 | 406.424 | 5879.021 | 112650.7 | 355.439 | 1716.489 | 297.495 | 1383.889 | 107.006 |
| 839.12 | 899.595 | 406.424 | 5871.119 | 112650.7 | 355.439 | 1711.945 | 284.188 | 1383.889 | 107.807 |
| 839.12 | 899.595 | 406.424 | 5873.753 | 112784.7 | 364.738 | 1700.585 | 284.188 | 1384.87 | 106.755 |
| 839.12 | 899.595 | 406.076 | 5873.753 | 112784.7 | 364.738 | 1700.585 | 284.188 | 1384.87 | 106.704 |
| 839.12 | 899.595 | 406.424 | 5871.119 | 112650.7 | 365.9 | 1702.857 | 282.763 | 1385.852 | 104.258 |
| 839.12 | 899.595 | 406.25 | 5865.851 | 112650.7 | 365.9 | 1702.857 | 282.763 | 1385.852 | 107.607 |
| 839.12 | 899.595 | 406.076 | 5865.851 | 112695.4 | 367.295 | 1700.585 | 282.525 | 1389.778 | 109.047 |
| 839.12 | 899.595 | 406.25 | 5865.851 | 112650.7 | 367.295 | 1700.585 | 282.525 | 1389.778 | 105.488 |
| 839.12 | 899.595 | 406.424 | 5852.681 | 112650.7 | 367.295 | 1700.585 | 282.763 | 1389.778 | 107.507 |
| 839.12 | 899.884 | 406.25 | 5852.681 | 112695.4 | 367.295 | 1700.585 | 283 | 1389.778 | 108.305 |
| 839.12 | 899.595 | 406.25 | 5839.512 | 112784.7 | 367.295 | 1700.585 | 283 | 1389.778 | 108.701 |
| 839.12 | 899.595 | 406.076 | 5831.609 | 112784.7 | 367.295 | 1700.585 | 283 | 1389.778 | 106.704 |
| 839.12 | 899.595 | 406.076 | 5810.538 | 112650.7 | 363.576 | 1700.585 | 293.693 | 1398.611 | 105.946 |
| 839.12 | 900.174 | 405.729 | 5800.002 | 112650.7 | 363.576 | 1700.585 | 286.565 | 1398.611 | 106.199 |
| 839.12 | 900.174 | 406.25 | 5797.368 | 112650.7 | 363.576 | 1700.585 | 286.802 | 1385.852 | 108.006 |
| 839.12 | 899.884 | 406.076 | 5786.832 | 112784.7 | 363.576 | 1700.585 | 286.802 | 1385.852 | 108.006 |
| 839.12 | 899.884 | 405.729 | 5784.198 | 112650.7 | 354.51 | 1717.625 | 299.158 | 1384.87 | 108.354 |
| 839.12 | 899.884 | 405.729 | 5781.564 | 112561.3 | 354.51 | 1717.625 | 299.158 | 1384.87 | 105.692 |
| 839.12 | 899.595 | 405.729 | 5773.662 | 112471.9 | 354.51 | 1717.625 | 299.158 | 1384.87 | 107.507 |
| 839.12 | 899.595 | 405.729 | 5773.662 | 112471.9 | 354.51 | 1717.625 | 299.158 | 1384.87 | 107.357 |
| 839.12 | 899.595 | 405.729 | 5773.662 | 112650.7 | 354.51 | 1717.625 | 299.158 | 1384.87 | 107.757 |



Annex 4

MONITORING INFORMATION

Description of the AMS installed at AEL's No. 11 nitric acid plant.

Currently, an Environnement MIR 9000 multigas infra red analyser is installed on the No11 nitric acid plant to measure the N₂O emissions. Due to the unreliability of the No. 9 nitric acid plant MIR 9000 analyser, a decision was made to replace both nitric acid plant's analysers with QAL 1 certified ABB URAS 14 analysers. The URAS 14 analyser will be installed on No11 nitric acid at the end of the current project campaign.

1. General Description of the AMS (Environnement MIR 9000)

The system currently installed at AEL's No. 11 nitric acid plant consists of an air dryer unit, a sample conditioning system and the analyser itself. The sampling system and analyser were designed to operate for extended periods between the regular maintenance intervals and communicate constantly with each other to ensure that all systems are fully operational during the plant's operation. Any alarm conditions are displayed and logged on the analyser for ease of identification and maintenance.

