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

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Project for the catalytic reduction of N_2O emissions with a secondary catalyst inside the ammonia reactor of the nitric acid plant at Dongbu Hannong Chemicals Ltd., Ulsan, Korea ("Dongbu").

Version 2.1

Date of Completion: 30 March 2010

A.2. Description of the project activity:

The Ulsan fertiliser factory owned by Dongbu Hannong Chemicals Ltd. produces Compound Fertilizers, Sulphuric Acid, Nitric Acid and Purified Phosphoric Acid. The single burner high pressure plant nitric acid plant on site was designed by Weatherly and commissioned in 1992. The nitric acid is used in the production of compound fertilisers on site but part of the nitric acid produced is also sold to external users in various concentrations (60%, 65%, 68%, 69%, 70%, 85% and 98%). The sole purpose of the proposed project activity is to significantly reduce current levels of N_2O emissions from the production of nitric acid at this plant.

To produce nitric acid, ammonia (NH_3) is reacted with air over precious metal – normally a platinum-rhodium (Pt-Rh) alloy – catalyst gauze pack in the ammonia oxidation reactor of nitric acid plants. The main product of this reaction is NO, which is metastable at the conditions present in the ammonia oxidation reactor and therefore reacts with the available oxygen to form NO_2, which is later absorbed in water to form HNO_3 – nitric acid. Simultaneously, undesired side reactions yield nitrous oxide (N_2O), nitrogen and water. N_2O is a potent greenhouse gas with a Global Warming Potential (GWP) of 310[1]. The project activity involves the installation of a new N_2O 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 N_2O emissions.

The project transfers a new, clean technology to Korea 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 N_2O abatement catalyst and the Automated Monitoring System.

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, Dongbu will also be able to improve its profitability and ensure employment, contribute to economic prosperity in the region. In these aspects, the project contributes to Korea's Sustainable Development.

A.3. Project participants:

Name of Party involved (*) ((host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of Korea (host)	Dongbu Hannong Chemicals Ltd. (Private)	No
Republic of Korea (host)	UPC Corporation Ltd. (Private)	No
United Kingdom	Johnson Matthey PLC (Private)	No

[1] IPCC Second Assessment Report (1995)

United Kingdom	N.serve Environmental Services GmbH (Private)	No
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Korea

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

Ulsan

A.4.1.3. City/Town/Community etc:

Ulsan

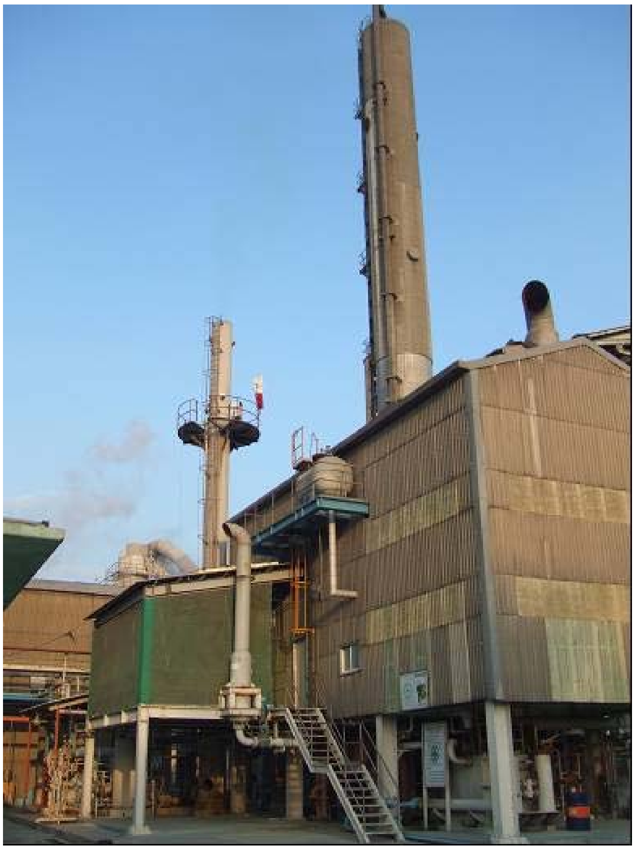
A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

Map of South Korea showing location of Ulsan City

Map of central and eastern Ulsan City showing location of Dongbu Hannong Chemicals Ltd.

Dongbu's Nitric Acid Plant:

Absorption tower (back) and stack of Dongbu's Nitric Acid Plant:



The nitric acid plant is physically located at #523, Maeam-dong, Nam-ku, Ulsan, 680-050, Korea

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

Sectoral Scope 5: Chemical Industry

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

The project activity entails a transfer of
- state-of-the art N_2O abatement technology which is not even commonly applied in Annex I countries.
- special monitoring equipment
- training of staff for installation, operation and maintenance of catalyst and monitoring equipment, etc.

A number of N_2O abatement technologies have become available in the past 2 years after some 10 years of research, development and industrial testing. Only now that N_2O regulation is going to be introduced in the EU by 2007 and with the incentives provided by the Kyoto Protocol nitric acid plant operators are considering adopting these technologies. N_2O abatement technology is now commercially available from a number of catalyst manufacturers, mainly from Germany and the UK. These technologies are proprietary and will be sold or leased to nitric acid plants. The financing of this technology is facilitated by the CDM. Hence, the CDM will enable nitric acid plants in non-Annex 1 countries to become the pioneers of N_2O abatement of the global nitric acid industry.

Dongbu is determined to install a secondary abatement catalyst upon the successful registration of a CDM project. Dongbu has contracted with Johnson Matthey plc to provide the N_2O abatement catalyst technology for this project on the basis of a lease agreement where Johnson Matthey receives a share of the CERs generated as compensation.

Catalyst Technology

Dongbu has contracted with Johnson Matthey PLC (JM) for the provision of the N2O abatement catalyst. JM has two different types of N2O abatement catalyst available. The choice of abatement catalyst type for any particular plant depends on technical aspects like (i) available bed depth, (ii) expected pressure drop, (iii) desired abatement performance etc.

Initially the Amoxis Hybrid® RN20/101 catalyst was installed (this type was later rebranded for legal reasons and is now called Amoxis 10 -1R®). To optimise the abatement performance of the installed catalyst and to reduce the observed pressure drop inside the reactor, JM and Dongbu decided to change the installed catalyst type to the YARA 58-Y1® catalyst. Both the Amoxis 10 -1R® and the YARA 58-Y1® catalyst contain cobalt as the active catalyst material.

Because N_2O is solely formed in the primary ammonia oxidation catalyst, the type of secondary catalyst has no effect on baseline emissions or on the baseline scenario. Because the cost for the secondary catalyst is the same the type of secondary catalyst has also no effect on the additionality test of the project.

The precious metal gauze pack – i.e. the primary catalyst required for the actual production of nitric acid – has been supplied to Dongbu by Johnson Matthey for a number of years. The design and composition of that gauze pack has remained unchanged so far and will remain unchanged for the remainder of the crediting period.

A secondary catalyst will reduce N_2O levels in the gas mix resulting from the primary ammonia oxidation reaction. A wide range of metals (e.g. Cu, Fe, Mn, Co and Ni) have shown to be of varied effectiveness in N_2O abatement catalysts.

The Amoxis Hybrid® RN20/101 abatement catalyst is made of clover leave shaped pellets containing a Lanthanum-Cerium-Cobalt-Perovskite.

Both of the catalysts have been tried and tested in a number of nitric acid plants in Europe. Their abatement efficiency has been shown to be at least 80% in the following reaction:

$2N_2O \rightarrow 2N_2 + O_2$

Both abatement catalyst do not contaminate the nitric acid produced in the respective nitric acid plant, neither with Cobalt nor with any of the other catalyst materials[2].

Operating a secondary catalyst system 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 on at the N_2O abatement catalyst.

Basket modifications and Heat Shield design

Most nitric acid plants have some sort of basket structure that gives structural support to the precious metal gauzes. The ammonia oxidation reaction in Dongbu’s nitric acid plant normally operates at between

[2] This has been proven in industrial testing. The underlying information is commercially sensitive and will be made available to the CDM EB / the validator upon request.

910 and 920°C, which causes basket assembly to expand compared to when the plant is not operational (i.e. during installation of the catalyst).

This effect increases the basket diameter by 1 - 1.5%. The ammonia reactor of the Dongbu plant has a diameter of 1143 mm that expands by approximately 10 - 20 mm when in operation. This would result in a gap of an average of 7.35 mm between the pelleted bed and the burner's outside wall. This gap will be of significantly lower ΔP than the pelleted bed. Hence an increase in gas flow will emerge equilibrating the ΔP throughout the system. The preferential gas flow through this gap can easily increase tenfold due to this effect.

To counter this occurrence, the basket which supports the gauze pack will have to be modified and an additional heat shield will have to be installed inside the existing basket to provide containment of the pelleted bed in a manner which prevents preferential gas flow at the perimeter.

N_2O 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 N_2O abatement catalyst – regardless whether the Amoxis 10-1R® or the YARA 58-Y1 system is being employed – is supplied to Dongbu by Johnson Matthey on a lease basis, which requires Johnson Matthey 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.

Dongbu's nitric acid plant operates at high pressure of between 13.25 and 14.75 bar inside the ammonia oxidation reactor. Through the introduction of a 150mm bed of secondary catalyst into the ammonia reactor, a slight pressure drop (ΔP) of approximately 105 mbar is expected to occur. This ΔP may lead to a very slight reduction in ammonia conversion efficiency and hence a very small reduction in nitric acid output. In practice, this loss of production will be insignificant.

Technology transfer and safety issues

As mentioned before, the secondary abatement technology has been tested in several industrial trials in which it has proven to be reliable in reducing N_2O and environmentally safe. Especially, its implementation does not lead to increased NO_X emissions. Neither is the environment directly or indirectly harmed in any other way.

The N_2O abatement catalyst is supplied to Dongbu by Johnson Matthey on a lease basis, which requires Johnson Matthey 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.

Once installed, the catalyst itself and the AMS will be operated by Dongbu staff. All project participants will work together on training the Dongbu workers to reliably supervise the effective operation of the catalyst technology, apply the installed monitoring system to measure the emission levels and collect the data in a manner that allows a successful completion of each verification procedure.

