



**Project design document form for
CDM project activities
(Version 05.0)**

Complete this form in accordance with the Attachment "Instructions for filling out the project design document form for CDM project activities" at the end of this form.

PROJECT DESIGN DOCUMENT (PDD)

Title of the project activity	PROJECT FOR THE CATALYTIC REDUCTION OF N ₂ O EMISSIONS WITH A SECONDARY CATALYST INSIDE THE AMMONIA REACTOR OF THE NO. 9 NITRIC ACID PLANT AT AFRICAN EXPLOSIVES LTD ("AEL"), SOUTH AFRICA
Version number of the PDD	3.0
Completion date of the PDD	01/07/2014
Project participant(s)	- African Explosives Ltd - N.serve Environmental Services GmbH
Host Party	South Africa
Sectoral scope and selected methodology(ies), and where applicable, selected standardized baseline(s)	- Sectoral scope: Chemical industries (5) - AM0034 (Version 2)
Estimated amount of annual average GHG emission reductions	117,419 tCO ₂ e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

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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. 9 Plant") at Modderfontein, South Africa. The No. 9 nitric acid plant was designed by Chemico and commissioned in 1968, it is a single burner high pressure plant operated at 9.0 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.

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 AECL 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 schoolchildren. 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. At AEL, the project implementation at the Nr. 9 plant also is a test for the installation of a secondary N₂O abatement catalyst at its larger Nr. 11 plant. Compared to tertiary catalyst technology, which requires additional natural gas for its operation, the implementation of secondary

¹ IPCC Second Assessment Report (1995)

catalyst technology also indirectly contributes to the South African Government's Energy Efficiency Strategy².

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 validated³.

The baseline scenario is the same as the scenario existing prior to the implementation of the project activity.

A.2. Location of project activity

A.2.1. Host Party

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South Africa

A.2.2. Region/State/Province etc.

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Gauteng / Modderfontein

A.2.3. City/Town/Community etc.

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City of Johannesburg

A.2.4. Physical/Geographical location

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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 smaller of the two nitric acid plants – named No. 9 – operated at this location. The exact longitude and latitude of the plant's location is 26° 5' 26" South and 28° 10' 17" East

A regional map shows the location of Modderfontein near Johannesburg

² See <http://www.dme.gov.za/energy/efficiency.stm>



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



No. 9 Nitric Acid Plant

No. 11 Nitric Acid Plant

A.3. Technologies and/or measures

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Currently, AEL operates its No. 9 plant without any N_2O abatement devices. The project proponents expect this practice to be continued, because there is neither a regulatory maximum limit for N_2O emissions from nitric acid production nor any incentive for voluntarily reducing such emissions (besides the CDM) that would apply to the plant. On the other hand, N_2O abatement technology requires considerable investment and its implementation into an existing plant is not totally risk free as it may negatively affect production output if done wrongly. Hence, the baseline

scenario is the same as the scenario existing prior to the start of the implementation of the project activity.

The main parts of the current plant are the ammonia burner in which the ammonia oxidation reaction takes place, the absorption tower where the gas mix from the burner is led through water in order to form nitric acid and the stack through which the off-gasses are vented into the atmosphere.

The project activity entails a technology transfer of:

- State-of-the-art N₂O abatement technology that will be inserted into the ammonia oxidation reactor after slight modifications to its interior structure;
- Specialized monitoring equipment to be installed at the stack (detailed information on the AMS is contained in the monitoring section of this PDD)

Catalyst Technology

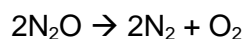
In the production process of nitric acid (HNO₃), NO₂ is produced as an intermediate material from ammonia (NH₃). The associated chemical reactions of oxidizing ammonia and simultaneous unwanted reactions are as follows:

1. $\text{NH}_3 + 2 \text{O}_2 \rightarrow \text{HNO}_3 + \text{H}_2\text{O}$ (overall desirable reaction)
2. $4 \text{NH}_3 + 5 \text{O}_2 \rightarrow 4 \text{NO} + 6 \text{H}_2\text{O}$ (desirable in the NH₃ oxidization process)
3. $2\text{NO} + \text{O}_2 \rightarrow 2 \text{NO}_2$ (desirable in the NO oxidization process)
4. $3 \text{NO}_2 + \text{H}_2\text{O} \rightarrow 2 \text{HNO}_3 + \text{NO}$ (desirable in the NO₂ absorption process)
5. $4 \text{NH}_3 + 3 \text{O}_2 \rightarrow 2 \text{N}_2 + 6 \text{H}_2\text{O}$ (undesirable)
6. $4 \text{NH}_3 + 4 \text{O}_2 \rightarrow 2 \text{N}_2\text{O} + 6 \text{H}_2\text{O}$ (undesirable)
7. $2 \text{NH}_3 + 8 \text{NO} \rightarrow 5 \text{N}_2\text{O} + 3 \text{H}_2\text{O}$ (undesirable)

Through the sixth and seventh reactions, some amount of N₂O is generated in the process.

AEL will install a catalyst system consisting of an additional base metal catalyst that is installed below the standard precious metal gauze pack. This technology will be implemented inside the ammonia burner.

A secondary catalyst will reduce N₂O levels in the gas mix resulting from the primary ammonia oxidation reaction. The secondary catalyst has been tried and tested in a number of nitric acid plants in Europe and is used in many JI and CDM projects. The abatement efficiency has been shown to be more than 80% in the following reaction:



If operated properly, the secondary catalyst system has a lifetime of several campaigns and may achieve satisfactory N₂O emissions reduction levels for three years or more, before the catalyst material needs to be replaced.

The secondary abatement catalyst does not contaminate the nitric acid produced in the respective nitric acid plant, neither with Cobalt nor with any of the other catalyst materials.

It does not require additional heat or other energy input, because the temperature levels present inside the Ammonia Oxidation Reactor suffice to ensure its optimum abatement efficiency. There are no additional greenhouse gases or other emissions generated by the reactions at the secondary N₂O abatement catalyst. Hence, the only gas to be included as project emissions is the N₂O that is not destroyed and is still present in the tail gas stream of the plant.

Basket modifications

Most nitric acid plants have some sort of basket structure that gives structural support to the precious metal gauzes. The ammonia oxidation reaction in a nitric acid plant operates at high temperatures, which causes basket assembly to expand compared to when the plant is not operational (i.e. during installation of the catalyst).

To counter this occurrence, the basket which supports the gauze pack will have to be modified. The design of the modification is yet to be finalized.

N₂O abatement catalyst installation

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

The N₂O abatement catalyst is supplied on a lease basis which requires the company to take back the catalyst at the end of its useful life and refine, recycle or dispose of it according to EU regulations, hence fulfilling sustainability standards.

Technology transfer and safety issues

As mentioned before, the secondary abatement technology has been tested in several industrial trials and has proven to provide a reliable and environmentally safe way for reducing N₂O. AEL will ensure that the chosen N₂O abatement catalyst vendor will take back the catalyst at the end of its useful life in order to refine, recycle or to otherwise dispose of the catalyst material according to the then prevailing EU regulations.

Once installed, the catalyst and the AMS will be operated, maintained and supervised by AEL employees according to European industry standards. The AEL workers will be trained to reliably oversee 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. Adherence to these standards will be ensured by thorough training sessions for the AEL employees involved.

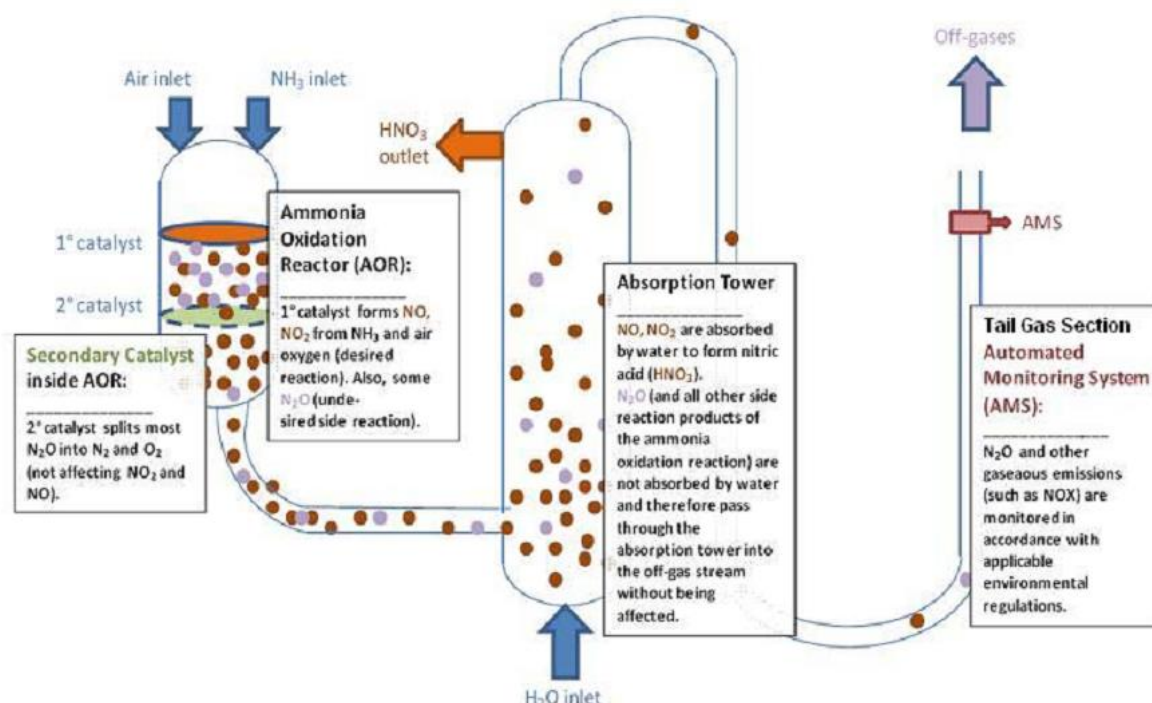


Figure: Image flow of secondary catalyst unit

A.4. Parties and project participants

Party involved (host) indicates host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
South Africa (host)	African Explosives Ltd ("AEL")	No
United Kingdom of Great Britain and Northern Ireland	N.serve Environmental Services GmbH ("N.serve")	No
Switzerland	N.serve Environmental Services GmbH African Explosives Ltd	No

A.5. Public funding of project activity

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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 selected approved baseline and monitoring methodology and standardized baseline**B.1. Reference of methodology and standardized baseline**

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

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

B.2. Applicability of methodology and standardized baseline

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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 106,621 metric tonnes of 100% concentrated nitric acid per year (based on 365⁴ operating days per year and a daily nameplate capacity of 292.2 t/d tonnes of nitric acid)
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.

⁴ As per AM0034 page 11.

6. The project activity will not increase NO_x emissions.
7. There is no NSCR DeNO_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 have been installed in the appropriate location as per the methodology. The AMS has been continuously operated since January 2006 (with a replacement of the flow meter in June 2006 just before the baseline campaign started) 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. Project boundary

The spatial extent of the project boundary encompasses the facility and equipment for the nitric acid production process from the inlet of the ammonia burner to the outlet of the tail gas section.