During operation, plant instrument air at 6-7 bar pressure is continuously pumped into the air dryer system where all moisture is extracted by means of a hydrophobic filter arrangement to provide clean and dry air with a dew point of -70 °C and a porosity of 0.45 micron. The physical condition of the air is crucial to the operation of the entire system. The air is continuously sent to both the sample probe as well as to the analyser's zero port. The air supply must at all times be open and available when the system is on-line.

2. Sample point

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

The sampling points for both NCSG and VSG are at least 3 times the stack diameter distance after any previous bend in the stack and behind the tail gas expander turbine.

3. Sample Conditioning System

The SEC sample conditioning system consists of a sample probe, fine filter, a heated section and a moisture removal device. The sample is drawn in from the process at a rate of 15-20 l/hr through a coarse 5-micron sinter-metal filter situated in the centre of the exit stack by means of an air-driven ejector. The sample is heated already in the probe to 180 °C in order to keep its temperature above the dew point throughout the analytic process.

Once the hot sample enters the sample box it is filtered further down to 0.5 micron and exposed in an oven to a temperature of 220 °C in order to prevent any formation of condensation. The dry air received from the air-drying system is piped through a dual-stage permeation drying tube that allows only the water molecules to permeate through the walls. The hot filtered sample flows in one direction through the permeation dryer. Simultaneously, the dry instrument air flows in the opposite direction removing the moisture that permeated through the dryer. A second dryer mounted in the "cool" area outside of the



oven further dries the gas whilst cooling it down at the same time. This method of moisture removal has several advantages compared to the conventional electric cooling methods: firstly, it removes only the moisture and not any of the components to be analysed. Secondly, the sample is already conditioned at the take-off point and can thereafter be transported to the remote analyser. In the case of AEL's No. 11 nitric acid plant this is done using an ordinary unheated high-density nylon or teflon tube allowing a high velocity gas flow at a comparatively low volume of sampled gas.

Because of the low sample volumes the loading on the primary and secondary filters in the SEC system is much lower than in the case of a conventional system. This is one of the main reasons why the system can stay operational for extended periods of time. Both air pressure and gas flow velocity at the filter, as well as the temperatures of both the probe and the oven are constantly monitored. Any fault conditions are displayed and logged at the analyser in the alarm menu.

Photographs of the sample conditioning unit (pump and dryer) at No. 11

(To be inserted subsequently)

4. Analyser

a. The Environnement MIR 9000 gas analyser installed in the historic and baseline campaign(s)

The MIR 9000 (Multi-component InfraRed analyser) is capable of analysing up to 12 components simultaneously. It employs the InfraRed filter correlation principle, which is one of the most suitable measuring techniques available for the elimination of interferences from any unknown background components in the process. The optical bench (inside the measuring chamber) has an internal structure consisting of a range of parabolic mirrors that provide it with an effective measuring length of 12 meters, which gives the analyser a very sensitive and stable performance with minimal long-term drift. The pressure, the gas flow velocity and the temperature of the bench are constantly monitored and the necessary corrections applied to the analysis results. The temperature of the chamber is accurately controlled at 49 °C whilst the other two parameters are just measured. Besides the three components of interest that the analyser is equipped for in this case (N₂O, NO and NO₂) it also analyses for moisture in the sample as well as the CO₂ concentration.

These additional parameters are used by the system for correction purposes and to protect the analyser (mainly the sensitive optical bench) in case the sample conditioning system suffers operational failure. Moisture could principally disadvantageously affect the gas sample analysis: water vapour is capable of absorbing IR waves and thereby skewing analysis-results; furthermore it can – when exposed to NO_x-gasses – form acidic compounds capable of damaging the analytic devices.

Moisture can in principle negatively affect the gas sample analysis as it is absorbed across the infrared spectrum and can also create acidic conditions when condensing and thereby absorbing some of the corrosive components in the sample.

The MIR 9000 analyser was designed with a standard safety feature that constantly analyses moisture levels. In the event of a faulty condition at the SEC sample conditioning unit (such as a loss or decrease in the condition of the dry air) it will automatically detect any increase in moisture. At a preset level (10,000 ppmv in the case of AEL No. 11 plant) the analyser will raise an alarm, freeze all outputs to the control room and switch over from sample into zero mode. The optical bench will then be flushed with



dry air from the dryer until the moisture conditions are back to normal, thereafter the unit will switch back to sampling mode and continue to analyse.