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

To estimate the amount of GHG emission reductions that the project activity will generate over the chosen crediting period, prospective future nitric acid production levels have to be taken into account.

Nitric acid is an intermediate product required for the production of high grade fertilisers. Dongbu's nitric acid plant is a high pressure, single reactor Weatherly plant which was commissioned in 1992 and is

expected to operate for at least another 15 years. The plant is designed to operate campaigns of 70 days length. Depending on fertiliser demand, Dongbu operates on average 4.3 campaigns (300 days) each year thus producing an average of approximately 90,000 $tHNO_3$ per year.

A complete Automated Monitoring System to monitor the mass emissions of N_2O at the stack of Dongbu's nitric acid plant was commissioned on 29 January 2007. The baseline campaign measurements were conducted from April 6 through June 14, 2007. The resulting baseline N_2O emissions factor (EF_{BL}) of 10.78 kg/$tHNO_3$ was derived (after deducting the 5.0% AMS uncertainty as established through the QAL2 audit). Assuming an average annual production of 90,000 $tHNO_3$ per year for the next 10 years, a 80% abatement efficiency of the N_2O abatement catalyst, the emission reductions are projected as per the table below.

Year	Annual estimation of emission reductions in tonnes of CO_2
2008	180,653
2009	240,651
2010	240,651
2011	240,651
2012	240,651
2013	240,651
2014	240,651
2015	240,651
2016	240,651
2017	240,651
2018	59,998
Total number of crediting years	10
Total estimated reductions (tonnes of CO_2e)	2,406,510
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	240,651

A.4.5 Public funding of the project activity:

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

SECTION B. Application of a baseline and monitoring methodology

B.1. Title and reference of the approved baseline and monitoring methodology applied to the project activity:

This project is based on Approved Baseline and Monitoring methodologies AM0034 (Version 02): "Catalytic reduction of N_2O inside the ammonia burner of nitric acid plants".

Furthermore, the project draws on approved baseline methodology AM0028 (in its most recent version) for the baseline scenario selection and employs the "Tool for the demonstration and assessment of additionality" (Version 03).

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

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

The use of the chosen methodology is applicable because:

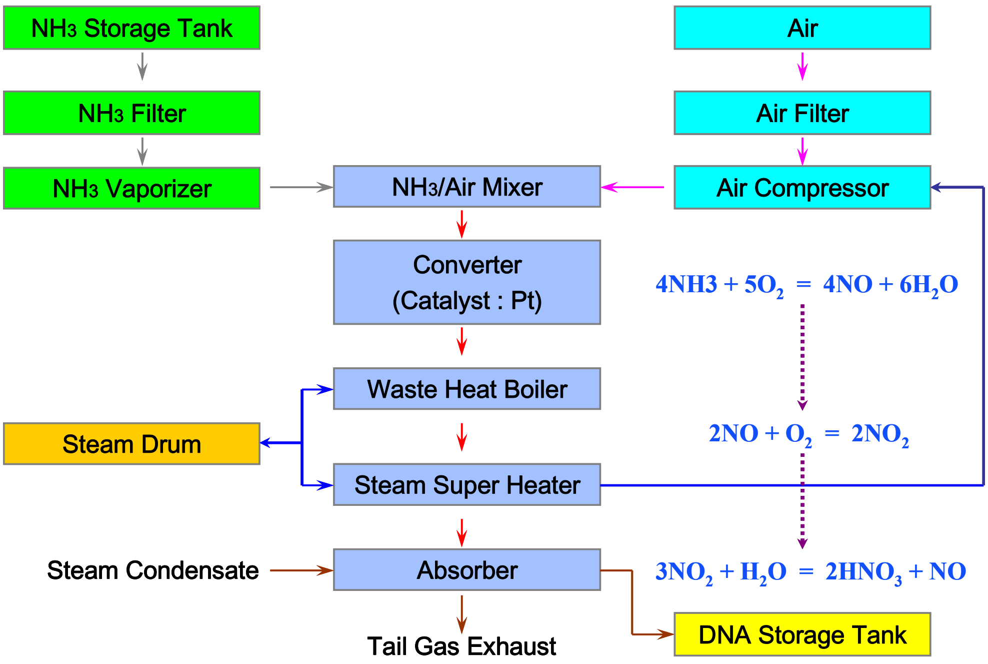
1. The proposed project activity will be applied to an existing production facility installed prior to the 31st December 2005. The plant has been commissioned and is in operation since 1992.
2. Currently, the plant does not have any N_2O destruction or abatement facilities that could be affected by the 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 N_2O emissions from nitric acid plants.
5. Presently, no N_2O abatement technology is installed in the plant.
6. The project activity will not increase in NOx emissions.
7. There is no NSCR DeNOx-unit installed in the plant.
8. The installation of the secondary N_2O 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 N_2O analyser and a volume flow meter have been commissioned at the plant in January 2007. The AMS is being operated continuously to collect the baseline data and will continue to be operated to measure concentration and total gas volume flow in the stack during the plant's operation throughout the crediting period of the project activity.

This baseline methodology shall be used in conjunction with the approved monitoring methodology AM0034 ("Catalytic reduction of N_2O inside the ammonia burner of nitric acid plants").

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

The following schematic flow-chart displays the nitric acid plant on which the project activity is to be applied. All of the production and storage facilities included in that diagramme are included in the project boundary.

Schematic flow diagramme of Dongbu's nitric acid plant



The gases relevant to the proposed project activity (and the nitric acid production plant which is subject to it) originate from the ammonia oxidation process that takes place at 910 to 920°C and 11.7 bar at the precious metal gauzes which are installed in the plant's ammonia oxidation reactor.

The main product of this reaction is NO created by oxidising ammonia (NH_3) with atmospheric oxygen (O_2) (reaction 1). NO readily oxidises further to form NO_2 (reaction 2) and thereafter put to react with water to form a mix of nitric and nitrous acid (reaction 3). Finally, nitrous acid is also transformed into nitric acid (reaction 4), entailing an emission of NO, which is partially oxidised to NO_2 (reaction 2). These intended chemical reactions (main reactions) are the following:

(1) $4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$

(2) $2\ NO + O_2 \rightarrow 2\ NO_2$

(3) $2\ NO_2 + H_2O \rightarrow HNO_3 + HNO_2$

(4) $3\ HNO_2 \rightarrow HNO_3 + NO + H_2O$

The ammonia oxidation process (see reaction 1 above) yields the desired NO molecules with a 95 to 97% probability, depending on the maintenance of the accurate temperature and pressure parameters inside the ammonia burner.

However, the operation of nitric acid plants entails several unwanted gaseous by-products that usually are emitted into the atmosphere. The undesired by-products are formed by the following reactions (side reactions) that also occur in the ammonia oxidation process:

(a) $4\ NH_3 + 3\ O_2 \rightarrow 6\ H_2O + 2\ N_2$

(b) $4\ NH_3 + 4\ O_2 \rightarrow 6\ H_2O + 2\ N_2O$

Side reaction (a) is irrelevant as it only results in the formation of water vapour and nitrogen, both present in the atmosphere in abundance. Reaction (b), however, leads to the emission of N_2O.

On leaving the ammonia oxidation reactor some of the N_2O generated may decompose

- In the high temperature homogenous gas phase inside the ammonia oxidation reactor (especially if the heat exchanger coils are inefficient or may be placed not directly underneath the ammonia oxidation section)
- At platinum deposits downstream of the ammonia oxidation reactor, provided that temperatures and contact time are sufficient and provided that any significant quantities of platinum are deposited in the first place
- In sections of the plant downstream of the ammonia oxidation reactor where temperatures are above 300°C when N_2O is thought to spontaneously decompose.

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

	Source	Gas	Included?	Justification / Explanation
Base-line	Nitric Acid Plant (Burner Inlet to Stack)	CO_2	No	The process does not lead to any CO_2 or CH_4 emissions
		CH_4	No	
		N_2O	Yes	
Project Activity	Nitric Acid Plant (Burner Inlet to Stack)	CO_2	No	The process does not lead to any CO_2 or CH_4 emissions
		CH_4	No	
		N_2O	Yes	
	Leakage emissions	CO_2	No	No leakage emissions are expected.
		CH_4	No	
		N_2O	No	

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

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 N_2O and NO_x abatement scenarios separately. This is omitted, because NO_X abatement options are only relevant if the NO_X – regulations in Korea would require an amendment of the plant. Currently the regulator NO_X emissions limit for Dongbu's nitric acid plant is 200ppmv. Dongbu uses chilled water in the final stages of the NO_2 absorption process, which brings NO_X

emission levels in the stack down to the regulatory level. Therefore, Dongbu is in full compliance with the current Korean NO_X regulation. An NDIR analyser (Environnement MIR 9000) continuously monitors NO_X concentration in the stack.

The baseline scenario alternatives should include all possible options that are technically feasible to handle N_2O emissions. For the Dongbu plant, the principally debatable options are:

1) Status quo: The continuation of the current situation, without installing any N_2O abatement technology in the plant
2) Switch to alternative production method not involving ammonia oxidation process
3) Alternative use of N_2O such as:
   a) recycling of N_2O as feedstock for the plant;
   b) The use of N_2O for external purposes.
4) Installation of a Non-Selective Catalytic Reduction (NSCR) De NO_x -unit[3]
5) Installation of an N_2O abatement or reduction technology
   a) Primary or tertiary measures to prevent the formation or reduce N_2O
   b) A secondary facility to reduce N_2O (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 NO_2 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* proceess. This was the main procedure used before now predominant Ostwald process was introduced. In 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, Dongbu could not switch to an alternative production method without building a completely new plant.

The use of N_2O as a feedstock for the Dongbu plant is technically not practicable as it is not possible to produce nitric acid from N_2O. The recovery of N_2O for the sake of gaining feedstock for the production process is not practiced in any known nitric acid plant.