As the project activity introduces secondary abatement, the only gas to be included as project emissions is the N₂O that is not destroyed and is still present in the tail gas stream of the plant.

The greenhouse gases included in or excluded from the project boundary are shown in the below table:

Source		GHGs	Included?	Justification/Explanation
Baseline scenario	Source 1	CO ₂	No	The process does not lead to any CO ₂ emissions.
		CH ₄	No	The process does not lead to any CH ₄ emissions.
		N ₂ O	Yes	
		...		
	Source 2	CO ₂		
		CH ₄		
		N ₂ O		
		...		
		
		...		
		...		
		...		
Project scenario	Source 1	CO ₂	No	The process does not lead to any CO ₂ emissions.
		CH ₄	No	The process does not lead to any CH ₄ emissions.
		N ₂ O	Yes	
		...		
	Source 2	CO ₂		
		CH ₄		
		N ₂ O		
		...		
		
		...		
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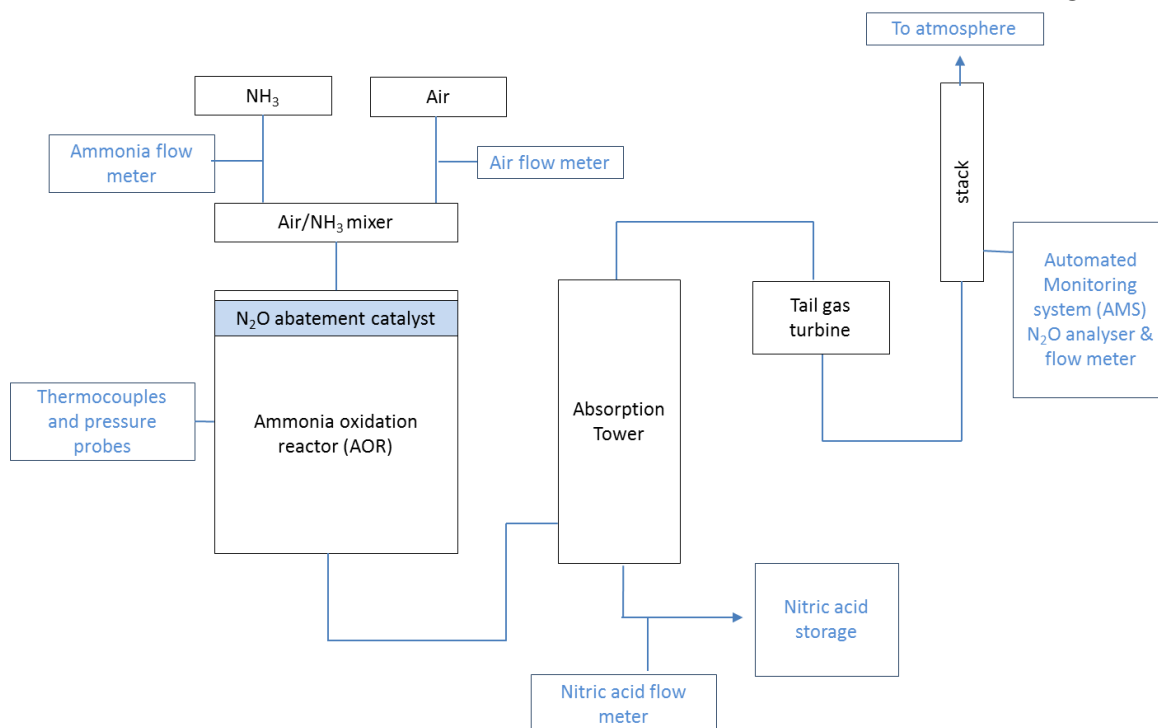


Figure: Flow chart for the project activity

B.4. Establishment and description of baseline scenario

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The approved baseline methodology AM0034 requires the application of the procedures for baseline scenario identification as per AM0028 (in its most recent version). The following steps are taken from this methodology, 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 alternative (step 1), those that would not comply with applicable legal standards are eliminated (step2). After conducting a barrier analysis (step 3a) the most likely “business as usual” scenario is assessed. This is the assumed baseline scenario.

As step 1 of the baseline scenario identification process will substitute the first step of the Additionality assessment (see B.5 below), the new features of 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: 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. 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.

The baseline scenario alternatives should include all possible options that are technically feasible to handle N₂O emissions. All scenarios that deliver outputs of comparable quality, properties and application area are to be taken into account. Because the nitric acid production process as such remains unaffected – there are no changes in the quantity or quality of the nitric acid produced – regardless of what technology is installed in order to decrease the plant’s GHG emissions, all direct or indirect N₂O-abatement options are to be considered.

For the AEL 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 -unit⁵
- 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 (proposed project activity)

These options should also include the CDM project activity not implemented as CDM project. This scenario alternative is included in 5 b) above. 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. It was applied for industrial production in Norway between 1902 and 1930. This method did not prevail as it entails significant production costs, especially from the use of large amounts of electricity.

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

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

The use of N₂O as a feedstock for the production of nitric acid is technically not feasible as it is not possible to produce nitric acid from N₂O.

The use of N₂O as a feedstock for the AEL No. 9 plant is technically not practicable as it is not possible to produce nitric acid from N₂O. The recovery of N₂O for the sake of gaining feedstock for the production process is not practiced in any known nitric acid plant.

The use of N₂O for external purposes is economically not viable as the quantity of gas to be filtered would be enormous compared to the amount of nitrous oxide that could be recovered. The N₂O concentration in the tail gas of AEL's No. 9 plant is currently around 923 ppmv.

The installation of a Non-Selective Catalytic Reduction (NSCR) De NO_x unit is not economically viable since AEL is already in compliance with the prevailing NO_x regulations. In any case, NSCR is an outdated technology which requires additional natural gas to achieve sufficient tail gas temperatures and/or the right reducing environment inside the catalyst. This would lead to much higher operational costs than a standard SCR unit.

Therefore, the baseline alternatives 2), 3) a) and b) as well as 4) 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.

⁵ 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.

Neither of AEL's nitric acid plants has NO_x abatement systems installed. AEL uses cooling water for heat removal in the NO₂ absorption process.

Currently, the NO_x emissions statutory limit for AEL's Number 9 nitric acid plants is 400 ppmv, and the average NO_x emission for this plant is 265 ppmv. AEL's nitric acid plants both have an atmospheric emissions certificate issued under the Atmospheric Pollution Prevention Act, Act No. 45 of 1965⁶.

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 N₂O 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.

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)

The installation of a Non-Selective Catalytic Reduction (NSCR) De NO_x unit is not economically viable since AEL is already in compliance with the prevailing NO_x regulations. 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) DeNO_x unit. NSCR units normally 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. Therefore, baseline scenario alternative 3) faces significant investment barriers.

None of the N₂O destruction technology options (including NSCR) are expected to generate any financial or economic benefits 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.

Therefore, any baseline scenario alternatives that include the implementation of N₂O abatement catalysts will entail considerable 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.

⁶ 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.

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).

Barriers due to prevailing practice

The installation of N₂O abatement technology currently is neither industrial practice in South Africa nor anywhere else in Sub Saharan Africa. However, currently all nitric acid producers in the region are pursuing the implementation of secondary or tertiary 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 this 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. Demonstration of additionality

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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). In the discussion above the new features of the Additionality Tool’s latest version were accounted for.

Step 2: Investment Analysis

To establish additionality, the Additionality Tool requires an investment analysis, focussing on the comparison of the proposed project activity with the identified baseline scenario.

Step 2a: Choice of the appropriate investment evaluation methodology

As demonstrated above (B.4.), neither the project activity nor the identified baseline scenario generates any additional financial or economic benefits besides those obtainable from the sale of CERs. This implies the applicability of a simple cost analysis (Option I of the Additionality Tool). 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 verifications⁷.

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.

Outcome of step 2: Continue with common practice analysis

As the proposed project activity is unlikely to be financially more attractive than the identified baseline scenario alternative, the Additionality Tool requires to conduct a common practice analysis (step 4) and thus to neglect step 3.

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.

Sub-step 4a: Analyse other activities similar to the proposed project activity

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. According to the Additionality Tool, other CDM project activities are not to be taken into account.

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

Sub-step 4b: Discuss any similar options that are occurring

Because there are no similar activities to the proposed project activity that take place in the region apart from other CDM activities (which are to be neglected), this step does not provide any additional content.

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

B.6. Emission reductions

B.6.1. Explanation of methodological choices

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⁷ More detailed, confidential information on investment and operation costs can be disclosed to the DOE and the CDM EB upon request

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. 9 nitric acid plant were used to derive these normal ranges⁸. 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). After removing the top 2.5 percentile values the maximum daily flow rate was derived which was then converted into an hourly Ammonia flow rate Nm³/hr, which was used to determine AIFR.

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:

- Calculate the sample mean (x)
- Calculate the sample standard deviation (s)
- Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)

⁸ See AM0034: Baseline Emissions, 1.i.b)

- 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 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”).

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} .

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 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 OTh, OPh, 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, N₂O 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 reduction s (EF_p). Thus:

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

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

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 a EF_n that is lower than EF_{min} , the calculation of the emission reductions for that particular campaign shall use EF_{min} and not EF_n .

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 106,621 metric tonnes of 100% concentrated nitric acid per year (based on 365⁹ operating days per year and a daily nameplate capacity of 292.1 t/d tonnes of nitric acid). Therefore, the No. 9 nitric acid plant shall not be eligible to earn CERs for any tonnes of nitric acid produced exceeding 106,621 in any one year.

It shall be noted however, that the “design” or “nameplate” capacity is the capacity figure that is guaranteed by the plant constructor, which is therefore conservative in nature, allowing for some safety margin for the guarantee. Back in 1968 the guaranteed nameplate capacity was given as 300 short tons, which converts to 272.2 metric tonnes. Immediately after commissioning, the constructor tested the plant and determined that the actual capacity of the plant is approximately 322 short tons¹⁰, which converts to 292.1 metric tonnes. This is approximately the average daily production that the plant has been performing in an average campaign for many years. Therefore, this value should be used to derive the maximum annual nitric acid production output (NAP) for which CERs may be earned.

⁹ As per AM0034 page 11.

¹⁰ Commissioning Report from Chemico, the plant constructor. Available onsite at AEL for inspection.

B.6.2. Data and parameters fixed ex ante

(Copy this table for each piece of data and parameter.)