The dry air is also constantly piped to the “Zero Reference” port of the analyser. At preset intervals (Currently set for every 3 hrs) the analyser switches over to zero reference mode and allow the optical bench to be flooded with dry air for 4 minutes. Once the bench is clean the electronics compare the status of all measuring parameters at zero conditions against the original conditions when the analyser was set up. The system will automatically adjust for any possible offsets to re-base itself on the original settings.

Once all settings are corrected the system switches back to sampling mode and allows the readings to stabilise before the outputs are switched back to active again. This method of constantly checking and adjusting the optical parameters is one of the outstanding features of the system. It thus can provide a very stable zero baseline with minimal drift over several months. The analysis results are delivered on the local display in terms of ppmv. The 4-20 mA outputs to the control room are scaled according to the programmed ranges (0-2,000 ppmv for N₂O during the baseline campaign, which will be adjusted downwards for the project campaigns).

Also, a measurement for O₂ concentration is part of the system. By piping the vent from the measuring chamber in a flow-through arrangement over an electrochemical oxygen cell, oxygen concentrations can be assessed. The oxygen cell is powered from the control room via a 2-wire arrangement. Once the parameters are analysed (except for the O₂) the microprocessor applies the necessary corrections based on the actual temperature and pressure of the sample in the measuring chamber. A standard factor is then applied to the final raw value to convert the reading to normal conditions. A further selection option allows the readings as well as the associated outputs to be converted in terms of mass. Because of the in-built automatic checks and the resulting stability of the analyser, re-adjustment intervals are longer than for conventional process analysers (see section on Monitoring Procedures below).

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

The system to be installed at AEL's No. 11 nitric acid plant consists of an air dryer unit, a sample conditioning system and the analyser itself. The sampling system and analyser were designed to operate for extended periods between the regular maintenance intervals and communicate constantly with each other to ensure that all systems are fully operational during the plant's operation. Any alarm conditions are displayed and logged on the analyser for ease of identification and maintenance.

During operation, plant instrument air at 6-7 bar pressure is continuously pumped into the air dryer system where all moisture is extracted by means of an aluminium oxide filter arrangement to provide clean and dry air with a dew point of 5 °C and a porosity of 0.3 micron. The physical condition of the air is crucial to the operation of the entire system. The air is continuously sent to both the sample probe as well as to the analyser's zero port. The air supply must at all times be open and available when the system is on-line.

2. Sample point

The location of the sample point was selected to provide ease of access and a location close to the analyser. The most suitable position is in the horizontal section of the exit stack. At this point, the gas is still hot (above dew point) and well mixed. The probe will be installed at the same location as the currently installed sampling probe. A heated sample line will be installed to insure that the dry gas sample does not condense before entering the analyser.



3. Sample Conditioning System

The SCC-F sample conditioning system consists of a sample probe, aluminium oxide filter, a heated section and a moisture removal device. The sample is drawn in from the process at a rate of 30 to 500 l/hr through a 0.3-micron aluminium oxide-metal filter situated in the centre of the exit stack by means of an air-driven ejector. The sample is heated already in the probe to 180 °C in order to keep its temperature above the dew point throughout the analytic process.

The hot filtered sample flows in one direction through a heated trace line to the analyser. Any fault conditions are displayed and logged at the analyser in the alarm menu.

4. Analyser

The URAS 14 (Multi-component Infrared analyser) is capable of analysing up to 4 components simultaneously. It employs the Non-dispersive infrared absorption principle in the $\lambda = 2.5 - 8 \mu\text{m}$ wave length. Besides the three components of interest that the analyser is equipped for in this case (N_2O , NO and NO_2) it also analyses for moisture in the sample gas.

These additional parameters are used by the system for correction purposes and to protect the analyser (mainly the sensitive optical bench) in case the sample conditioning system suffers operational failure. Moisture could principally disadvantageously affect the gas sample analysis: water vapour is capable of absorbing IR waves and thereby skewing analysis-results; furthermore it can – when exposed to NO_x -gases – form acidic compounds capable of damaging the analytic devices.

Moisture can in principle negatively affect the gas sample analysis as it is absorbed across the infrared spectrum and can also create acidic conditions when condensing and thereby absorbing some of the corrosive components in the sample.