The use of N_2O 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 N_2O concentration in the tail gas of Dongbu's plant measured during the baseline campaign is between approximately 1300 and 2000 ppmv. This translates to a maximum volume concentration of 0.2% of N_2O

[3] NSCR: As a NSCR DeNO_x -unit would reduce N_2O emissions as a side reaction to the NO_x -reduction, a new NSCR installation can be regarded as an alternative N_2O reduction technology.

in the stack gas. In consequence, the effort for obtaining reasonably high concentrations of N_2O would be enormous.

The latest recommendation document[4] issued under the European Integrated Pollution Prevention and Control (IPPC) Directive contains a very detailed discussion of the known and feasible options to reduce N_2O emissions from Nitric Acid production. The capturing, purification and recycling of N_2O is not discussed at all in these best practice recommendations, because it is widely accepted that this is not a technically and economically feasible option.

The installation of a Non-Selective Catalytic Reduction (NSCR) De NO_X unit is not economically viable since Dongbu is already in compliance with the prevailing NO_X regulations. Should these NO_X regulations change in a way that would require Dongbu 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. Moreover, NSCR units require additional natural gas to achieve sufficient tail gas temperatures and/or the right reducing environment inside the catalyst. Korea is a major net importer of natural gas and ammonia (which is also produced from natural gas) and therefore it is highly unlikely that Dongbu would choose a technology that would require it to purchase even more natural gas.

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.

As stated in Step 1 above, current NO_X regulations in Korea allow for the continued operation of Dongbu's nitric acid plant in its current state. There is no legal limit for N_2O emissions in Korea.

Currently, there are no laws or regulations in place that would be applicable to any of the named 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).

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)**

None of the N_2O destruction facilities (baseline scenario alternatives 5) a) and b)) 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 costs. The legislative and regulatory environment in Korea does not require any investment in N_2O abatement technology. Thus, any investment would be an entirely voluntary financial burden.

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

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[4] IPPC Reference Document on Best Available Techniques fort he Manufacture of Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers, dated December 2006.

Therefore, any baseline scenario alternatives implementing catalysts will entail considerable investment barriers. Thus, scenario alternatives 4), 5) a) and b) all are hampered by significant investment barriers and only the project activity scenario may not be hindered due to investment requirements if one assumes that CER revenues outstrip investment costs.

- **Technical barriers**

Any of the available N_2O abatement technologies are installed in a way that they will become part of the nitric acid production plant. Primary and secondary abatement technologies are installed inside the ammonia oxidation reactor of the nitric acid plant where they may, if not correctly designed and installed, interfere with the nitric acid production process which may cause a deterioration of product quality or loss of production output.

Primary abatement technology is not proven and has only shown a very limited abatement efficiency compared to secondary and tertiary measures.

Tertiary measures require the installation of a complete catalyst container between the absorption column and the stack which results in significant investment costs and may cause significant downtime of the plant during construction and commissioning.

For these reasons the baseline scenario alternatives 5 a) were not considered by Dongbu for the proposed project activity and they are excluded from further assessment.

- **Barriers due to prevailing practice**

The installation of N_2O abatement technology currently is neither industrial practice in Korea nor in the East Asian region. Proof for this claim can be derived from the CDM and JI projects at nitric acid plants around the world currently being determined / validated. None of these plants face any regulatory constraints on N_2O emissions and all of them are now implementing N_2O abatement driven solely by the incentives from the CDM. In South Korea, two CDM-projects at Hu-Chems[5] and Hanwha[6] (both using AM0028) have been registered as CDM-projects in the recent past.

In the EU there are a number of plants that have been operating with N_2O abatement catalysts for some time (up to three years) but all of these were either driven by CO_2-taxation (France and Norway) or trial operations within research & development procedures (namely Yara and BASF). Some EU operators are considering the installation of N_2O abatement catalysts[7] in preparation for the mandatory N2O emissions limits that will be imposed by the latest IPPC BAT recommendations and a possible inclusion of N2O in the EU Emissions Trading System[8].

However, all of the nitric acid plants in the host country region (Korea and China) are currently pursuing the installation of N_2O abatement technology as a CDM project. Therefore, the Dongbu CDM project is amongst the "first of its kind", not only in the region but also in the world.

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[5] UNFCCC reference no. 0765; registered on 22nd January 2007.

[6] UNFCCC reference no. 0922; registered on 3rd May 2007.

[7] For example proposed BASF JI project in Germany to be viewed at http://www.netinform.de/KE/Wegweiser/Guide22.aspx?ID=4530&Ebene1_ID=50&Ebene2_ID=1402&mode=5

[8] Responding to Article 30 of the EU ETS Directive 2003/87/EC, the Commission has submitted a report to the European Parliament and the Council considering the functioning of the Scheme. See the EU homepage under http://ec.europa.eu/environment/climat/emission/pdf/com2006_676final_en.pdf for this report which expressly considers extending the EU ETS into N_2O emissions (see page 6 therein).

Step 3b Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except for the proposed project activity).

Under step 3 a) it was demonstrated that those baseline scenario alternatives entailing the installation of N_2O abatement catalysts face considerable obstacles.

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 Korea is the status quo: The continuation of the current situation, without installing any N_2O 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	**Technical**	**Common practice**	
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_2O	Yes (Technical)	Irrelevant	Irrelevant	Irrelevant	Excluded
3 b	N_2O 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	N_2O abatement technology without CDM registration	No	Yes	No	Yes	Very Low

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

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

In November 2006 N.serve, Johnson Matthey and Dongbu signed a CDM project agreement to jointly develop the CDM project activity at Dongbu's nitric acid plant. This agreement proofs that the CDM was seriously considered before the first step of project implementation.

Step 1: Identification of alternatives to the project activity consistent with current laws and regulations

As suggested by AM0034 (Version 02), step 1 of procedure proposed by the Additionality Tool has been omitted. The identification of scenarios alternative to the proposed 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.

Steps 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 costs for the installation of a modified basket and a new heat-shield in addition to the regular lease costs payable for the installation and regular replacements of the N_2O abatement catalyst.

The total investment and operating costs of the project activity for these items throughout the 10 year crediting period (excluding the CDM related costs like Monitoring System, Validations etc.) will be considerable [9]. Since Johnson Matthey plc provides the abatement catalyst against CERs (not cash) as compensation, the basis for the simple cost analysis is the cash lease fee that Johnson Matthey charges to a comparable nitric acid plant plus the costs for providing the modified basket and heat-shield.

There may be increased energy costs associated with the slight pressure drop inside the ammonia oxidation reactor resulting from the introduction of the catalyst.

The chosen baseline scenario alternative – the continuation of the current situation, operating the nitric acid plant without an N_2O 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 has the purpose to assess the common industrial practice in the area, where the project activity is to be implemented and thus verify the results obtained in the previous steps. If the technology that is to be installed already is the common industrial practice in the region, this would be a counter-indication for the

[9] More detailed confidential information on investment and operation costs can be disclosed to the DOE upon request during the validation process.

assumption that there are financially and economically more attractive alternatives and / or 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 N_2O abatement technologies have not yet spread out into the nitric acid industry in Annex 1 countries, apart from occasional industrial testing. The main reason for this is a lack of regulation / incentive to reduce N_2O 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 N_2O emission caps. EU legislation initiating such a limit is under way already and will probably enter into force in 2007[10].

The installation of N_2O abatement technology currently is neither industrial practice in Korea nor anywhere else in the Region (i.e. for example Japan and China). Apart from other CDM project activities, the common practice in the area is to operate such facilities without any N_2O abatement technology. According to the Additionality Tool, other CDM project activities are not to be taken into account.

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:

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 monitored:
OTh Oxidation temperature for each hour (°C)
OPh Oxidation pressure for each hour (Pa)
OTnormal Normal range for oxidation temperature (°C)

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[10] Responding to Article 30 of the EU ETS Directive 2003/87/EC, the Commission has submitted a report to the European Parliament and the Council considering the functioning of the Scheme. See the EU homepage under http://ec.europa.eu/environment/climat/emission/pdf/com2006_676final_en.pdf for this report which expressly considers extending the EU ETS into N_2O emissions (see page 6 therein).

OPnormal Normal range for oxidation pressure (Pa)

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

Parameters monitored:
AFR Ammonia gas flow rate to the AOR (tNH3/h)
AFRmax Maximum ammonia gas flow rate to the AOR (tNH3/h)
AIFR_ Ammonia to air ratio (%)
AIFRmax_ Maximum ammonia to air ratio (%)

For the determination of the permitted operating conditions, the historic operating data for OTh, OPh, AFR and AIFR were recorded by the process control system for the previous 5 campaigns and analysed by using the hourly average values.

2. Determination of baseline emission factor: measurement procedure for N_2O concentration and gas volume flow

N_2O 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 N_2O concentration (NCSG) and gas volume flow (VSG) continuously. Error readings (e.g. downtime or malfunction) and extreme values are to be automatically eliminated from the output data series by the monitoring system.

Measurement results can be distorted before and after periods of downtime or malfunction of the monitoring system and can lead to mavericks. To eliminate such extremes and to ensure a conservative approach, the following statistical evaluation is to be applied to the complete data series of N2O concentration as well as to the data series for gas volume flow. The statistical procedure will be applied to data obtained after eliminating data measured for periods where the plant operated outside the permitted ranges:

a) Calculate the sample mean (x)
b) Calculate the sample standard deviation (s)
c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
d) Eliminate all data that lie outside the 95% confidence interval
e) Calculate the new sample mean from the remaining values (volume of stack gas (VSG) and N2O concentration of stack gas (NCSG))

The average mass of N_2O emissions per hour is estimated as product of the NCSG and VSG. The N_2O emissions per campaign are estimates product of N_2O emission per hour and the total number of complete hours of operation of the campaign using the following equation:

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

The plant specific baseline emissions factor representing the average N_2O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N_2O 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 N_2O 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 N_2O emissions in Korea, 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 EFBL 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 N_2O emission levels, the historic campaign lengths and the baseline campaign length are to be determined and compared to the project campaign length. Campaign length is defined as the total number of metric tonnes of nitric acid at 100% concentration produced with one set of gauzes.

The average historic campaign length (CL_{normal}) defined as the average campaign length for the historic campaigns used to define operating condition (the previous five campaigns), will be used as a cap on the length of the baseline campaign.