Data / Parameter	B.1 / NCSG_{BC}
Unit	mgN ₂ O/Nm ³
Description	N ₂ O concentration in the stack gas during the baseline campaign.
Source of data	NDIR N ₂ O gas analyser (Environnement S.A. MIR 9000)
Value(s) applied	1,814
Choice of data or Measurement methods and procedures	<p>AM0034 requires the determination of the concentration of N₂O in the stack gas. NCSG is continuously monitored with an NDIR gas analyser¹¹ 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:</p> <ul style="list-style-type: none"> a) Calculate the sample mean (x) b) Calculate the sample standard deviation (s) c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation) d) Eliminate all data that lie outside the 95% confidence interval e) Calculate the new sample mean from the remaining NCSG values
Purpose of data	Calculation of baseline emissions
Additional comment	<p>The Environnement S.A. MIR 9000 gas analyser was found to be too inaccurate to be used for the determination of a baseline. Therefore, the NCSG data collected so far will be used as an indication for the baseline emissions. In May 2007 a new analyser will be installed and the baseline campaign will be repeated subsequently from which the actual NCSG values will be derived in accordance with AM0034. EF_{BL} shall then be checked and approved by the verifying DOE and not the validating DOE. A complete QAL2 audit in accordance with EN 14181 will be conducted on the AMS, once the new analyser has been installed.</p>

¹¹ The Environnement S.A. MIR 9000 gas analyser has been certified according to ISO 14956, QAL 1 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. 9 plant, no analyser was available on the market that had already passed the QAL 1 suitability certification for N₂O.

Data / Parameter	B.2 VSG_{BC}
Unit	Nm ³ /h
Description	Normal gas volume flow rate of the stack gas during the baseline campaign
Source of data	Gas Volume Flow meter, Emerson Rosemount Annubar® Model 485
Value(s) applied	43,194.0
Choice of data or Measurement methods and procedures	<p>AM0034 requires the determination of the gas volume flow (VSG) in the stack. VSG is continuously monitored with a flow meter and monitoring results are taken and recorded for every two seconds of plant operation. Hourly means for VSG are derived by the SCADA data acquisition system. VSG data taken during times when the plant was operating outside the permitted operating range were eliminated.</p> <p>The remaining VSG data series will have to be subjected to the following adjustment.</p> <p>When the flow meter was originally installed it was ranged to a maximum flow of 97,292 m³/h (corresponding to actual m³) and a maximum differential pressure of 3.1768 kPa (gauge). However, the flow meter should have been ranged to a maximum flow of 45,000 m³/h (corresponding to normal m³ at a stack temperature of 165°C and stack pressure of 85.6 kPa (absolute) or 856 mbar) and a maximum differential pressure of 2.414 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 0.5306 in order to give the normal flow for the above assumed conditions.</p> <p>Also, the corrected measured data need to be compensated for the actual prevailing temperature and pressure in the stack through the following calculation:</p> $\frac{P_s * V_s}{T_s} = \frac{P_a * V_a}{T_a}$ <p>Where: P refers to the Pressure (mBar) [conversion from kPa to mbar is a factor of 10] V the volumetric flow rate (m³/hr) T the temperature in Kelvin (Note 1 K = T(°C) + 273). Subscript "s" refers to the actual stack values Subscript "a" refers to the assumed stack conditions.</p> <p>This simplifies to:</p> $V_s = V_a * \frac{P_a}{T_a} * \frac{T_s}{P_s}$ <p>As an example</p> <p>The assumed stack temperature and pressure values are 165°C and 856 mbar. The measured values are: 164.497 °C and 858.507 mbar. Using a flow from the acquisition system of 81 697.563 and the conversion of 0.5306 gives a final flow of 43 172.5 Nm³/hr.</p>

	$81697.563 * 0.5306 * \frac{856 * (164.497 + 273)}{(273 + 165) * 858.507} = 43172.5$ <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: 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 e) Calculate the new sample mean from the remaining VSG values</p>
Purpose of data	Calculation of baseline emissions
Additional comment	None

Data / Parameter	B.3 BE_{BC}
Unit	tN ₂ O
Description	Total N ₂ O gas flow for baseline campaign
Source of data	Calculation from measured data.
Value(s) applied	145.7
Choice of data or Measurement methods and procedures	<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> $BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC}$
Purpose of data	Calculation of baseline emissions
Additional comment	None

Data / Parameter	B.4 OH_{BC}
Unit	hours
Description	Operating hours
Source of data	Process Control System.
Value(s) applied	1859
Choice of data or Measurement methods and procedures	<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 800°C and 915°C, by definition the plant is offline if the temperature recorded is at or below 800°C. For practical purposes, each hour for which the ammonia oxidation temperature (OTh) was recorded to be below 810°C is excluded from the determination of OH_{BC}.</p>
Purpose of data	Calculation of baseline emissions
Additional comment	None

Data / Parameter	B.5 NAP_{BC}
Unit	tHNO ₃
Description	Metric tonnes of 100% concentrated nitric acid produced during the baseline campaign.
Source of data	Mass balance calculation and coriolis flow measurements at the No. 9 plant.
Value(s) applied	23,168.2
Choice of data or Measurement methods and procedures	<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 in the following way:</p> <p>1. Mass Balance calculation for both plants combined</p> <p>Both of AEL's nitric acid plants feed into one single storage tank. 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 are delivered to consumers outside of AEL. A pipeline delivers nitric acid to external consumers based on the same site as the No. 9 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 Calculated Production. Because both of AEL's nitric acid plants on site (No. 9 and No. 11) produce into the same storage tank, the Calculated Production is a combined result for both plants.</p> <p>2. Apportionment to No. 9 and No. 11</p> <p>Each of the two plants has a coriolis flow meter installed at the nitric acid product outlet before it goes into the production storage tank to determine the mass of nitric acid produced from each plant. However, these coriolis flow meters are experiencing a drift which makes their measurements less accurate. Therefore, AEL uses the calculated values for its financial planning and reporting and uses the flow meter results only for plausibility checks.</p> <p>Nevertheless, the coriolis flow meter results are a useful tool to apportion the Calculated Production resulting from the mass balance calculation to each of the two nitric acid plants by determining the ratio of production resulting from the two coriolis flow meters and applying that to the Calculated Production.</p>

	<p><u>NAP \neq CL_{BL}</u></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 this “test baseline” of AEL No. 9, the 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>
Purpose of data	Calculation of baseline emissions
Additional comment	None

Data / Parameter	B.6 TSG
Unit	°C
Description	Temperature in the stack gas
Source of data	Stack temperature probe situated next to the volume flow meter.
Value(s) applied	Not applicable
Choice of data or Measurement methods and procedures	AM0034 requires the determination of gas volume flow at normal conditions in the stack. In order to calculate from the measured VSG values to VSG at normal conditions, the actual temperature in the stack is measured by temperature probes inserted directly next to the flow meter inside the stack. The resulting measurements are applied to each hourly mean VSG value for calculation of normal volume flow.
Purpose of data	Calculation of baseline emissions
Additional comment	None

Data / Parameter	B.7 PSG
Unit	mbar (absolute)
Description	Pressure in the stack
Source of data	Stack pressure probe situated directly next to the volume flow meter.
Value(s) applied	Not applicable
Choice of data or Measurement methods and procedures	AM0034 requires the determination of gas volume flow at normal conditions in the stack. In order to calculate from the measured VSG values to VSG at normal conditions, the actual pressure in the stack has to be determined and applied to each hourly mean VSG value.
Purpose of data	Calculation of baseline emissions
Additional comment	None

Data / Parameter	B.8 EF_{BL}
Unit	tN ₂ O / tHNO ₃
Description	Emissions factor for baseline period
Source of data	Calculated from measured data (tons of nitric acid produced / tons of N ₂ O emitted)
Value(s) applied	0.00601
Choice of data or Measurement methods and procedures	As required by AM0034 the plant specific baseline emissions factor representing the average N ₂ O emissions per tonne of nitric acid during the baseline campaign is derived by dividing the total mass of N ₂ O emissions by the total output of 100% concentrated nitric acid during the baseline campaign. The overall uncertainty of the monitoring system shall also be determined and the measurement error will be expressed as a percentage (<i>UNC</i>). The N ₂ O emission factor per tonne of nitric acid produced in the baseline period (EF _{BL}) shall then be reduced by the percentage uncertainty as follows: $EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100) (tN_2O/tHNO_3)$
Purpose of data	Calculation of baseline emissions
Additional comment	None

Data / Parameter	B.9 UNC
Unit	%
Description	Calculated uncertainty of the overall Automated Monitoring System (AMS)
Source of data	Engineering reports and calculations conducted by the manufacturer of the components of the AMS.
Value(s) applied	4.40
Choice of data or Measurement methods and procedures	In accordance with AM0034 the overall measurement uncertainty of the AMS is applied in the calculation of the baseline emissions factor (EF _{BL}). No uncertainty data was available from the analyser vendor. Therefore, Calibration data from the analyser vendor was used to calculate the expected uncertainty. 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.
Purpose of data	Calculation of baseline emissions
Additional comment	The applicable uncertainty value for the AMS will only be established as a result of the QAL2 audit to be conducted after the new analyser has been installed, i.e. after May 2007.

Data / Parameter	B.10 AFR
Unit	tNH ₃ /h
Description	Mean Ammonia gas flow rate to the ammonia oxidation reactor
Source of data	Orifice plate
Value(s) applied	Not applicable, monitored data of AFR will be used to determine if plant was operating outside of AFR _{max} .
Choice of data or Measurement methods and procedures	The monitoring of AFR is required by AM0034 in order to determine AFR _{max} .
Purpose of data	Calculation of baseline emissions
Additional comment	None

Data / Parameter	B.11 AFR _{max}																																			
Unit	tNH ₃ /h																																			
Description	Maximum Ammonia gas flow rate to the ammonia oxidation reactor																																			
Source of data	AFR data																																			
Value(s) applied	3,877																																			
Choice of data or Measurement methods and procedures	<p>AFR_{max} is used to determine those periods where the plant may be operating outside of the permitted operating conditions.</p> <p>Historic data of daily NH₃ consumption was used to obtain determine the range of AFR for the five historic campaigns.</p> <p>Table: Maximum NH₃ gas flow to the AOR</p> <table><tr><th>Campaign No.</th><th>Start Date</th><th>End date</th><th>Total NH₃ consumed</th><th>Maximum NH₃ consumed per day</th></tr><tr><td></td><td></td><td></td><td>tonnes</td><td>tonnes</td></tr><tr><td>H6</td><td>4-Jun-04</td><td>16-Sep-04</td><td>7448.377</td><td>93.131</td></tr><tr><td>H7</td><td>24-Sep-04</td><td>27-Dec-04</td><td>7372.149</td><td>89.508</td></tr><tr><td>H8</td><td>14-Mar-04</td><td>21-Jun-05</td><td>7828.5427</td><td>92.187</td></tr><tr><td>H9</td><td>23-Sep-05</td><td>20-Dec-05</td><td>6838.168</td><td>90.425</td></tr><tr><td>H10</td><td>17-Feb-06</td><td>20-Jul-06</td><td>6907.924</td><td>91.204</td></tr></table> <p>After removing the top 2.5 percentile values the maximum daily flow rate was 93.037 tons. This corresponds to an hourly flow rate of 3,877kg/hr or 5,110Nm³/hr. The ammonia flow in Nm³/hr is used in the ratio calculation.</p>	Campaign No.	Start Date	End date	Total NH ₃ consumed	Maximum NH ₃ consumed per day				tonnes	tonnes	H6	4-Jun-04	16-Sep-04	7448.377	93.131	H7	24-Sep-04	27-Dec-04	7372.149	89.508	H8	14-Mar-04	21-Jun-05	7828.5427	92.187	H9	23-Sep-05	20-Dec-05	6838.168	90.425	H10	17-Feb-06	20-Jul-06	6907.924	91.204
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H9	23-Sep-05	20-Dec-05	6838.168	90.425																																
H10	17-Feb-06	20-Jul-06	6907.924	91.204																																
Purpose of data	Calculation of baseline emissions																																			
Additional comment	None																																			