The dry air is also constantly piped to the “Zero Reference” port of the analyser. At preset intervals (Currently set for every 3 hrs) the analyser switches over to zero reference mode and allow the optical bench to be flooded with dry air for 4 minutes. Once the bench is clean the electronics compare the status of all measuring parameters at zero conditions against the original conditions when the analyser was set up. The system will automatically adjust for any possible offsets to re-base itself on the original settings.

Once all settings are corrected the system switches back to sampling mode and allows the readings to stabilise before the outputs are switched back to active again. This method of constantly checking and adjusting the optical parameters is one of the outstanding features of the system. It thus can provide a very stable zero baseline with minimal drift over several months. The analysis results are delivered on the local display in terms of ppmv. The 4-20 mA outputs to the control room are scaled according to the programmed ranges (0-2,000 ppmv for N_2O during the baseline campaign, which will be adjusted downwards for the project campaigns).

Photographs of the contents of the housing for the analyser (the MIR 9000 is the box in the middle) and the front cover with display of the analyser.

(To be inserted subsequently)

- b. The ABB Uras 14 analyser that will be installed before the beginning of the crediting period**

To be completed after installation.

5. Flow Meter

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

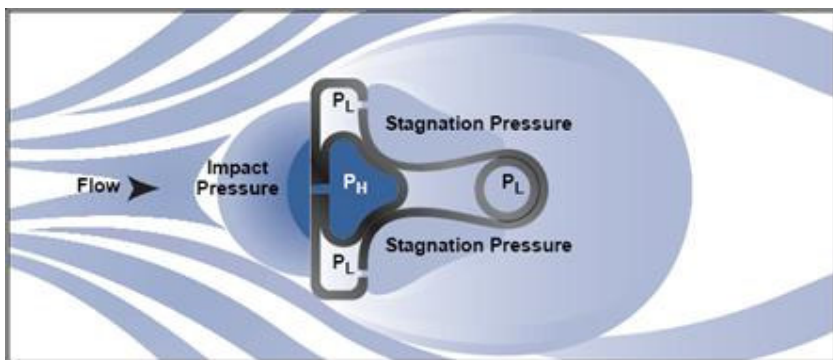


The Rosemount Annubar® 485 is a device used to measure the flow-velocity of a liquid, gas or steam fluid that passes through a pipe. It measures by creating a differential pressure (DP) that is proportional to the square of the velocity of the fluid in the pipe, in accordance with Bernoulli's theorem.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

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

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

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



**Annex 5****SOUTH AFRICAN DNA: SUSTAINABLE DEVELOPMENT CRITERIA**

| ENVIRONMENTAL | | |
|--|--|--|
| CRITERIA | INDICATOR | PROJECT CONTRIBUTION TO SUSTAINABLE DEVELOPMENT |
| Impact on local environmental quality | Impact of the project on: <ul style="list-style-type: none">- Air quality- Water pollution- Generation or disposal of solid waste- Any other positive or negative environmental impacts, such as noise, safety, visual impacts or traffic. | <ul style="list-style-type: none">- The project will have no impact on local air pollution.- The project will have no impact on water pollution.- The N₂O abatement catalyst will be leased from an overseas supplier. The catalyst will be replaced from time to time and the spent catalyst returned to the supplier for recycling or disposal in accordance with prevailing EU regulations. There will therefore be no generation of wastes in South Africa.- There are no other positive or negative impacts on the local environment quality. |
| Change in usage of natural resources | <ul style="list-style-type: none">- Impact of the project on community access to natural resources.- Impact of the project on the sustainability of use of water, minerals or other non-renewable natural resources.- Impact of the project on the efficiency of resource utilization. | <ul style="list-style-type: none">- The project will not require any additional resources.- The project does not impact on the community's access to natural resources.- The project does not require additional water and will therefore not impact on the sustainable use of water.- The project has no impact on the use of other non-renewable natural resources.- The project has no impact on the efficiency of resource utilization. |
| Impacts on biodiversity and ecosystems | <ul style="list-style-type: none">- Changes in local or regional biodiversity arising from the project | <ul style="list-style-type: none">- The project will have no negative impacts on local or regional biodiversity. |