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

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

Statistical Tests comparing Baseline Campaign with "normal" operating conditions

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

Since no specific statistical tests 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, N_2O concentration and gas volume flow in the stack of the nitric acid plant as well as the temperature and pressure of ammonia gas flow and ammonia-to-air ratio will be measured continuously.

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

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

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

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

Step1: estimate campaign specific emissions factor for each campaign during the project's crediting period by dividing the total mass of N_2O emissions during that campaign by the total production of 100% concentrated nitric acid during that same campaign. For example, for campaign n the campaign specific emission factor would be:

$EF_n = PE_n / NAP_n$

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

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

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:

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

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

Minimum Project Emissions Factor

N_2O emissions that may result from a potential built up of platinum deposits. After the first ten campaigns of the crediting period of the project, the lowest EF_n observed during those campaigns will be adopted as a minimum (EF_{min}). EF_{min} Is equal to the lowest EF_n observed during the first 10 campaigns of the project crediting period ($N_2O/tHNO_3$). If any of the later project campaigns results in a EF_n that is lower than EF_{min}, the calculation of the emission reductions for that particular campaign shall used 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 N_2O values measured during the baseline campaign can be used for the calculation of EF (subject to the elimination of data from the Ammonia/Air analysis, see above). If $CL_n < CL_{normal}$, recalculate EF_{BL} by eliminating those N_2O values that were obtained during the production of tonnes of nitric acid beyond the CL_n (i.e. the last tonnes produced) from the calculation of EF_n.

Emission Reductions

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

$ER = (EF_{BL} – EF_P) * NAP * GWP_{N2O}$

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 109,500 metric tonnes of 100% concentrated nitric acid per year (based on 365[11] operating days per year and a daily nameplate capacity of 300 tonnes per day of nitric acid). Therefore, the Dongbu's nitric acid plant shall not be eligible to earn CERs for any tonnes of nitric acid produced exceeding 64,605 in any one year.

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

The monitoring procedures for the parameters have been made part of the ISO 9001 procedures.

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

The baseline campaign at Dongbu has started on April 6, 2007 and was completed on 14 June 2007. The data in the table below is based on measurements during part of the previous campaign and are therefore considered approximations for the expected baseline data.

Data / Parameter:	**B.1 $NCSG_{BC}$**
Data unit:	mg N_2O / m³
Description:	N_2O concentration in the stack gas during the baseline campaign.
Source of data used:	ADC MGA 3000 gas analyser[12]
Value applied:	3,318.9
Justification of the choice of data or description of measurement methods and procedures actually applied :	AM0034 requires the determination of the concentration of N_2O in the stack gas. NCSG is continuously monitored with the gas analyser installed and commissioned on January 29, 2007. Monitoring results are recorded for every two seconds of plant operation. Hourly means for NCSG are derived from the collected data. NCSG data taken during times when the respective plant was operating outside the permitted operating range were eliminated. The remaining NCSG values where subjected to the following adjustment. The analyser reads ppmv (parts per million in volume); in order to obtain mg/Nm^3 is necessary use the next equation: $NCSG = ppmv * \frac{RMM}{v}$ Where: *NCSG* is N_2O concentration in the stack gas (mg/N m^3) *ppmv* means parts per million in volume *RMM* means relative molecular mass of N_2O (44.013 mg) *v* means standard volume of an ideal gas (22.4 Nm^3) The resulting hourly average NCSG values are now expressed in mg/Nm^3 as required by AM0034 and where subsequently subjected to the following statistical analysis:

11 As per AM0034 page 11.

12 The ADC MGA 3000 is currently undergoing the suitability testing to be certified under QAL1 of ISO 14956 and EN14181. It is expected that the suitability testing will be concluded and certification is expected occur by late 2007.

	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 During the QAL2 reference measurements it was determined that the analyser consistently overestimates the N_2O concentration in the stack. As a result from the QAL2 calibration curve, it was determined that a correction factor of 0.945 will have to be applied to all NCSG measurements. Therefore, the result of the above statistical analysis, i.e. the mean NCSG value will be multiplied by 0.945 before going into the calculation of BE_{BC}.
Any comment:	None

Data / Parameter:	**B.2 VSG_{BC}**
Data unit:	Nm^3/h
Description:	Normal gas volume flow rate of the stack gas during the baseline campaign.
Source of data used:	Systec DF25 [13]
Value applied:	41,713.1
Justification of the choice of data or description of measurement methods and procedures actually applied :	AM0034 requires the determination of the gas volume flow (VSG) in the stack. VSG is continuously monitored with a flow meter (operational since Jan 29, 2007) and monitoring results are recorded for every two seconds of plant operation. Hourly means for VSG are derived from the collected data. VSG data taken during times when the respective plant was operating outside the permitted operating range were eliminated. The remaining VSG data series has been subjected to the following adjustment. The flow meter was installed with an operational range of 0 – 10 mbar of differential pressure. To obtain the flow (Nm3/h) at normal conditions (101.325 kPa and 0°C) from measured differential pressure the instrument equation – taken from the AMS manual – is used which includes pressure and temperature correction factors. Calculation formula (standard volume flow): $V_n = K_x * \frac{\sqrt{P}}{\sqrt{(273{,}15+T)}} * \sqrt{dP}$ whereby: $K_x = \frac{0{,}020763 * D^2 * k}{\sqrt{\rho_N}}$ calculated: Kx = 7774 Where: *VSG* means standard volume flow (Nm^3/h) *D* means stack inner diameter (mm) *ρN* means standard density (kg/Nm^3)

[13] The Systec Flow meter has already been approved by TÜV under the German 17. BImSchV.

	k means instrument correction factor (specific for each individual instrument) *P* means pressure working conditions (mbar) *T* means temperature working conditions (°C) ΔP means differential pressure (mbar) *0.020763* is the unit conversion factor The resulting hourly average VSG values are now expressed in Nm^3/h as required by AM0034 and where subsequently subjected to the following statistical analysis: a) Calculate the sample mean (x) b) Calculate the sample standard deviation (s) c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation) d) Eliminate all data that lie outside the 95% confidence interval e) Calculate the new sample mean from the remaining VSG values During the QAL2 reference measurements it was determined that the flow meter's range is set lower than the maximum flow in the stack. As a result, the flow meter consistently underestimates the total gas volume flow in the stack. As a result from the QAL2 calibration curve, it was determined that a correction factor of 1.096 will have to be applied to all VSG measurements. Therefore, the result of the above statistical analysis, i.e. the mean VSG value will be multiplied by 1.096 before going into the calculation of BE_{BC}.
Any comment:	none

Data / Parameter:	**B.3 BE_{BC}**
Data unit:	tN_2O
Description:	Total N_2O gas flow for baseline campaign
Source of data used:	Calculation from measured data (B.1 and B.2)
Value applied:	To be determined for complete baseline campaign
Justification of the choice of data or description of measurement methods and procedures actually applied :	The total mass N_2O emissions during the baseline campaign are determined as a product of NSCG, VSG and the total hours of operation during that baseline campaign: $BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC}$
Any comment:	None

Data / Parameter:	**B.4 OH_{BC}**
Data unit:	Hours
Description:	Operating hours
Source of data used:	Plant operating log
Value applied:	1,506
Justification of the choice of data or	Every hour of operation for which there is a record of nitric acid produced will be considered as an operational hour for the purposes of BE_{BC} calculation.

description of measurement methods and procedures actually applied :	However, if the plant exceeds certain design parameters, it will automatically shut down (“trip limits”). Periods during the ongoing campaign during which the plant was considered not in operation will be eliminated from the determination of OH. The plant was considered to be not in operation when any of the following parameters where outside the “trip” limits as determined by the plant manuals: AIFR > 0.075 (i.e. if the Ammonia concentration in Air is higher than 7.5%, the plant shuts itself off automatically) OTh > 955°C OPh < 10.55 bar The following additional criteria were applied to exclude any obviously non-sensical values and the corresponding operating hours (OH) eliminated: OTh < 550°C AFR = 0 (These values were chosen arbitrarily with a view to capture and exclude such values that where obviously not valid or non-sensical)
Any comment:	None

Data / Parameter:	**B.5 NAP_{BC}**
Data unit:	$tHNO_3$
Description:	Nitric acid (100% conc.) over baseline campaign
Source of data used:	Tank level measurements
Value applied:	19,026.6
Justification of the choice of data or description of measurement methods and procedures actually applied :	Please refer to table P. 5 NAP below for a detailed description of NAP determination. To make the adjusted tank level measurements suitable for monitoring in this CDM project, any adjustments will be done at the end of each campaign (baseline and project), in addition to the irregular intervals throughout each month. At the beginning of the baseline campaign Dongbu took a tank level measurement and adjusted the NAP number accordingly for that day to establish a correct starting point for the determination of NAP throughout the baseline. The same will be done at the end of the campaign.
Any comment:	None

Data / Parameter:	**B.6 TSG**
Data unit:	Degrees Centigrade (°C)
Description:	Temperature of the stack gas
Source of data used:	Thermocouple situated next to the flow meter probe.

Value applied:	n/a
Justification of the choice of data or description of measurement methods and procedures actually applied :	The temperature measurement of the stack gas is required to calculate the Normal Volume Flow (Nm^3/h) in the stack and is not required to be reported as a separate parameter in accordance with AM0034.
Any comment:	None.