Data / Parameter	B.12 AIFR
Unit	% v/v
Description	Mean Ammonia to air ratio into the ammonia oxidation reactor
Source of data	Measurements of AFR and primary air flow rates (measured by orifice plate).
Value(s) applied	8.4 to 11.5 (AIFR will be used to determine AIFR _{max}).
Choice of data or Measurement methods and procedures	The monitoring of AIFR is required by AM0034 in order to determine AIFR _{max} . The allowable NH ₃ to Air ratio is taken from the controller data sheet (No. 9 Ratio Controller, August 1997). The range is 8.4 % v/v - 11.5 % v/v.
Purpose of data	Calculation of baseline emissions
Additional comment	None

Data / Parameter	B.15 AIFR_{max}
Unit	% v/v
Description	Maximum Ammonia to air ratio into the ammonia oxidation reactor.
Source of data	Plant operating manual
Value(s) applied	11.5
Choice of data or Measurement methods and procedures	<p>In accordance with AM0034 AIFR_{max} is used to determine those periods where the plant may be operating outside of the permitted operating conditions.</p> <p>The upper limits for ammonia flow and ammonia to air ratio shall be determined using one of the following three options, in preferential order:</p> <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 9 Ratio Controller, August 1997). The range is 8.4 % v/v - 11.5 % v/v, therefore the maximum ammonia to air ratio is 11.5%.</p>
Purpose of data	Calculation of baseline emissions
Additional comment	None

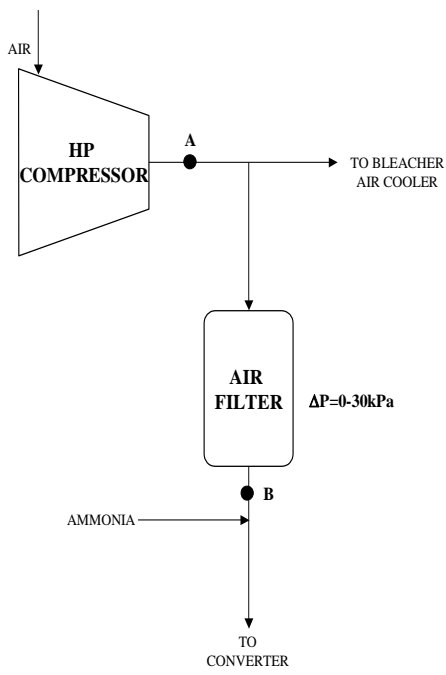
Data / Parameter	B.13 CL_{BL}
Unit	tHNO ₃
Description	Length of the baseline campaign measured in metric tonnes of 100% concentrated nitric acid produced during that baseline campaign.
Source of data	NAP _{BC}
Value(s) applied	24,055.6
Choice of data or Measurement methods and procedures	<p>In accordance with AM0034 the baseline campaign length (CL_{BL}) has to be compared to the established average historic campaign length (CL_{normal}); 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>
Purpose of data	Calculation of baseline emissions
Additional comment	None

Data / Parameter	B.14 CL _{normal}																												
Unit	tHNO ₃																												
Description	Average length of the historic campaigns measured in metric tonnes of 100% concentrated nitric acid produced during that baseline campaign.																												
Source of data	Mass Balance calculations and flow meter measurements as described in NAP.																												
Value(s) applied	23,337.0																												
Choice of data or Measurement methods and procedures	<p>In accordance with AM0034 the average historic campaign length (CL_{normal}) is defined as the average campaign length for the historic campaigns that were used to define operating condition. CL_{normal} presents the cap on the length of the baseline campaign from which the baseline emissions factor will be derived.</p> <p>During the five historic campaigns, the following amounts of metric tonnes of 100% concentrated nitric acid have been produced:</p> <table><tr><th>Campaign</th><th>Start</th><th>End</th><th>Production (tHNO3)</th></tr><tr><td>H6</td><td>04-Jun-04</td><td>16-Sep-04</td><td>23,753.0</td></tr><tr><td>H7</td><td>24-Sep-04</td><td>27-Dec-04</td><td>23,909.2</td></tr><tr><td>H8</td><td>14-Mar-04</td><td>21-Jun-05</td><td>25,849.4</td></tr><tr><td>H9</td><td>23-Sep-05</td><td>20-Dec-05</td><td>22,986.9</td></tr><tr><td>H10</td><td>17-Feb-06</td><td>20-Jul-06</td><td>20,186.3</td></tr><tr><td>Mean</td><td></td><td></td><td>23,337.0</td></tr></table> <p>Therefore, the average historic campaign length (CL_{normal}) is 23,337.0 tonnes of 100% concentrated nitric acid.</p>	Campaign	Start	End	Production (tHNO3)	H6	04-Jun-04	16-Sep-04	23,753.0	H7	24-Sep-04	27-Dec-04	23,909.2	H8	14-Mar-04	21-Jun-05	25,849.4	H9	23-Sep-05	20-Dec-05	22,986.9	H10	17-Feb-06	20-Jul-06	20,186.3	Mean			23,337.0
Campaign	Start	End	Production (tHNO3)																										
H6	04-Jun-04	16-Sep-04	23,753.0																										
H7	24-Sep-04	27-Dec-04	23,909.2																										
H8	14-Mar-04	21-Jun-05	25,849.4																										
H9	23-Sep-05	20-Dec-05	22,986.9																										
H10	17-Feb-06	20-Jul-06	20,186.3																										
Mean			23,337.0																										
Purpose of data	Calculation of baseline emissions																												
Additional comment	None.																												

Data / Parameter	B.16 OT_h
Unit	°C
Description	Oxidation temperature for each hour during the baseline campaign
Source of data	Monitoring results of a composite thermocouple inside the ammonia oxidation reactor and recorded by SCADA.
Value(s) applied	Not applicable
Choice of data or Measurement methods and procedures	<p>In accordance with AM0034 the oxidation temperature in the ammonia oxidation reactor (OT_h) has to be monitored and compared to the Normal range for oxidation temperature (OT_{normal}). 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>
Purpose of data	Calculation of baseline emissions
Additional comment	The uncertainty of the thermocouples in the converter is 1.0% according to the vendor. However, since the measurement uncertainty during the baseline campaign and during the project campaigns is the same, the two data series will always be comparable.

Data / Parameter	B.17 OT_{normal}
Unit	°C (min and max)
Description	Normal range operating temperature
Source of data	Design specifications and operating manual of the No. 9 nitric acid plant (Technical Manual (TM24 June 1977, p94) ¹² .
Value(s) applied	810°C (min.) and 915°C (max.)
Choice of data or Measurement methods and procedures	<p>AM0034 requires the establishment of the normal range of operating temperatures in the ammonia oxidation reactor. Since no historical data for the No. 9 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 810°C will be excluded.</p>
Purpose of data	Calculation of baseline emissions
Additional comment	None

¹² Technical plant manuals will be available for validation during site visit of the DOE .

Data / Parameter	B.18 OP_h
Unit	kPa (gauge)
Description	Oxidation Pressure for each hour
Source of data	Design specifications and operating manual of the No. 9 nitric acid plant (Technical Manual (TM24 June 1977, p94) ¹³ .
Value(s) applied	Not applicable.
Choice of data or Measurement methods and procedures	<p>In accordance with AM0034 the oxidation pressure in the ammonia oxidation reactor (OPh) has to be monitored and compared to the Normal range for oxidation temperature (OP_{normal}). VSG and NCSG data obtained during times when OPh was above or below OP_{normal} has to be eliminated from the calculation of EF_{BL}.</p> <p>AM0034 prescribes the monitoring and recording of the Oxidation Pressure for each hour (OPh) 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 OPh.</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. 9.</p>  <pre> graph TD AIR[AIR] --> COMP[HP COMPRESSOR] COMP --> A((A)) A --> COOL[TO BLEACHER AIR COOLER] A --> FILTER[AIR FILTER] FILTER --> B((B)) B --> CONV[TO CONVERTER] AMMONIA[AMMONIA] --> B FILTER -.-> DP["ΔP=0-30kPa"] </pre> <p>During the baseline campaign (as well as for project campaigns) OP is monitored as air pressure to the ammonia to air mixer. Unlike during historic campaigns, these data will be archived and analysed as required by AM0034.</p>
Purpose of data	Calculation of baseline emissions

¹³ Technical plant manuals will be available for validation during site visit of the DOE.

Additional comment	The uncertainty of the pressure sensor is 0.125% according to the vendor. However, since the measurement uncertainty during the baseline campaign and during the project campaigns is the same, the two data series will always be comparable.
---------------------------	--

Data / Parameter	B.19 OP_{normal}
Unit	kPa (gauge)
Description	Normal operating pressure of the ammonia oxidation reactor.
Source of data	Plant operating manual.
Value(s) applied	860kPa – 910kPa (gauge)
Choice of data or Measurement methods and procedures	<p>AM0034 requires the establishment of the normal range of operating pressure in the ammonia oxidation reactor. Since no historical data for the No. 9 plant are available, the range of temperature stipulated in the operating manual was applied to derive OP_{normal}.</p> <p>The pressure range for the HP compressor (see drawing for B.18 OPh above) as stated in the HP compressor design data sheet is 890 – 910 kPa (g). The pressure drop (ΔP) across the air filter ranges from 0 to 30 kPa (g) (AEL No. 9 logsheets¹⁴). Hence, the pressure range at point B is 860kPa - 910kPa (g). This range also falls within the range given in literature. For high-pressure processes, the pressure range suggested is 700 -1100 kPa (Ullmann's Encyclopedia of Industrial Chemistry, 6th Ed, Vol. 23, p3).</p>
Purpose of data	Calculation of baseline emissions
Additional comment	None

¹⁴ These are available on request from AEL/N.serve

Data / Parameter	B.20 GS_{normal}
Unit	Name of Supplier
Description	Gauze supplier for the operating condition campaigns
Source of data	Monitored / Invoices
Value(s) applied	W.C. Heraeus
Choice of data or Measurement methods and procedures	<p>AM0034 requires the monitoring of the supplier of the ammonia oxidation catalyst gauze. The recorded information is not further processed in the methodology but it is used as a plausibility check against the information for GC.</p> <p>AEL has been using ammonia oxidation catalyst gauzes ("FTCplus") supplied by Heraeus for the past several years, except for three campaigns (01. Jan to 15. Mar 05, 22. Jun to 18. Sep 05 and 23.12.05 to 15 Feb 06) where ammonia oxidation catalyst gauzes supplied by Johnson Matthey were used. The composition of the Johnson Matthey gauzes was different from the Heraeus FTCplus gauze normally used at the plant. The Heraeus FTCplus gauze contains significant levels of Palladium (approximately one third). The main motivation for this is that it leads to a weight reduction of the (more expensive) Platinum. A side effect of this gauze type is that the generation of N₂O in the ammonia oxidation process tends to be lower than with gauzes containing little or no Palladium.</p> <p>AEL has used FTCplus gauzes supplied by Heraeus during the baseline campaign and intends to continue using the same or very similar composition of gauzes for the foreseeable future. Therefore, it is more appropriate to use only those historic campaigns where this type of gauze was used for the determination of the permitted operating conditions.</p>
Purpose of data	Calculation of baseline emissions
Additional comment	None