| ECONOMIC | | |
|---------------------------------|--|--|
| CRITERIA | INDICATOR | PROJECT CONTRIBUTION TO SUSTAINABLE DEVELOPMENT |
| Economic impacts | <p>Impact of the project on:</p> <ul style="list-style-type: none">- Foreign exchange requirements.- Existing economic activity in the area.- Cost of energy.- Foreign direct investment. | <ul style="list-style-type: none">- Through the sale of CERs to buyers in Annex 1 countries such as the European Union, Japan and Canada the project will make positive contributions to foreign exchange reserves and to foreign direct investment.- Expected income from selling CERs will, after covering the project costs, add to the profitability of AEL's nitrates business. This will strengthen AEL's international competitive position in its markets. As a result, the project is likely to have a long term positive impact on existing economic activity in the area. The project will have the effect of making long term jobs more secure for all AEL employees.- Production of N₂O abatement catalyst in South Africa at a later stage might be possible, although the amount of catalyst used is small and such a project may not be economically viable.- The cost of energy will not be impacted in any way by the project. |
| Appropriate technology transfer | <ul style="list-style-type: none">- Positive or negative implications for the transfer of technology to South Africa arising from the project.- Impacts of the project on local skills development.- Demonstration and replication potential of the project. | <ul style="list-style-type: none">- This project will strengthen the overall competitive position of the nitric acid plant through the introduction of advanced instrumentation, measurement technology and procedures.- The project will lead to some enhancement of skills of AEL employees on the nitric acid plants, for example advanced emissions monitoring systems.- The project will act as a stimulant to other companies in South Africa which are considering implementing CDM projects. |



| SOCIAL | | |
|---|--|---|
| CRITERIA | INDICATOR | PROJECT CONTRIBUTION TO SUSTAINABLE DEVELOPMENT |
| Alignment with national, provincial and local development priorities. | <ul style="list-style-type: none"> - How the project is aligned with provincial and national government objectives. - How the project is aligned with local developmental objectives. - Impact of the project on the provision of, or access to, basic services to the area. - Impact of the project on the relocation of communities if applicable. - Contribution of the project to any specific sectoral objectives, for example, renewable energy targets. | <ul style="list-style-type: none"> - South Africa is a signatory to the Kyoto Protocol, and this project will contribute to international objectives towards the reducing of global greenhouse gas emissions. - As described above the project will contribute to sustaining economic activity in the area. - The project does not impact on the local provision, or access to, services in the area. - The project has no impact on the relocation of communities. - The project makes no significant contribution to sectoral objectives. |
| Social equity and poverty alleviation. | <ul style="list-style-type: none"> - Impact of the project on employment levels, number of jobs created or lost, duration of time employed, distribution of employment opportunities, categories of employment changes in terms of skill levels and gender and racial equity. - Impact of the project on community social structures. - Impact of the project on social heritage. - Impact of the project on the provision of social amenities to the community in which the project is situated. - Contribution of the project to the development of previously underdeveloped areas or specially designated de- | <ul style="list-style-type: none"> - The catalyst will be installed and replaced with local labour, which will create a small number of intermittent jobs. - Local companies will probably be employed to carry out the annual monitoring and verification of the emission reductions. This will create a small number of jobs over the entire crediting period of ten years. - In general the project has no significant direct impact on community social structures, social heritage, social amenities, or development of previously undeveloped areas. - A portion of additional profits in AEL arising from this N₂O abatement project will be passed on to local communities through the partnership arrangements which exist between AECI and Tiso in terms of the Tiso-AEL Development Trust. The focus is on deploying income from Tiso's investment in AEL to the benefit of local communities, principally in Alexandra and Tembisa, which are nearby to Modderfontein. - Furthermore AEL will spend a portion of the profit |



| | | |
|--|------------------|---|
| | velopment nodes. | <p>generated by the project on an experiential environmental education project aimed at local school-children. The details of this are being worked out in consultation with local communities and external organisations with experience in such projects.</p> <p>- Through the proposed Environmental Education Project the project will benefit community social structures and social amenities, and several permanent local jobs will be created. The project will also enhance the environmental social heritage.</p> |
|--|------------------|---|

GENERAL

| CRITERIA | INDICATOR | PROJECT CONTRIBUTION TO SUSTAINABLE DEVELOPMENT |
|-------------------------------|--|--|
| General Project acceptability | - Is the distribution of project benefits reasonable and fair? | <p>- The project is balanced and fair.</p> <p>- It will contribute to the sustainable development objectives of South Africa in accordance with the National Environmental Management Act No. 107 of 1998.</p> |