Data / Parameter:	**B.7 PSG**
Data unit:	Bar
Description:	Pressure of stack gas
Source of data used:	Probe (part of the gas volume flow meter)
Value applied:	
Justification of the choice of data or description of measurement methods and procedures actually applied :	The pressure measurement of the stack gas is required to calculate the Normal Volume Flow (Nm^3/h) in the stack and is not required to be reported as a separate parameter in accordance with AM0034.
Any comment:	None

Data / Parameter:	**B.8 EF_{BL}**
Data unit:	tN_2O / $tHNO_3$
Description:	Emissions factor for baseline period
Source of data used:	Calculated from measured data (tons of nitric acid produced / tons of N_2O emitted)
Value applied:	0.01078
Justification of the choice of data or description of measurement methods and procedures actually applied :	As required by AM0034 the plant specific baseline emissions factor representing the average N_2O emissions per tonne of nitric acid during the baseline campaign is derived by dividing the total mass of N_2O 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 (UNC). The product of the NCSG, VSG and OH is the total N_2O mass emissions during the baseline campaign. The N_2O emission factor per tonne of nitric acid produced in the baseline period (EF_{BL}) shall then be reduced by the percentage uncertainty as follows: $EF_{BL} = (BE_{BC} / NAP_{BC})\ (1 – UNC/100)$ $[tN_2O/tHNO_3]$
Any comment:	None

Data / Parameter:	**B.9 UNC**
Data unit:	%

Description:	Overall measurement uncertainty of the monitoring system
Source of data used:	Calculation of combined uncertainty of the applied monitoring equipment
Value applied:	5.0%
Justification of the choice of data or description of measurement methods and procedures actually applied :	A complete QAL2 audit, including SRM measurements, based on the provisions of EN 14181 was carried out by a qualified testing house in April and June 2007. As a result of this audit, the overall total uncertainty of the AMS was determined and applied to the EF_{BL}.
Any comment:	None

Data / Parameter:	**B.10 AFR**
Data unit:	$kgNH_3/h$
Description:	Mean Ammonia gas flow rate to the Ammonia Oxidation Reactor (AOR)
Source of data used:	Monitored by Orifice plate
Value applied:	Not applicable, monitored data of AFR will be used to determine if plant was operating outside of AFR_{max}.
Justification of the choice of data or description of measurement methods and procedures actually applied :	The monitoring of AFR is required by AM0034 in order to determine when the plant was operating outside of AFR_{max} and to eliminate those NCSG and VSG data.
Any comment:	none

Data / Parameter:	**B.11 AFR_{max}**
Data unit:	$kgNH_3/h$
Description:	Maximum Ammonia flow rate
Source of data used:	Plant operations records from previous five campaigns.
Value applied:	3,797
Justification of the choice of data or description of measurement methods and procedures actually applied :	AFR_{max} is used to determine those periods where the plant may be operating outside of the permitted operating conditions. The AFR data from the previous 5 campaigns was used to determine AFR_{max} during these campaigns after the exclusion of the upper and lower 2.5% percentiles.
Any comment:	None

Data / Parameter:	**B.12 AIFR**
Data unit:	% v/v of NH_3 in air
Description:	Mean Ammonia to air ratio into the ammonia oxidation reactor
Source of data used:	Calculated from measured data of AFR and primary air flow rate.
Value applied:	Not applicable, monitored data of AIFR will be used to determine if plant was operating outside of $AIFR_{max}$.
Justification of the	The monitoring of AIFR is required by AM0034 in order to determine $AIFR_{max}$.

choice of data or description of measurement methods and procedures actually applied :	The permitted range for the NH_3 to Air ratio is taken from the data of the historic campaigns.
Any comment:	AM0034 (Version 02) states that the units for AIFR should be m^3/h, this is a mistake. AIFR should be expressed as a ratio or percentage volume by volume of Ammonia in Air.

Data / Parameter:	**B.13 CL_{BL}**
Data unit:	$tHNO_3$
Description:	Length of the baseline campaign measured in metric tonnes of 100% concentrated nitric acid produced during that baseline campaign.
Source of data used:	NAP_{BC}
Value applied:	19,026.6
Justification of the choice of data or description of measurement methods and procedures actually applied :	CL_{BL} is comprised of each and every tonne of nitric acid produced during the baseline campaign, regardless of whether the measured NCSG and VSG data were excluded from the relevant period. In accordance with AM0034 the respective baseline campaign length for each plant (CL_{BL}) has to be compared to the established average historic campaign length (CL_{normal}); and If $CL_{BL} \leq CL_{normal}$, then all N_2O values measured during the baseline campaign can be used for the calculation of EF_{BL} (subject to the elimination of data that was monitored during times where the plant was operating outside of the "permitted range"). If $CL_{BL} > CL_{normal}$, then N_2O values that were measured beyond the length of CL_{normal} during the production of the quantity of nitric acid (i.e. the final tonnes produced) are to be eliminated from the calculation of EF_{BL}. The Baseline campaign was shorter than CL_{normal} and hence no baseline cut has to be conducted.
Any comment:	None

Data / Parameter:	**B.14 CL_{normal}**
Data unit:	$tHNO_3$
Description:	Average length of the five historic campaigns measured in metric tonnes of 100% concentrated nitric acid.
Source of data used:	Production logs
Value applied:	20,672
Justification of the choice of data or description of measurement methods and procedures actually applied :	CL_{normal} is used to adjust CL_{BL} and NAPBC in accordance with AM0034.´ Please refer to table P.5 NAP below for reference. In the past, the regular readjustment of the measured nitric acid storage tank levels of the calculated NAP did not normally coincide with the end of each campaign. Therefore, it is now impossible to derive adjusted figures for each of

	the historic campaigns. However, since the adjustments were done several times each month, the small imprecision in one campaign will be corrected by the number in the next campaign. Therefore, the derived average NAP from the five historic campaigns will result in a correct average NAP, which can be used as CL_{normal}.
Any comment:	None.

Data / Parameter:	**B.15 $AIFR_{max}$**
Data unit:	% v/v of NH_3 in air
Description:	Maximum Ammonia to air ratio into the ammonia oxidation reactor
Source of data used:	Calculated from measured data of AFR and primary air flow rate.
Value applied:	0.08
Justification of the choice of data or description of measurement methods and procedures actually applied :	In accordance with AM0034 $AIFR_{max}$ is used to determine those periods where the plant may be operating outside of the permitted operating conditions. The AIFR data from the previous 5 campaigns was used to determine $AIFR_{max}$ during these campaigns after the exclusion of the upper 2.5% percentile. The value of $AIFR_{max}$ in this case is higher than the AIFR trip value defined by the plant operating manual, which is 0.075. $AIFR_{max}$ is derived from the monitoring data. However, this still includes extreme values during plant start-up and shut-down. For the determination of the correct OH_{BC} (see B.4 above) the AIFR trip value was in fact applied to the complete data set. Therefore, any NCSG and VSG data measured while the plant was outside the trip values was not considered for the determination of BE_{BC}. As can be seen from the table for query 6 a + b below (section B.6.3), the allowed $AIFR_{max}$ is 0.08 but the maximum value observed from the remaining data is exactly the trip value of 0.075.
Any comment:	AM0034 (Version 02) states that the unit for AIFR is m^3/h, this is a mistake: AIFR should be expressed as a ratio or percentage volume by volume of Ammonia in Air.

Data / Parameter:	**B.16 OT_h**
Data unit:	°C
Description:	Oxidation temperature for each hour during the baseline campaign
Source of data used:	Thermocouple inside Ammonia Oxidation Reactor (AOR)
Value applied:	Not applicable, used to determine if OTh during baseline campaign falls outside OT_{normal}.
Justification of the choice of data or description of measurement methods and procedures actually applied :	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}.
Any comment:	None.

Data / Parameter:	B.17 OT_{normal}
Data unit:	°C (min and max)
Description:	Normal range of operating temperatures during the 5 historic campaigns.
Source of data used:	Thermocouples inside Ammonia Oxidation Reactor (AOR) during historical campaigns.
Value applied:	907.3 (min.) and 932.0 (max.)
Justification of the choice of data or description of measurement methods and procedures actually applied :	Measurements are taken continuously by two thermocouples inside the AOR, all data taken during the 5 historic campaigns have been interpreted as a sample of a stochastic variable. All data falling within the upper and lower 2.5% percentile have been eliminated, the range of the remaining values represents the maximum and minimum normal operating temperatures in the AOR.
Any comment:	None

Data / Parameter:	B.18 OP_h
Data unit:	kg / cm^2
Description:	Oxidation Pressure for each hour during the baseline campaign
Source of data used:	Monitored by pressure transmitter.
Value applied:	Not applicable, used to determine if OP_h during baseline campaign falls outside OP_{normal}.
Justification of the choice of data or description of measurement methods and procedures actually applied :	AM0034 requires the monitoring of the oxidation pressure in the ammonia oxidation reactor. In Dongbu's nitric acid plant, the pressure is measured after the air compressor discharge and not inside the ammonia oxidation reactor. However, since the location of this pressure probe remains the same during the historic campaigns, the baseline period and the project campaigns, it is appropriate to use this value for comparison of OP_h between these campaigns. 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 OPh was above or below OP_{normal} has to be eliminated from the calculation of EF_{BL}.
Any comment:	None.

Data / Parameter:	B.19 OP_{normal}
Data unit:	kg / cm^2
Description:	Oxidation Pressure for each hour during the five historic campaigns.
Source of data used:	Monitored by pressure transmitter.
Value applied:	13.25 (min.) and 14.75 (max.)
Justification of the choice of data or description of measurement methods and procedures actually applied :	In accordance with AM0034 the oxidation pressure in the ammonia oxidation reactor during the five historic campaigns is used to determine the normal range of operating pressures (OP_{normal}). All data taken during the 5 historic campaigns have been interpreted as a sample of a stochastic variable. All data falling within the upper and lower 2.5% percentile have been eliminated; the range of the remaining values represents the maximum and minimum normal operating

	temperatures in the AOR.
Any comment:	None.

Data / Parameter:	**B.20 GS_{normal}**
Data unit:	Name of supplier.
Description:	Gauze supplier for the five historic campaigns
Source of data used:	Monitored / Invoices.
Value applied:	Johnson Matthey Noble Metals
Justification of the choice of data or description of measurement methods and procedures actually applied :	The value for GS_{normal} is only a plausibility check; the decisive value in determining if the baseline campaign data is applicable is the comparison of GC_{normal} and GC_{BL}. Dongbu has been using gauzes supplied by Johnson Matthey continuously for the past several years.
Any comment:	None.

Data / Parameter:	**B.21 GS_{BL}**
Data unit:	Name of supplier.
Description:	Gauze supplier for the baseline campaign
Source of data used:	Monitored / Invoices
Value applied:	Johnson Matthey plc.
Justification of the choice of data or description of measurement methods and procedures actually applied :	See B.20 above.
Any comment:	None.