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

Data / Parameter	B.23 GC_{normal}																																						
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	Monitored / Gauze supplier invoices																																						
Value(s) applied	Platinum (Pt) 59% Rhodium (Rh) 4% Palladium (Pd) 37%																																						
Choice of data or Measurement methods and procedures	<p>In accordance with AM0034, if the composition of the ammonia oxidation catalyst used for the baseline campaign and after the implementation of the project are identical to that used in the campaign for setting the operating conditions (previous five campaigns), then there shall be no limitations on N₂O baseline emissions.</p> <p>Record of Gauze compositions installed during the historic campaigns¹⁵:</p> <table border="1"> <thead> <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> </thead> <tbody> <tr> <td>H6</td><td>Heraeus</td><td>59</td><td>4</td><td>37</td></tr> <tr> <td>H7</td><td>Heraeus</td><td>59</td><td>4</td><td>37</td></tr> <tr> <td>H8</td><td>Heraeus</td><td>59</td><td>4</td><td>37</td></tr> <tr> <td>H9</td><td>Heraeus</td><td>59</td><td>4</td><td>37</td></tr> <tr> <td>H10</td><td>Heraeus</td><td>59</td><td>4</td><td>37</td></tr> <tr> <td colspan="2">Average</td><td>59</td><td>4</td><td>37</td></tr> </tbody> </table>	Campaign	Gauze Supplier	Gauze Composition			Pt (%)	Rh (%)	Pd (%)	H6	Heraeus	59	4	37	H7	Heraeus	59	4	37	H8	Heraeus	59	4	37	H9	Heraeus	59	4	37	H10	Heraeus	59	4	37	Average		59	4	37
Campaign	Gauze Supplier			Gauze Composition																																			
		Pt (%)	Rh (%)	Pd (%)																																			
H6	Heraeus	59	4	37																																			
H7	Heraeus	59	4	37																																			
H8	Heraeus	59	4	37																																			
H9	Heraeus	59	4	37																																			
H10	Heraeus	59	4	37																																			
Average		59	4	37																																			
Purpose of data	Calculation of baseline emissions																																						
Additional comment	None																																						

¹⁵ The figures shown here are rounded figures. More exact figures are commercially sensitive information but can be inspected by the DOE during the site visit and can be made available to the CDM EB upon request.

Data / Parameter	B.24 GC_{BL}
Unit	%
Description	Gauze composition during the baseline campaign expressed as percentage by weight of the precious metals Platinum, Rhodium and, if applicable, Palladium comprising the Ammonia Oxidation Catalyst gauzes.
Source of data	Monitored / Gauze supplier invoices
Value(s) applied	Platinum (Pt) 58% Rhodium (Rh) 4% Palladium (Pd) 38%
Choice of data or Measurement methods and procedures	<p>A change in the composition of the ammonia oxidation catalyst in the baseline campaign to a composition other than that used in the previous five campaigns, is permissible without any limitation on the N₂O baseline emissions if the following conditions are met</p> <p>(i) The baseline catalyst composition is considered as common practice in the industry, or</p> <p>(ii) The change in catalyst composition is justified by its availability, performance, relevant literature etc.</p> <p>Otherwise, the baseline emission factor shall be set to the conservative IPCC default emission factor for N₂O from nitric acid plants which have not installed N₂O destruction measures (4.5 kg-N₂O / t HNO₃).</p> <p>GC_{BL} at AEL's No. 9 nitric acid plant is the same as GC_{normal}, therefore, the results of the baseline campaign are fully valid and applicable.</p>
Purpose of data	Calculation of baseline emissions
Additional comment	None

B.6.3. Ex ante calculation of emission reductions

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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	<i>Short name of the project</i>
ProjOwner	Text	<i>Operator of the installation</i>
ProjLoc	Text	<i>Location of the installation (City)</i>
ProjCountry	Text	<i>Location of the installation (Country)</i>

Sample content of table Projects

Projects				
ProjId	ProjName	ProjOwner	ProjLoc	ProjCountry
1	No. 9	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

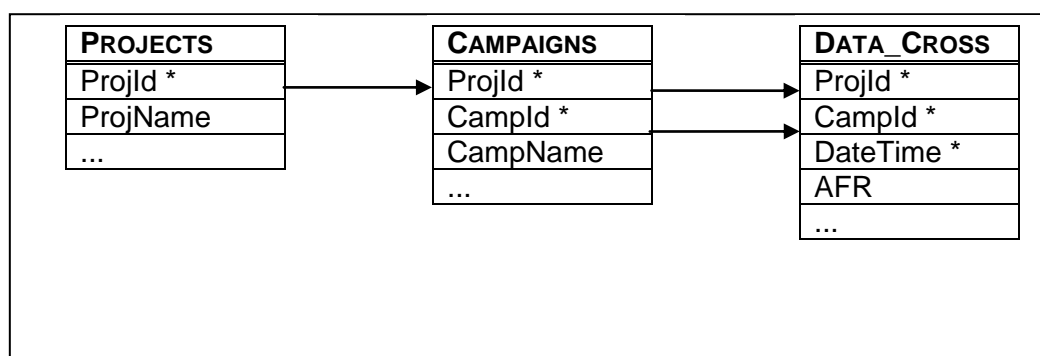
FieldName	FieldType	Comment
ProjId	Integer	Identifier of the project, to which the campaign belongs
CampId	Integer	Identifier of the campaign
CampName	Text	Campaign name defined by owner
CampType	Text	Type of campaign: H (historical), B (baseline), I (Intermediate, between BL and CDM registration), P (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. 9, no such historical data are available and therefore, this calibration is not carried out.

Queries from N.DBMS to determine EF_{BL}

Query 1¹⁶: Results from Raw Data for exact campaign duration

¹⁶ All queries are available and can be provided to the DOE upon request.

	OH	AFR	AIFR	Oph	OTh	NCSG	VSG	NAP	
Baseline campaign	Q1: without limits, data beyond documented CL excluded								
	h	kg NH3 / h		mbar-g	oC	ppm-v	mg N2O / Nm3	Nm3 / h	t
Count	2,098	2,097	2,098	2,097	2,097	2,097	4,120	2,098	88
Remaining share of data sets									
Minimum		4	0.00	0	800	0	0	0	
Maximum		3,530	0.78	917	901	1,946	3,823	44,500	
Mean		3,113	0.11	834	892	811	1,594	40,399	
Standard deviation		873	0.09	226	26	323	635	10,122	
95% confidence level (1.96 * SD)									
Sum									24,055.6
Permitted range acc. to AM0034									
Lower limit									
Upper limit									
Baseline emissions	BE		VSG * NCSG * 10-6 * Oh				t N2O		136
Emission factor	EF		BE / NAP				kg N2O / t HNO3		5.65

As a first step, several data from the raw data set had to be excluded because accidentally some data from the previous campaign were incorporated into the database. The campaign started on 21. June 2006 at 00:00 and ran until 16. October 2006 17:00. Any data in the database before or after those dates were excluded.

Query 2: Determination of NAP

	OH	AFR	AIFR	Oph	OTh	NCSG	VSG	NAP	
Baseline campaign	Q2: CLBL cut in accordance with CLnormal								
	OH	kg NH3 / h		mbar-g	oC	ppm-v	mg N2O / Nm3	Nm3 / h	NAP
Count	2,002	2,001	2,002	2,001	2,001	2,001	3,932	2,002	84
Remaining share of data sets	95%	95%	95%	95%	95%	95%		95%	
Minimum		4	0.00	0.3	800	0	0	0	
Maximum		3,530	0.78	916.7	901	1,946	3,823	44,500	
Mean		3,121	0.11	836.3	893	800	1,572	40,465	
Standard deviation		863	0.09	223.8	26	317	624	10,020	
95% confidence level (1.96 * SD)						622	1,222	19,639	
Sum									23,168.2
Permitted range acc. to AM0034	<13.10.2006								
Lower limit									
Upper limit									
Baseline emissions	BE	VSG * NCSG * 10-6 * Oh					t N2O	128	
Emission factor	EF	BE / NAP					kg N2O / t HNO3	5.54	

Since the baseline campaign (NAPBC) was longer than the historic normal campaign length (CLnormal), 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 CLnormal. Because NAP is only determined for each whole day of production, NAP is now slightly lower than CLnormal (23,168 instead of 23,337).

Query 3: Application of limits from "permitted operating range"

	OH	AFR	AIFR	Oph	OTh	NCSG	VSG	NAP
Baseline campaign	Q3: data to be excluded, operational limits from plant manual							
	OH	kg NH3 / h		mbar-g	oC	ppm-v	mg N2O / Nm3	Nm3 / h
Count	1,592	1,592	1,592	1,592	1,592	1,592	3,128	1,592
Remaining share of data sets	76%	76%	76%	76%	76%	76%		76%
Minimum		3,247	0.10	860.5	892	491	964	42,083
Maximum		3,530	0.10	910.0	901	1,645	3,233	44,071
Mean		3,360	0.10	898.6	900	917	1,802	43,190
Standard deviation		49	0.00	6.6	1	160	315	287
95% confidence level ($1.96 * SD$)						314	617	563
Sum	1859							18,933
Permitted range acc. to AM0034	<13.10.2006							
Lower limit				860	810			
Upper limit		3,877	0.115	910	915			
Baseline emissions	BE	$VSG * NCSG * 10^{-6} * Oh$					t N2O	144.7
Emission factor	EF	BE / NAP					kg N2O / t HNO3	6.25

In the next step, the limits provided by the permitted operating range, derived from the plant operating manual, were applied, including the exclusion of any data while the OTh value was smaller than 810°C as the plant is considered to be offline below those temperatures.

The remaining time data series determines the total number of operational hours of the plant (OH).

Also, several periods had to be excluded from the measured VSG and NCSG data. These periods are as follows:

From	To	Reason for exclusion
21/07/2006 - row no:2	25/07/2006 - row no:147	Leak on the sample probe inlet, causing dilution of the sample being analysed.
25/08/2006 - row no:365	25/08/2006 - row no:23211	Sample pump drive belt snapped causing incorrect readings.
16/09/2006 - row no:27116	21/09/2006 - row no:16292	Perished sample line on the exit of the sample probe drying oven caused dilution of the sample being analysed.

AM0034 monitoring methodology actually suggests that in the event that the monitoring system is down, the lowest between the conservative IPCC (4.5 kg N2O/ton nitric acid) 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. 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 4.5kg value.

Query 4: Confidence Intervals and determination of BE and EF

	OH	AFR	AIFR	Oph	OTh	NCSG	VSG	NAP
Baseline campaign	Q4: confidence intervals							
	OH	kg NH ₃ / h		mbar-g	oC	ppm-v	mg N ₂ O / Nm ³	Nm ³ / h
Count	1,441	1,441	1,441	1,441	1,441	1,441	2,831	1,441
Remaining share of data sets	69%	69%	69%	69%	69%	69%		69%
Minimum		3,247	0.10	874.6	897	603	1,185	42,628
Maximum		3,530	0.10	910.0	901	1,228	2,413	43,753
Mean		3,360	0.10	898.8	900	923.4	1,814	43,194.0
Standard deviation		48	0.00	6.1	1	138	272	250
95% confidence level ($1.96 * SD$)								
Sum								16,958
Permitted range acc. to AM0034	<13.10.2006							
Lower limit				860	810	603		42,627
Upper limit		3,877	0.115	910	915	1,231		43,754
Baseline emissions	BE	$VSG * NCSG * 10^{-6} * Oh$					t N ₂ O	145.7
Emission factor	EF	BE / NAP					kg N ₂ O / t HNO ₃	6.01
Uncertainty	UNC						%	4.4

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:

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

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 is applied to the EF calculation.

The resulting baseline emissions factor is 6.01 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 69,629 tonnes of nitric acid (based on the average production during the past five years including a projection for 2006)
- 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 90% of baseline N₂O emissions. Taking EF_{BL} of 6.01 kgN₂O/tHNO₃ and applying 90% abatement efficiency, the annual baseline emissions would be 129,755 tCO₂E and the annual emission reductions 116,779 tCO₂E.

These values are applied in the calculations for table B.6.4 below.

B.6.4. Summary of ex ante estimates of emission reductions

Year	Baseline emissions (t CO ₂ e)	Project emissions (t CO ₂ e)	Leakage (t CO ₂ e)	Emission reductions (t CO ₂ e)
2008	129,755	12,975	0	116,779

2009	129,755	12,975	0	116,779
2010	129,755	12,975	0	116,779
2011	129,755	12,975	0	116,779
2012	129,755	12,975	0	116,779
2013	129,755	12,975	0	116,779
2014	129,755	12,975	0	116,779
2015	129,755	12,975	0	116,779
2016	129,755	12,975	0	116,779
2017	129,755	12,975	0	116,779
Total	1,297,550	129,750	0	1,167,790
Total number of crediting years	10			
Annual average over the crediting period	129,755	12,975	0	116,779

B.7. Monitoring plan**B.7.1. Data and parameters to be monitored**

(Copy this table for each piece of data and parameter.)

Data / Parameter	P.1 NCSG
Unit	mg N ₂ O / Nm ³
Description	N ₂ O concentration in the stack gas during each project campaign.
Source of data	NDIR N ₂ O gas analyser (Environnement S.A. MIR 9000)
Value(s) applied	Not available yet. For the purpose of calculating expected emission reductions, the total projected annual baseline emissions of 129,755 were multiplied with the projected N ₂ O abatement efficiency factor of 90%. Hence, the other relevant factors (VSG, OH and NAP) are also not inserted as “projected values” into the tables below.
Measurement methods and procedures	AM0034 requires the determination of the concentration of N ₂ O in the stack gas. NCSG is continuously monitored with an NDIR gas analyser ¹⁷ 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: <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
Monitoring frequency	Continuously (every 2 seconds)

¹⁷ The Environnement S.A. MIR 9000 gas analyser has been certified according to ISO 14956, QAL 1 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. 9 plant, no analyser was available on the market that had already passed the certification for N₂O.

QA/QC procedures	<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 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 MIR 9000 is performed fully automatically and is done on programmable intervals. The analyser at No. 9 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 = $\frac{\text{Concentration of the calibration gas} \times \text{Old calibration factor}}{\text{Reading of the analyser once stabilised}}$</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>
Purpose of data	Calculation of project emissions.
Additional comment	None

Data / Parameter	P.2 VSG
Unit	Nm ³ /h
Description	Normal gas volume flow rate of the stack gas during each project campaign.
Source of data	Gas Volume Flow meter, Emerson Rosemount Annubar® Model 485
Value(s) applied	Not available yet.
Measurement methods and procedures	<p>AM0034 requires the determination of the gas volume flow (VSG) in the stack. VSG is continuously monitored with a flow meter and monitoring results are taken and recorded for every two seconds of plant operation. Hourly means for VSG are derived by the SCADA data acquisition system. VSG data taken during times when the plant was operating outside the permitted operating range are to be eliminated. The remaining VSG data series will have to be subjected to the following adjustment.</p> <p>The standard correction factor (0.5306) applied during the baseline campaign will not have to be applied during the project campaigns as the flow meter measuring range was re-adjusted to a maximum value of 45,000 m³/h.</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]</p> <p>V the volumetric flow rate (m³/hr)</p> <p>T the temperature in Kelvin (Note 1 K = T(°C) + 273).</p> <p>Subscript “s” refers to the actual stack values</p> <p>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
Monitoring frequency	continuously - every 2 sec. used for calculation of campaign mean (average, after exclusion of extreme values and outliers)

QA/QC procedures	<p>The flow meter is calibrated at least every 4 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>
Purpose of data	Calculation of project emissions.
Additional comment	None.

Data / Parameter	P.3 PE_n
Unit	tN ₂ O
Description	Total mass N ₂ O emissions in each project campaign.
Source of data	Calculated from the measurements from measured data.
Value(s) applied	Not available yet.
Measurement methods and procedures	Not applicable, calculated value as per the following formula: PE _n = VSG * NCSG * 10 ⁻⁹ * OH
Monitoring frequency	Not applicable. Calculated value.
QA/QC procedures	Not applicable. Calculated value.
Purpose of data	Calculation of project emissions.
Additional comment	None.

Data / Parameter	P.4 OH_n
Unit	hours
Description	Total operating hours during each project campaign
Source of data	Process Control System.
Value(s) applied	Not available yet.
Measurement methods and procedures	<p>Required by AM0034 to determine the total mass emissions of N₂O during the baseline.</p> <p>Each hour for which the ammonia oxidation temperature (OT_n) was recorded to be 810°C or above is included. Since the design plant operating temperature is between 800°C and 915°C, by definition the plant is offline if the temperature recorded is at or below 800°C.</p>
Monitoring frequency	hourly
QA/QC procedures	Subject to SABS ISO 9001/14001 procedures
Purpose of data	Calculation of project emissions.
Additional comment	None.

Data / Parameter	P.5 NAP
Unit	tHNO ₃
Description	Metric tonnes of 100% concentrated nitric acid during each project campaign.
Source of data	Nitric acid flow meter - Flexim Ultrasonic flow meter Laboratory results
Value(s) applied	Not available yet
Measurement methods and procedures	NAP is determined by a flow meter according to the following procedures: The density and temperature as measured by the flow meter, which also determines the concentration of the nitric acid produced. This value is then used to convert the total mass flow to 100% nitric acid produced. The correct measurement of acid concentration is checked by manual tests.
Monitoring frequency	NAP is determined by continuous measurement of the HNO ₃ production and concentration
QA/QC procedures	The flow meter is calibrated in regular intervals. NAP results are crosschecked against process parameters as ammonia consumption and against product stock levels and product consumption
Purpose of data	Calculation of project emissions.
Additional comment	None

Data / Parameter	P.6 TSG
Unit	°C
Description	Temperature in the stack gas
Source of data	Stack temperature probe situated next to the volume flow meter.
Value(s) applied	Not applicable
Measurement methods and procedures	AM0034 requires the determination of gas volume flow at normal conditions in the stack. In order to calculate from the measured VSG values to VSG at normal conditions, the actual temperature in the stack is measured by a temperature probe directly next to the flow meter.
Monitoring frequency	Continuously
QA/QC procedures	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 gauge change between the campaigns.
Purpose of data	Calculation of project emissions.
Additional comment	None.

Data / Parameter	P.7 PSG
Unit	mbar (absolute)
Description	Pressure in the stack
Source of data	Stack pressure probe situated directly next to the volume flow meter.
Value(s) applied	Not applicable.
Measurement methods and procedures	AM0034 requires the determination of gas volume flow at normal conditions in the stack. In order to calculate from the measured VSG values to VSG at normal conditions, the actual pressure in the stack has to be determined and applied to each hourly mean VSG value. The measurements are taken continuously by a pressure probe inside the stack very close to the stack gas volume flow meter.
Monitoring frequency	Continuously
QA/QC procedures	<p>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.</p> <p>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>
Purpose of data	Calculation of project emissions.
Additional comment	None.

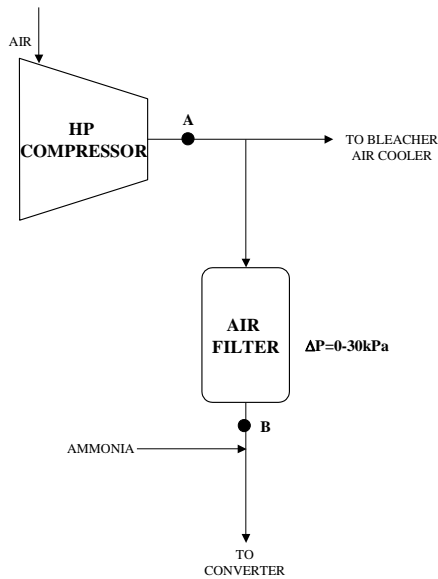
Data / Parameter	P.8 EF_n
Unit	tN ₂ O/tHNO ₃
Description	Emissions factor for campaign n.
Source of data	Calculation from total mass N ₂ O emissions of campaign n (PE _n) and total nitric acid production (NAP _n).
Value(s) applied	Not available yet.
Measurement methods and procedures	<p>The campaign specific emissions factor for each campaign during the project's crediting period is calculated 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 campaign n the campaign specific emission factor would be:</p> $EF_n = PE_n / NAP_n$
Monitoring frequency	Not applicable
QA/QC procedures	Not applicable
Purpose of data	Calculation of project emissions.
Additional comment	None

Data / Parameter	P.9 EF_{ma,n}
Unit	tN ₂ O/tHNO ₃
Description	Moving average emissions factor derived over time from campaign specific emissions factors.
Source of data	Calculation from campaign specific emissions factors EF _n
Value(s) applied	Not available yet.
Measurement methods and procedures	<p>In order to take into account possible long-term emissions trends over the duration of the project activity and to take a conservative approach a moving average emission factor shall be estimated as follows:</p> $EF_{ma,n} = (EF_1 + EF_2 + \dots + EF_n) / n$ <p>This process is repeated for each campaign such that a moving average, EF_{ma,n} is established over time, becoming more representative and precise with each additional campaign.</p>
Monitoring frequency	Not applicable.
QA/QC procedures	Not applicable.
Purpose of data	Calculation of project emissions.
Additional comment	None

Data / Parameter	P.12 CL_n
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	NAP
Value(s) applied	Not available yet.
Measurement methods and procedures	<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 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).</p> <p>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.</p>
Monitoring frequency	Continuously
QA/QC procedures	See comments for NAP
Purpose of data	Calculation of project emissions.
Additional comment	None.