Data / Parameter:	**B.22 GS_{PC}**
Data unit:	
Description:	Gauze supplier for the project campaign
Source of data used:	Monitored / Invoices
Value applied:	Johnson Matthey plc.
Justification of the choice of data or description of measurement methods and procedures actually applied :	See B.20 above.
Any comment:	None.

Data / Parameter:	**B.23 GC_{normal}**
Data unit:	%

Description:	Gauze composition during the five historic operating campaigns expressed as percentage by weight of the precious metals Platinum, Rhodium and, if applicable, Palladium comprising the Ammonia Oxidation Catalyst gauzes.
Source of data used:	Monitored / Invoices
Value applied:	Platinum: 90.0 Rhodium: 5.0 Palladium: 5.0
Justification of the choice of data or description of measurement methods and procedures actually applied :	In accordance with AM0034, if the composition of the ammonia oxidation catalyst used for the baseline campaign and after the implementation of the project are identical to that used in the campaign for setting the operating conditions (previous five campaigns), then there shall be no limitations on N_2O baseline emissions.
Any comment:	None.

Data / Parameter:	**B.24 GC_{BL}**
Data unit:	%
Description:	Gauze composition during the baseline campaign expressed as percentage by weight of the precious metals Platinum, Rhodium and, if applicable, Palladium comprising the Ammonia Oxidation Catalyst gauzes.
Source of data used:	Monitored / Invoices
Value applied:	Platinum: 90.0 Rhodium: 5.0 Palladium: 5.0
Justification of the choice of data or description of measurement methods and procedures actually applied :	In accordance with AM0034, if the composition of the ammonia oxidation catalyst used for the baseline campaign and after the implementation of the project are identical to that used in the campaign for setting the operating conditions (previous five campaigns), then there shall be no limitations on N_2O baseline emissions. Since the values for GC are the same during the baseline campaign as during the historic campaigns, there is no limitation on the N_2O baseline emissions.
Any comment:	None.

Data / Parameter:	**B.25 $GC_{project}$**
Data unit:	%
Description:	Gauze composition during the baseline campaign expressed as percentage by weight of the precious metals Platinum, Rhodium and, if applicable, Palladium comprising the Ammonia Oxidation Catalyst gauzes.
Source of data used:	Monitored / Invoices
Value applied:	To be obtained during the project campaigns.
Justification of the choice of data or description of measurement methods	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

and procedures actually applied :	factor applied.
Any comment:	None.

Data / Parameter:	**B.26 EF_{reg}**
Data unit:	$tN_2O/tHNO_3$
Description:	Emissions cap for N_2O from nitric acid production set by government regulation
Source of data used:	Ministry of Environment
Value applied:	None
Justification of the choice of data or description of measurement methods and procedures actually applied :	There is currently no regulation in Korea that limits the emissions of N_2O from nitric acid production. The development of regulations will be checked regularly for any possible developments towards a regulatory limit for N_2O emissions. If such regulation should be implemented, the corresponding regulatory emissions factor EF_{reg} will be established in accordance with AM0034.
Any comment:	None.

B.6.3 Ex-ante calculation of emission reductions:

Description of the N.serve Database Management System (N.DBMS)

All data necessary for the monitoring and verification procedures related to the project activity are transferred from the nitric acid plant's data acquisition system into a dedicated relational database management system ("N.DBMS") based on Microsoft Access 2002. Database management systems are designed for a structured storage of large amounts of data providing for minimum redundancy and maximum flexibility to allow best practice data analysis. Relation DBMS organize all data in tables. N.DBMS mainly consists of three such tables, labelled PROJECTS, CAMPAIGNS, and DATA_CROSS.

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

Structure of table PROJECTS

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

Sample content of table PROJECTS

Projects				
ProjId	**ProjName**	**ProjOwner**	**ProjLoc**	**ProjCountry**
1	Dongbu	Dongbu Hannong Chemicals Ltd.	Ulsan	Korea

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

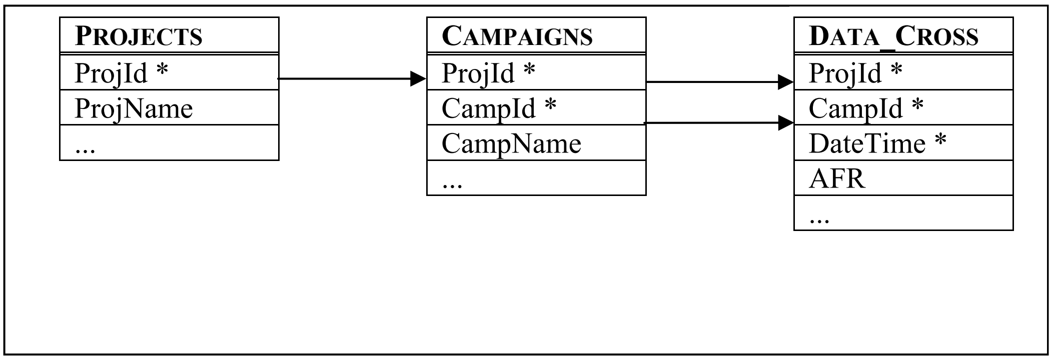
Finally, the times series of the parameter values listed above are stored in table DATA_CROSS. Each set of values for the different parameters is identified by the ProjId, CampId and a date/time-stamp.

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, there is no practical limit (other than disk space and computer performance) 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

Historical Query 1: Analysis of the raw historical campaign data

In a first step, a number of statistical calculations are carried out for the historical and baseline data using Query 1[14]:

- Number of data sets
- Minimum value
- Maximum value
- Mean value and/or sum (depending on the character of the parameter)
- Standard deviation
- 95% confidence interval

The resulting Access table is shown in part below:

Query 1: Without parameter limits

ProjId	CampType	Count(DT)	Max(AFR)	Max(AIFR)	Min(Oph)	Max(Oph)	Min(OTh)	Max(OTh)	Sum(NAP)
11	H	4,148.00	333.28	11.41	0.00	144.00	0.00	941.00	103,360.43

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

[14] All queries are available and can be provided to the DOE upon request.

N.DBMS	Dongbu (Ulsan, Korea)								
Historical campaig	Query 1: Without parameter limits								
Parameter	OH	AFR	AIFR	Oph	OTh	NCSG		VSG	NAP
Unit	h	t NH3 / h	ratio	kg / cm2	°C	ppm	mg N2O / Nm3	Nm3 / h	kg HNO3
Count	4,148	4,148	4,126	4,147	4,142				
Minimum		0	0.006	0.00	0				
Maximum		333	6.691	144.0	941				
Mean		3.37	0.068	14.0	915				
Standard deviation		5.15	0.105	2.3	64				
95% Confidence Interval		10.10	0.206	4.5	125				
Sum									103,360
CL normal									20,672

This set of data also shows the total tonnes of nitric acid produced during the five historic campaigns. This number is divided by five to derive the average historic nitric acid production during those five campaigns, which represents the value of CL_{normal}.

In the next query, lines of data in which at least one value is missing or obviously wrong (e.g. negative or an OPh value of 100 bar etc.) are completely eliminated. To make this more systematic, the following exclusion criteria were applied:

AFR < 10 kgNH3/h

OPh < 50 bar (i.e. if the ammonia oxidation pressure in the raw data log for a particular point in time is higher than 50 bar, the whole line of data is excluded from further analysis)

AIFR < 0.12 (this excludes only one single value)

OTh > 550°C (The OTh cut off was chosen at 550°C to be consistent with the trip criteria applied during the baseline campaign)

Historical Query 2: Analysis of the raw historical campaign data

N.DBMS	Dongbu (Ulsan, Korea)								
Historical campaigns	Query 2: With limits on historical data								
Parameter	OH	AFR	AIFR	Oph	OTh	NCSG	NCSG	VSG	NAP
Unit	h	t NH3 / h	ratio	kg / cm2	°C	ppm	mg N2O / Nm3	Nm3 / h	kg HNO3
Count	4,106	4,106	4,106	4,106	4,106				
Remaining share of data set	99%	99%	100%	99%	99%				
Minimum		0.32	0.006	1.9	817				
Maximum		3.80	0.080	16.3	941				
Mean		3.30	0.066	14.0	919				
Standard deviation		0.09	0.003	0.4	7				
95% Confidence Interval		0.17	0.005	0.9	13				
Sum									101,992
Limits acc. to consistency check		not blank	not blank	not blank	not blank				
Lower limit					550				
Upper limit		10	0.081	50					

In a next step, the remaining historical data are analysed in excel to determine and eliminate the upper and lower 2.5% percentiles for OPh and OTh. In the case of Dongbu, the plant is operating under very stable conditions resulting in fairly narrow “permitted operating ranges” from this analysis of historical data:

OPh range: 13.25 to 14.75 kg/cm^2 or bar

OTh range: 907.3 to 932.0 °C

This permitted range is then applied in Query 5 below.

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

Baseline Query 1: Analysis of the raw baseline data without any operating limits applied

N.DBMS	Dongbu (Ulsan, Korea)								
Baseline campaign	**Query 1: Without parameter limits**								
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	ratio	kg / cm2	°C	ppm	mg N2O / Nm3	Nm3 / h	kg HNO3
Count	1,507	1,507	1,507	1,507	1,507	1,507		1,507	0
Minimum		1.86	0.060	11.48	661	139	*275*	3,198	
Maximum		3.36	0.143	15.01	932	2,300	*4,554*	43,683	
Mean		3.21	0.068	13.65	920	1,682	*3,330*	41,297	
Standard deviation		0.09	0.003	0.43	11	198	*393*	2,313	
Sum	1,507								19,027
Baseline emissions	**BE**	*= VSG * NCSG * OH*						t N2O	**207.3**
Emission factor	**EF**	*= BE / NAP*						kg N2O / t HNO3	**10.89**

This table gives the raw results for NAP, OH, NCSG, VSG and EF_{BL}.

Next, in queries 3 and 4, the OPh and OTh values are subjected to the 2.5% percentile analysis and subsequently the complete baseline data set will be subjected to the permitted operating range resulting from the historic operating parameters.