Data / Parameter	P.13 EF_p
Unit	tN ₂ O/tHNO ₃
Description	Emissions factor used for the specific campaign n to determine the emission reductions of that campaign
Source of data	Calculation of EF_n and $EF_{ma,n}$.
Value(s) applied	Not available yet.
Measurement methods and procedures	<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>
Monitoring frequency	Not applicable
QA/QC procedures	Not applicable
Purpose of data	Calculation of project emissions.
Additional comment	None

Data / Parameter	P.14 EF_{min}
Unit	tN ₂ O/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	Calculations of $EF_{ma,n}$.
Value(s) applied	Not available yet.
Measurement methods and procedures	<p>A campaign-specific emissions factor shall be used to cap any potential long-term trend towards decreasing 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}). If any of the later project campaigns results in a EF_n that is lower than EF_{min}, the calculation of the emission reductions for that particular campaign shall use EF_{min} and not EF_n.</p>
Monitoring frequency	Not applicable.
QA/QC procedures	Not applicable.
Purpose of data	Calculation of project emissions.
Additional comment	None.

Data / Parameter	OP_h
Unit	kPa (gauge)
Description	Oxidation Pressure for each hour
Source of data	Pressure probe at ammonia to air mixer.
Value(s) applied	Not applicable. Used to determine when plant is operating outside of permitted range.
Measurement methods and procedures	<p>In accordance with AM0034 the oxidation pressure in the ammonia oxidation reactor (OP_h) has to be monitored and compared to the Normal range for oxidation temperature (OP_{normal}). VSG and NCSG data obtained during times when OP_h was above or below OP_{normal} has to be eliminated from the calculation of EF_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. 9.</p>  <p>During the project campaigns OP is monitored as air pressure to the ammonia to air mixer. Unlike during historic campaigns, these data will be archived and analysed as required by AM0034.</p>
Monitoring frequency	Continuously
QA/QC procedures	<p>Subjected to complete SABS testing loops as part of the ISO 9001/14001 procedures.</p> <p>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>
Purpose of data	Calculation of project emissions.

Additional comment	None
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Data / Parameter	OT_h
Unit	°C
Description	Oxidation temperature in the ammonia oxidation reactor (AOR).
Source of data	Thermocouples inside the AOR.
Value(s) applied	Not applicable. Used to determine when plant is operating outside of permitted range.
Measurement methods and procedures	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 OTh. OTh is controlled by AIFR which is a controlled parameter and should stay as constant as possible. OTh is therefore a control parameter for AIFR.
Monitoring frequency	Continuously
QA/QC procedures	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 gauge change between the campaigns.
Purpose of data	Calculation of project emissions.
Additional comment	None

Data / Parameter	AFR
Unit	tNH ₃ /h
Description	Ammonia gas flow rate to the ammonia oxidation reactor.
Source of data	Orifice plate
Value(s) applied	Not applicable, monitored data of AFR will be used to determine if plant was operating outside of AFR _{max} .
Measurement methods and procedures	The ammonia flow is continuously measured by orifice plate.
Monitoring frequency	Continuously
QA/QC procedures	Subjected to complete SABS testing loops as part of the ISO 9001/14001 procedures.
Purpose of data	Calculation of project emissions.
Additional comment	None.

Data / Parameter	AIFR
Unit	% v/v
Description	Ammonia to air ratio into the ammonia oxidation reactor
Source of data	Calculation for each hour of plant operation based on measurements of AFR and primary air flow rates.
Value(s) applied	Not applicable
Measurement methods and procedures	<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} was determined to be 11.5% v/v. During the analysis of the measured data, any of the NCSG and VSG data obtained from an hour during which the AIFR was above AIFR_{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>
Monitoring frequency	Continuously
QA/QC procedures	Subjected to complete SABS testing loops as part of the ISO 9001/14001 procedures.
Purpose of data	Calculation of project emissions.
Additional comment	None.

Data / Parameter	P.17 GS_{PC}
Unit	Name of supplier.
Description	Gauze supplier for the project campaign
Source of data	Invoices
Value(s) applied	Not available yet.
Measurement methods and procedures	<p>AM0034 requires the monitoring of the supplier of the ammonia oxidation catalyst gauze. The recorded information is not further processed in the methodology but it is used as a plausibility check against the information for GC.</p> <p>AEL has been using ammonia oxidation catalyst gauzes ("FTCplus") supplied by Heraeus for the past several years, except for three campaigns (01. Jan to 15. Mar 05, 22. Jun to 18. Sep 05 and 23.12.05 to 15 Feb 06) where ammonia oxidation catalyst gauzes supplied by Johnson Matthey were used. The composition of the Johnson Matthey gauzes was different from the Heraeus FTCplus gauze normally used at the plant. 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 Heraeus FTCplus gauzes for the foreseeable future.</p>
Monitoring frequency	Each campaign
QA/QC procedures	Not applicable
Purpose of data	Calculation of project emissions.
Additional comment	None.

Data / Parameter	P.18 GC _{project}
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	Invoices
Value(s) applied	To be obtained during the project campaigns
Measurement methods and procedures	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.
Monitoring frequency	Each campaign
QA/QC procedures	Not applicable
Purpose of data	Calculation of project emissions.
Additional comment	None.

B.7.2. Sampling plan

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Not applicable

B.7.3. Other elements of monitoring plan

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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 EN14181 (2004) "*Stationary source emissions - Quality assurance of automated measuring systems*"¹⁸ 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. 9 nitric acid plant was ordered in the second half of 2005 and has been installed and operated since January 2006. However, the flow meter had to be replaced in June 2006 because of a faulty configuration (which is roughly a week before the No. 9 Baseline campaign started) at which time a full data acquisition system was also commissioned. As an operator of the nitric acid plants since 1932 and of the No. 9 nitric acid plant since 1968, AEL staff in general and its Instrument Department in particular is accustomed to operating technical equipment to a high level of quality standards.

¹⁸ This standard describes the quality assurance procedures needed to assure that an Automated Measuring System (AMS) installed to measure emissions to air are capable of meeting the uncertainty requirements on measured values given by legislation, e.g. EU Directives, or national legislation, and more generally by competent authorities.

The responsibilities within AEL for the operation and maintenance of the AMS are set out in the internal AEL Nitrates Operations Instructions (Document Ref. NIT 002) "CDM Project Data Accuracy Procedure". According to this, the Production Manager (PM) has the overall responsibility for the ongoing operation of the project.

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

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

Operation, maintenance, calibration and service intervals are being carried out by staff from the instrumentation department according to the vendor's specifications 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 appendix 5 for a detailed description of the Automated Monitoring System (AMS) installed at AEL's No. 9 nitric acid plant.

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

QAL 1

In accordance with EN14181 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 and it was not known if any vendors were in the process of obtaining this.

The currently installed Environnement S.A. MIR 9000 analyser was found to deliver too inaccurate results, probably due to damage during transportation to the site. As a consequence, AEL will install a new analyser at No. 9. The ABB type Uras 14 which is to be installed in May 2007, has already passed the QAL1 suitability test for N₂O.

QAL2 / SRM

Once the new analyser has been installed, an ISO 17025 accredited testing house will conduct the QAL2 audit and the reference measurements according to the SRM. This QAL2 audit will be repeated again after 5 years of operation of the AMS.

Pre-validation of the AMS by a DOE

While this is not explicitly required by either AM0034 or EN14181, 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.

QAL3: 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.

Analyser Zero Calibration

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 is performed fully automatically and is done on programmable intervals. Currently the analyser at No. 9 plant is set to the standard default time interval, which means that an automatic zero calibration is done every 3 hrs. A correction is done each time the analyser is found to deviate by more than 2%. If the drift is found to be very low, i.e. corrections are only required rarely, then the interval of automatic zero calibrations may be set to be longer.

Analyser Span calibration

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 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.

Laboratory Analysis of Stack Sample

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

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.

During the "test baseline" and up until today, 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 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.

This procedure may be discontinued after the new analyser has been commissioned and successfully passed the QAL2 audit.

Flow meter calibration procedures

The flow meter is calibrated at least every 4 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 indicated flow by 450 m³/hr (equal to 1% of range), then the pressure transmitter is recalibrated and the previous procedure repeated.

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

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

Annual Surveillance Test (AST)

As part of QAL3, EN14181 requires an Annual Surveillance Tests (AST) to be conducted, these are a series of reference measurements that need to be conducted by independent measurement equipment in parallel to the existing AMS.

In view of the fact that there are no ISO 17025 accredited testing houses present in South Africa that have the necessary equipment for this application (especially the N₂O analyser to conduct the reference measurements), the AST at AEL will not include any reference measurements. However, a qualified and independent agency should annually check the set up and functionality of the AMS.

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 discdrive. 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: OTh, OPh, AFR, AIFR, NAP, GS, GC, CL, incoming N₂O 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.7.4. Date of completion of application of methodology and standardized baseline and contact information of responsible persons/ entities

>>

Date of completion of study on application of the selected methodologies: 05/04/2007

Contact information of the entities responsible for the application of the selected methodologies:

Organization name	African Explosives Ltd.
Street/P.O. Box	PO Modderfontein
Building	Acid House
City	Modderfontein
State/Region	Gauteng Province
Postcode	1645
Country	South Africa
Telephone	
Fax	
E-mail	
Website	www.explosives.co.za
Contact person	Trevor Roberts
Title	Executive Director Global Business Services
Salutation	Mr
Last name	Roberts
Middle name	
First name	Trevor
Department	AEL Mining Services
Mobile	+27 82 373 2270
Direct fax	+27 11 605 0004
Direct tel.	+27 11 606 0489
Personal e-mail	Trevor.roberts@aelms.com

Organization name	N.serve Environmental Services GmbH
Street/P.O. Box	Grosse Theaterstr. 14
Building	-
City	Hamburg
State/Region	Hamburg
Postcode	20354
Country	Germany
Telephone	+494030997860
Fax	+4940309978610
E-mail	contact@nserve.net
Website	www.nserve.net
Contact person	Marten von Velsen-Zerweck
Title	Managing Director
Salutation	Mr
Last name	von Velsen-Zerweck
Middle name	
First name	Marten
Department	Geschaefsfuehrung
Mobile	+49163 613 43 03
Direct fax	+4940309978610
Direct tel.	+4940309978612
Personal e-mail	velsen@nserve.net

Both entities are also project participants and are listed in Appendix 1. below.

SECTION C. Duration and crediting period

C.1. Duration of project activity

C.1.1. Start date of project activity

>>

06/08/2007

C.1.2. Expected operational lifetime of project activity

>>

AEL's No. 9 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. Crediting period of project activity

C.2.1. Type of crediting period

>>

Fixed

C.2.2. Start date of crediting period

>>

06/08/20007

C.2.3. Length of crediting period

10 years

SECTION D. Environmental impacts**D.1. Analysis of environmental 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. Environmental impact assessment

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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 Department¹⁹.