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

N.DBMS	Dongbu (Ulsan, Korea)								
Baseline campaign	**Query 5: Permitted Range applied to BL data, invalid data sets excluded**								
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	ratio	kg / cm2	°C	ppm	mg N2O / Nm3	Nm3 / h	kg HNO3
Count	1,231	1,231	1,231	1,231	1,231	1,231		1,231	
Remaining share of data set	82%	82%	82%	82%	82%	82%		82%	
Minimum		2.98	0.062	13.3	907	668	*1,323*	28,705	
Maximum		3.36	0.075	14.7	931	2,262	*4,479*	43,683	
Mean		3.22	0.068	14	920	1,687	*3,342*	41,645	
Standard deviation		0.05	0.003	0.3	5	194	*385*	983	
95% Confidence Interval		0.10	0.006	0.7	9	381	*754*	1,927	
Sum	1,506								19,027
Limits acc. to consistency check									
Lower limit		0	0	13.25	907.3				
Upper limit		3.797	0.080	14.75	932.0				
Baseline emissions	**BE**	*= VSG * NCSG * OH*						t N2O	**209.6**
Emission factor	**EF**	*= BE / NAP*						kg N2O / t HNO3	**11.01**

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

The remaining share of the operating data after Query 5 is 82% of the raw data and therefore meets the criterion set by AM0034 that the plant must be operating within the permitted range at least 50% of the time during the baseline campaign.

The results of this query are the OH (1,506) and NAP (19,026.6) values used for the calculation of BE and EF_{BL} respectively.

Query 6 a + b: Application of 95% confidence interval, AMS UNC and calculation of EF_{BL}

N.DBMS	Dongbu (Ulsan, Korea)									
Baseline campaign	**Query 6a+b: Confidence levels for NCSG and VSG**									
	Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
	Unit	h	t NH3 / h	ratio	kg / cm2	°C	ppm	mg N2O / Nm3	Nm3 / h	kg HNO3
Count							1,174		1,195	
Minimum			2.977	0.062	13.3	907	1,313	2,599	39,740	
Maximum			3.357	0.075	14.7	931	2,066	4,090	43,492	
Mean			3.220	0.068	13.7	920	1,676	3,318.9	41,713.1	
Standard deviation							169	335	842	
95% Confidence Interval										
Sum		1,506.0								19,026.6
Limits acc. to consistency check			not blank	not blank	not blank	not blank	not blank		not blank	
Lower limit					13.25	907.3	1,307		39,717	
Upper limit			3.797	0.080	14.75	932.0	2,068		43,572	
		Correction factors resulting from QAL2					**0.945**		**1.096**	
Baseline emissions		**BE**		*= VSG * NCSG * OH*					t N2O	**215.9**
Emission factor		**EF**		*= BE / NAP * (1 - UNC/100)*					kg N2O / t HNO3	**10.78**
Uncertainty		UNC								**5.00**

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.

Resulting EFBL

The EF_{BL} derived from this analysis of historic and baseline data is 10.78 $kgN_2O/tHNO_3$.

Statistical test if the baseline is representative of a normal campaign

Compare BL campaign with Historic Campaigns

Historic campaigns:

Historic upper 95% CI level	3.46	0.071	14.9	932.5
Baseline mean values	3.22	0.068	13.7	920.1
Historic lower 95% CI level	3.13	0.060	13.2	905.9

The values appearing in green letters in the above table indicate that the values during the BL campaign were within 1.96 times the standard deviation of the mean values from the historic 5 campaigns. Therefore, it can be concluded that the baseline is representative of a normal campaign.

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):

- Production output of nitric acid (NAP) per year is expected to be 90,000 tonnes of nitric acid over the next 10 years.
- Emissions Factor during each of the project campaigns (EF_P) which is mainly influenced by the abatement efficiency of the N_2O abatement catalyst, which is conservatively assumed to be 80% of baseline N_2O emissions.
- EF_{BL} of 10.78 $kgN_2O/tHNO_3$.
- Project start in mid January 2008.

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

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

Year	Estimation of project activity emissions (tonnes of CO2 e)	Estimation of baseline emissions (tonnes of CO2 e)	Estimation of leakage (tonnes of CO2 e)	Estimation of overall emission reductions (tonnes of CO2 e)
2008	45,163	225,816	0	180,653
2009	60,163	300,814	0	240,651
2010	60,163	300,814	0	240,651
2011	60,163	300,814	0	240,651
2012	60,163	300,814	0	240,651
2013	60,163	300,814	0	240,651
2014	60,163	300,814	0	240,651
2015	60,163	300,814	0	240,651
2016	60,163	300,814	0	240,651
2017	60,163	300,814	0	240,651
2018	14,999	74,997	0	59,998
Total	**601,627**	**3,008,137**	**0**	**2,406,510**

B.7 Application of the monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

The monitoring procedures as described for each parameter below are an integral part of the company's ISO 9001 QA system, certified to and audited by "The Standards Institution of Korea".

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

Data / Parameter:	**P.1 NCSG**
Data unit:	mg N_2O / m³ (converted from ppmv, if necessary)
Description:	N_2O concentration in the stack gas during each project campaign.
Source of data to be used:	ADC MGA 3000 gas analyser[15]
Value of data applied for the purpose of calculating expected emission reductions in section B.5	To be determined during project campaigns.
Description of measurement methods and procedures to be applied:	AM0034 requires the determination of the concentration of N_2O in the stack gas. NCSG is continuously monitored with the gas analyser. Monitoring results are recorded for every two seconds of plant operation. Hourly means for NCSG are derived from the collected data. NCSG data taken during times when the respective plant was operating outside the permitted operating range were eliminated. The remaining NCSG values where subjected to the following adjustment. The analyser reads ppmv (parts per million in volume); in order to obtain mg/Nm^3 is necessary use the next equation: $$NCSG = ppmv * \frac{RMM}{v}$$ Where: *NCSG* is N_2O concentration in the stack gas (mg/N m^3) *ppmv* means parts per million in volume *RMM* means relative molecular mass of N_2O (44.013 mg) *v* means standard volume of an ideal gas (22.4 Nm^3) The resulting hourly average NCSG values are now expressed in mg/Nm^3 as required by AM0034 and where subsequently subjected to the following statistical analysis: a) Calculate the sample mean (x) b) Calculate the sample standard deviation (s)

[15] The ADC MGA 3000 is currently undergoing the suitability testing to be certified under QAL1 of ISO 14956 and EN14181. It is expected that the suitability testing will be concluded and certification is expected occur by late 2007.

	c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation) d) Eliminate all data that lie outside the 95% confidence interval e) Calculate the new sample mean from the remaining NCSG values
QA/QC procedures to be applied:	Zero calibration gas is pure N2 with a certified accuracy of +/- 2% is supplied by MS General Gas Co. in Korea (analytical report available on site for DOE to inspect). The zero gas cylinder must always be open and connected to the analyser. Analyser is set to automatic zero calibration every 8 hours. At the end of the zero calibration, the zero point is reset automatically by the analyser. Span calibration gas is 2007 µmol/mol N_2O in Air with a certified accuracy of +/- 2% is supplied by Research Institute of Gas Analytical Science (RIGAS) (analytical report available on site for DOE to inspect). Dongbu plant staff conduct a span calibration once per week. At the end of the span calibration, the measuring output of the analyser has to be reset manually by the person conducting the span calibration. The person conducting the calibration has to fill out the calibration log-sheet with the following information
Any comment:	None.

Data / Parameter:	**P.2 VSG**
Data unit:	Nm^3/h
Description:	Normal gas volume flow rate of the stack gas during each project campaign
Source of data to be used:	Systec DF25 [16]
Value of data applied for the purpose of calculating expected emission reductions in section B.5	To be determined during project campaigns.
Description of measurement methods and procedures to be applied:	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 recorded for every two seconds of plant operation. Hourly means for VSG are derived from the collected data. VSG data taken during times when the respective plant was operating outside the permitted operating range were eliminated. The remaining VSG data series has been subjected to the following adjustment. The flow meter was installed with an operational range of 0 – 10 mbar of differential pressure. To obtain the flow (Nm3/h) at normal conditions (101.325 kPa and 0°C) from measured differential pressure the instrument equation – taken from the AMS manual – is used which includes pressure and temperature correction factors. $VSG = \frac{0.020763 * D^2 * k}{\sqrt{\rho_N}} * \frac{\sqrt{P}}{\sqrt{(273.15 + T)}} * \sqrt{dP}$ Where:

[16] The Systec Flow meter has already been approved by TÜV under the German 17. BImSchV.

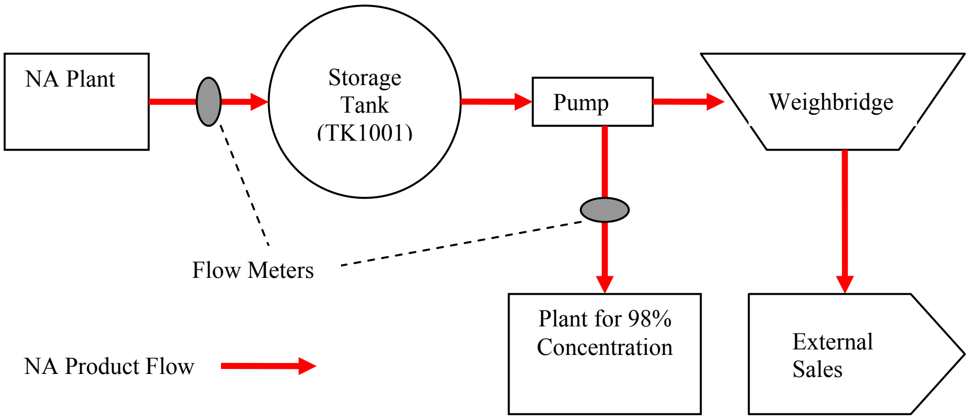
	VSG means standard volume flow (Nm^3/h) *D* means stack inner diameter (mm) ρN means standard density (kg/Nm^3) *k* means instrument correction factor (specific for each individual instrument) *P* means pressure working conditions (mbar) *T* means temperature working conditions (°C) ΔP means differential pressure (mbar) *0.020763* is the unit conversion factor The resulting hourly average VSG values are now expressed in Nm^3/h as required by AM0034 and where subsequently subjected to the following statistical analysis: a) Calculate the sample mean (x) b) Calculate the sample standard deviation (s) c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation) d) Eliminate all data that lie outside the 95% confidence interval e) Calculate the new sample mean from the remaining VSG values
QA/QC procedures to be applied:	After each campaign the flow meter probe and the thermocouple need to be taken out of the stack and inspected for physical condition. The person doing this has to fill out the flow meter inspection log-sheet with the following information: Date, Time, Name, confirmation that flow meter probe and thermocouple were taken out of the stack, general description of the condition of the probes, confirmation that both were re-installed correctly. Also, the differential pressure transmitter is disconnected from the Flow Tube and the transmitter is then connected to an absolute pressure simulator and the pressure transmitter is readjusted as appropriate. Once per year (max. after 14 months of continuous operation), the pressure transducer on the flow meter has to be taken off the flow meter and connected to an absolute pressure simulator for readjustment, if necessary. The flow meter probe (pitot tube) itself does not need to be calibrated since it is a physical device which will not have drift.
Any comment:	None

Data / Parameter:	**P.3 PE_n**
Data unit:	tN_2O
Description:	Total mass N_2O emissions in each project campaign.
Source of data to be used:	Calculated from the measurements from measured data.
Value of data applied for the purpose of calculating expected emission reductions in	To be determined during project campaigns.

section B.5	
Description of measurement methods and procedures to be applied:	Not applicable, calculated value as per the following formula: $PE_n = VSG * NCSG * 10^{-9} * OH$
QA/QC procedures to be applied:	Not applicable. Calculated value.
Any comment:	None.