SECTION E. Local stakeholder consultation**E.1. Solicitation of comments from local stakeholders**

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AEL has conducted a stakeholder consultation process by hiring a local consultancy²⁰ 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.

¹⁹ See letter of the Gauteng Provincial Government (Department for Agriculture, Conservation and Environment) dated the 19th of September 2006, confirming that an Environmental Impact Assessment is not required. This letter is available during the on site audit by the DOE.

²⁰ Willchem cc, Environmental & Risk Consultants; the consultant's Stakeholder Engagement Report can be found in Annex 5.

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 comments received

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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 consideration of 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 AECI 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. (this section should be moved/repeated in the Sustainable Development criteria).

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

SECTION F. Approval and authorization

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A letter of Approval from the South African government is only obtainable once the project has been validated.

- - - - -

Appendix 1. Contact information of project participants and responsible persons/ entities

Project participant and/or responsible person/ entity	<input checked="" type="checkbox"/> Project participant <input checked="" type="checkbox"/> Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	African Explosives Ltd.
Street/P.O. Box	PO Modderfontein
Building	Acid House
City	Modderfontein
State/Region	Gauteng Province
Postcode	1645
Country	South Africa
Telephone	+27 11 606 0489
Fax	+27 11 605 0004
E-mail	Trevor.roberts@aelms.com
Website	www.explosives.co.za
Contact person	Trevor Roberts
Title	Executive Director Global Business Services
Salutation	Mr
Last name	Roberts
Middle name	
First name	Trevor
Department	AEL Mining Services
Mobile	+27 82 373 2270
Direct fax	+27 11 605 0004
Direct tel.	+27 11 606 0489
Personal e-mail	Trevor.roberts@aelms.com

Project participant and/or responsible person/ entity	<input checked="" type="checkbox"/> Project participant <input checked="" type="checkbox"/> Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	N.serve Environmental Services GmbH
Street/P.O. Box	Grosse Theaterstr. 14
Building	-
City	Hamburg
State/Region	Hamburg
Postcode	20354
Country	Germany
Telephone	+494030997860
Fax	+4940309978610
E-mail	contact@nserve.net
Website	www.nserve.net

Contact person	Marten von Velsen-Zerweck
Title	Managing Director
Salutation	Mr
Last name	von Velsen-Zerweck
Middle name	
First name	Marten
Department	Geschaeftsfuehrung
Mobile	+49163 613 43 03
Direct fax	+4940309978610
Direct tel.	+4940309978612
Personal e-mail	velsen@nserve.net

Appendix 2. Affirmation regarding public funding

Not applicable

Appendix 3. Applicability of methodology and standardized baseline

Not applicable

Appendix 4. Further background information on ex ante calculation of emission reductions

Not applicable

Appendix 5. Further background information on monitoring plan

MONITORING INFORMATION

Background on EN14181

The objective is to achieve the highest practically possible level of accuracy in conducting those measurements and transparency in the evaluation process.

While EN14181 provides the most advanced procedures, its practical application is currently limited for the following reasons:

- Specific procedures for N₂O are not yet defined in EN14181;
- Only very limited experience exists with monitoring systems for N₂O emissions;
- No applicable regulatory N₂O levels exist in the EU (or elsewhere) that are required to conduct some of the calculations and tests of EN14181; and

As a result, at the time of ordering and installation of the AMS at AEL's nitric acid plants, no AMS vendors had yet achieved the certification for suitability in accordance with EN14181. Back in 2005 AEL therefore decided to purchase and install an Environnement MIR 9000 analyser. During a pre-validation of the AMS it was determined that this analyser was delivering somewhat unreliable results. As a consequence the already established baseline was considered too inaccurate to be used for the purpose of the CDM project. Nevertheless, the results of this "test baseline" are used for the projection of CERs in this PDD.

Early in 2007 AEL decided to replace the installed analysers with new analysers from ABB, type Uras 14, which are QAL1 suitability tested for N₂O. These will be installed in May 2007 following which the actual baseline campaign for the No. 9 nitric acid plant will commence.

Description of the AMS currently installed at AEL's No. 9 nitric acid plant.

1. General Description of the AMS

The system installed at AEL's No. 9 nitric acid plant consists of an air dryer unit, a sample conditioning system and the actual multi-component 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. 9 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. 9



4. Analyser

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-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 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. 9 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).

The current analyser will be replaced in May 2007 with a new analyser, following which the baseline campaign will commence.

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.



5. Flow Meter

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

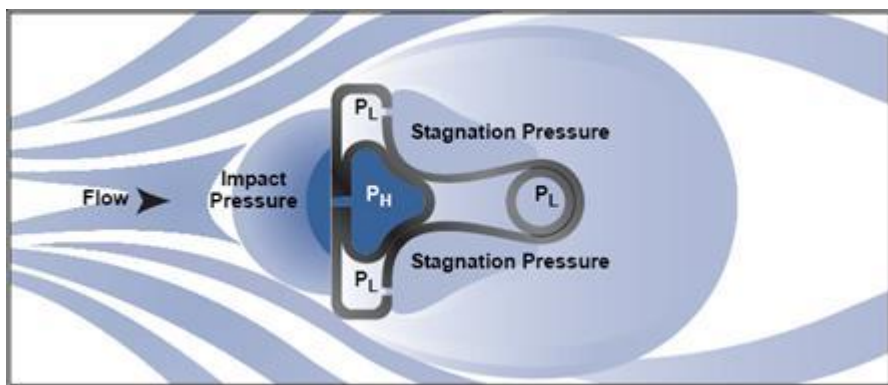


The Rosemount Annubar® 485 is a device used to measure the flow-velocity of a liquid, gas or steam fluid that passes through a pipe. It measures by creating a differential pressure (DP) that is proportional to the square of the velocity of the fluid in the pipe, in accordance with Bernoulli's theorem.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



Appendix 6. Summary of post registration changes

The Emerson coriolis mass flow meter used to measure the nitric acid production has been increasingly unreliable and maintenance intensive due to corrosion issues. The following cause was identified for the corrosion:

The acid temperature that leaves the NO_x column at plant No. 9 is $\pm 65^\circ\text{C}$. At this temperature, nitric acid becomes very corrosive. The mass flow meters measure the flow of the product by changes in the vibration of two measurement tubes. The rigidity and integrity of these tubes is critical to the accurate measurement of the flow. The acid corrodes the measurement tubes which causes the mass flow meter's readings to first drift and then fail. Please note that at plant No. 11 the same flow meter was installed, but it does not suffer from any such problems. The mass flow meters on that plant are very reliable and the production flows as recorded by the flow meters can be used directly. This is due to the fact that the production acid temperature from the plant is more than 20°C lower than that of No. 9 and no issue with corrosion occurs.

Several options were considered to resolve the issue:

1. Cool the nitric acid.
2. Change the mass flow meter material.
3. Alternative flow meters.

Cooling the production nitric acid is possible, but the cost and time frame of such a project would be far too long and costly. Thus this option was disregarded.

Several options exist for alternative materials of construction for the mass flow measurement tubes. These include materials like zirconium, tantalum and titanium. The costs of these materials are prohibitive and there is no guarantee that they would last long enough to justify the extra cost. All indications are that these exotic material mass flow meters would not significantly increase the life or reliability of the measurements to justify their elevated cost. This option is not workable either and was disregarded.

The final option was to look at an alternative flow meter. Several different options were looked at including the installation of a differential pressure flow meter with an inline densimeter. All these were discarded for various reasons. Finally, an ultrasonic flow meter was introduced.

Like the mass flow meter, the ultrasonic flow meter also measures temperature, the mass flow, liquid density and is able to give an acid concentration reading.

Although the measured output for the ultrasonic flow meters and the mass flow meters are the same, the principles of their operation are completely different. The ultrasonic flow meter makes use of two ultrasonic transducers mounted, a set distance apart on the outside of a pipe in which the flow needs to be measured. The sound velocity of the flow medium is determined by the density of the medium and from that it is easy to calculate the concentration. The time gap difference between the pulses for the two transducers determines the flow direction and velocity. From the flow velocity and known pipe diameter the volume and then using the density the mass flow can be calculated.

This type of flow meter has various advantages:

- It is non-invasive and is merely clamped to the outside of a pipe. This makes calibration and changing the flow meter easy without the need for the plant to be offline.
- It will not be affected by corrosion.
- Also there would be no extra pressure drop due to the installation of the flow meter.
- Generally, coriolis mass flow meters are mechanical devices and experience drift as soon as they are installed. They therefore require regular maintenance and calibration. A major advantage of the newly installed ultrasonic meter is that does not have any moving or mechanical parts. Therefore it is maintenance and drift free after it has been installed. The manufacturer recommends carrying out a calibration every five years.

As a result of the in-depths analysis the Flexim ultrasonic flow meter was chosen. Since 02/08/2011 a Flexim Ultrasonic flow meter has been installed in parallel to the Emerson coriolis mass flow meter, initially for testing purposes. During the tests, the ultrasonic flow meter has proven to be capable of accurately and reliably measure the nitric acid production. Since 20/06/2012, the values from the new ultrasonic flow meter were recorded and utilized for the calculation used to measure the final nitric acid production of plant No. 9 has been replaced by a Flexim Ultrasonic flow meter.

The details of the new flow meter are listed in the parameter table below:

Data / Parameter	P.5 NAP
Unit	tHNO ₃
Description	Metric tonnes of 100% concentrated nitric acid during each project campaign.
Source of data	Nitric acid flow meter - Flexim Ultrasonic flow meter Laboratory results
Value(s) applied	Not available yet
Measurement methods and procedures	NAP is determined by a flow meter according to the following procedures: The density and temperature as measured by the flow meter, which also determines the concentration of the nitric acid produced. This value is then used to convert the total mass flow to 100% nitric acid produced. The correct measurement of acid concentration is checked by manual tests.
Monitoring frequency	NAP is determined by continuous measurement of the HNO ₃ production and concentration
QA/QC procedures	The flow meter is calibrated in regular intervals. NAP results are crosschecked against process parameters as ammonia consumption and against product stock levels and product consumption
Purpose of data	Calculation of project emissions.
Additional comment	None

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Document information

<i>Version</i>	<i>Date</i>	<i>Description</i>
05.0	25 June 2014	Revisions to: <ul style="list-style-type: none"> • Include the Attachment: Instructions for filling out the project design document form for CDM project activities (these instructions supersede the "Guidelines for completing the project design document form" (Version 01.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for the application of the methodology (ies) to the project activity in B.7.4 and Appendix 1; • Change the reference number from <i>F-CDM-PDD</i> to <i>CDM-PDD-FORM</i>; • Editorial improvement.
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b
04.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the project design document form for CDM project activities" (EB 66, Annex 8).
03.0	26 July 2006	EB 25, Annex 15
02.0	14 June 2004	EB 14, Annex 06b
01.0	03 August 2002	EB 05, Paragraph 12 Initial adoption.
Decision Class: Regulatory Document Type: Form Business Function: Registration Keywords: project activities, project design document		