Data / Parameter:	**P.4 OH_n**
Data unit:	hours
Description:	Total operating hours during each project campaign
Source of data to be used:	Production log
Value of data applied for the purpose of calculating expected emission reductions in section B.5	To be determined during project campaigns.
Description of measurement methods and procedures to be applied:	Required by AM0034 to determine the total mass emissions of N_2O during each project campaign (PE_n).
QA/QC procedures to be applied:	Every hour of operation for which there is a record of nitric acid produced will be considered as an operational hour for the purposes of BE_{BC} calculation. However, if the plant exceeds certain design parameters, it will automatically shut down ("trip limits"). The plant is considered to be not in operation when any of the following parameters is outside the "trip" limits as determined by the plant manuals: AIFR > 0.075 (i.e. if the Ammonia concentration in Air is higher than 7.5%) OTh > 955°C OPh < 10.55 bar Periods during the ongoing campaign during which the plant was outside the trip limits will be eliminated from the determination of OH.
Any comment:	None.

Data / Parameter:	**P.5 NAP**
Data unit:	$tHNO_3$
Description:	Metric tonnes of 100% concentrated nitric acid produced during each project campaign.
Source of data to be used:	Production log
Value of data applied for the purpose of calculating expected	To be determined during project campaigns.

emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Dongbu has a liquid flow meter (coriolis) installed in the product line out of the absorption column into the storage tank (TK1001). This flow meter delivers continuous measurements into the control room, logged by hand on daily log sheets and Dongbu's data acquisition system. However, the measurements are assuming standard acid concentration of 65% and standard specific gravity of 1.373. In addition, every day at midnight a measurement of the acid level inside the storage tank is taken. Diagramme of Dongbu's Nitric Acid Product Flow:  Each day at 8:00 a.m. two samples are taken, one from the product line (V1001) before the storage tank and one from the storage tank itself (TK1001), both are then analysed in the on-site lab for specific concentration and specific gravity. The results from this analysis are then used to adjust the flow meter and tank level measurements according to the measured specific concentration and gravity. There are two consumers out of the storage tank: Dongbu's own concentration plant which converts the 65% concentrated nitric acid into 98% concentrated nitric acid and external sales. The product flow pipe to the concentration plant is again equipped with a flow meter. The external sales leave the site by tank-truck each of which has to pass the on-site weighbridge before and after loading to determine the weight of nitric acid sold. Each day the total production volume of the nitric acid plant is calculated according to the following formula: Today's tank level – Yesterday's tank level + Weighbridge sales + Flow meter measurements from tank to concentration plant + Blending (60, 68 and 70%) nitric acid – 98% concentrated acid transfer

	= Total daily NA Production The total daily NA production figures are accumulated for monthly NA production. Dongbu produces nitric acid in two different concentrations (65 and 98%) but it sells nitric acid in five different concentrations (60, 65, 68, 70 and 98%). Therefore, at least once per month the NA production figure is adjusted for these differences in concentrations. This calculated NA production figure is considered the most reliable and accurate by Dongbu and is therefore the figure used for accounting, planning and reporting purposes. Therefore, this is the figure that will also be used for the purposes of this CDM project. To make it suitable for monitoring in this CDM project, any adjustments will be done at the end of each campaign (baseline and project), in addition to the irregular intervals throughout each month. At the beginning of the baseline period Dongbu will also take a tank level measurement and adjust this number accordingly to establish a correct starting point for the determination of NAP throughout the baseline. In addition to the irregular adjustments throughout each month and in addition to the adjustments at the end of each campaign, Dongbu will also take a tank level measurement and adjust this number accordingly to establish a correct end point for the determination of NAP throughout the baseline. Through this procedure it is ensured that an accurate NAP is established for the baseline period as well as for each project campaign for the correct calculation of EF_{BL} and EF_{P}. The total value of NAP that can be applied for the calculation of CERs in any one calendar year may not exceed the design capacity (daily plant capacity and assuming 365 days of operation per year). For Dongbu this effective NAP-cap is 300 $tHNO_3$/day * 365 days = 109,500 $tHNO_3$
QA/QC procedures to be applied:	ISO 9001 procedures and documented in the applicable ISO handbooks.
Any comment:	None.

Data / Parameter:	**P.6 TSG**
Data unit:	°C
Description:	Temperature in the stack gas
Source of data to be used:	Temperature Probe (part of gas volume flow meter)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not applicable
Description of	The temperature measurements of the stack gas are required to calculate the

measurement methods and procedures to be applied:	Normal Volume Flow (Nm^3/h) in the stack and is not required to be reported as a separate parameter in accordance with AM0034.
QA/QC procedures to be applied:	ISO9001 procedures and documented in the applicable ISO handbooks.
Any comment:	None.

Data / Parameter:	**P.7 PSG**
Data unit:	bar
Description:	Pressure of stack gas
Source of data to be used:	Pressure Probe (part of gas volume flow meter)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not applicable.
Description of measurement methods and procedures to be applied:	AM0034 requires the determination of gas volume flow at normal conditions in the stack. In order to calculate from the measured VSG values to VSG at normal conditions, the actual pressure in the stack has to be determined and applied to each hourly mean VSG value. The measurements are taken continuously by a pressure probe inside the stack very close to the stack gas volume flow meter.
QA/QC procedures to be applied:	ISO9001/14001 procedures and documented in the applicable ISO handbooks.
Any comment:	None.

Data / Parameter:	**P.8 EF_n**
Data unit:	$tN_2O/tHNO_3$
Description:	Emissions factor for campaign n.
Source of data to be used:	Calculation from total mass N_2O emissions of campaign n (PE_n) and total nitric acid production (NAP_n).
Value of data applied for the purpose of calculating expected emission reductions in section B.5	To be determined during project campaigns.
Description of measurement methods and procedures to be applied:	The campaign specific emissions factor for each campaign during the project's crediting period is calculated by dividing the total mass of N_2O emissions during that campaign by the total production of 100% concentrated nitric acid during that same campaign. For campaign n the campaign specific emission factor would be: $EF_n = PE_n / NAP_n$
QA/QC procedures to be applied:	Not applicable.
Any comment:	None

Data / Parameter:	**P.9 $EF_{ma,n}$**
Data unit:	$tN_2O/tHNO_3$
Description:	Moving average emissions factor derived over time from campaign specific emissions factors.
Source of data to be used:	Calculation from campaign specific emissions factors EF_n.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	To be determined during project campaigns, starting with the second project campaign.
Description of measurement methods and procedures to be applied:	In order to take into account possible long-term emissions trends over the duration of the project activity and to take a conservative approach a moving average emission factor shall be estimated as follows: $EF_{ma,n} = (EF_1 + EF_2 + \dots + EF_n) / n$ This process is repeated for each campaign such that a moving average, $EF_{ma,n}$ is established over time, becoming more representative and precise with each additional campaign.
QA/QC procedures to be applied:	Not applicable.
Any comment:	None

Data / Parameter:	**P.10 AFR**
Data unit:	$kgNH_3/h$
Description:	Ammonia gas flow rate to the Ammonia Oxidation Reactor (AOR)
Source of data to be used:	Monitored by Orifice plate
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not applicable, monitored data of AFR will be used to determine if plant was operating outside of AFR_{max}.
Description of measurement methods and procedures to be applied:	The ammonia flow is continuously measured by orifice plate.
QA/QC procedures to be applied:	ISO9001 procedures and documented in the applicable ISO handbooks.
Any comment:	A new ammonia gas mass flow meter or dp volume meter will be installed shortly.

Data / Parameter:	**P.11 AIFR**

Data unit:	% v/v
Description:	Ammonia to air ratio into the ammonia oxidation reactor
Source of data to be used:	Calculation for each hour of plant operation based on measurements of AFR and primary air flow rates.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not applicable, monitored data of AIFR will be used to determine if plant was operating outside of $AIFR_{max}$.
Description of measurement methods and procedures to be applied:	The monitoring of AIFR is required by AM0034 in order to determine whether the plant was operating within the permitted operating range. 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.
QA/QC procedures to be applied:	ISO9001 procedures and documented in the applicable ISO handbooks.
Any comment:	AM0034 (Version 02) states that the units for AIFR should be m^3/h, this is a mistake. AIFR should be expressed as a ratio or percentage volume by volume of Ammonia in Air.

Data / Parameter:	**P.12 CL_p**
Data unit:	$tHNO_3$
Description:	Length of each project campaign measured in metric tonnes of 100% concentrated nitric acid produced during that campaign.
Source of data to be used:	NAP
Value of data applied for the purpose of calculating expected emission reductions in section B.5	To be determined during project campaigns.
Description of measurement methods and procedures to be applied:	In accordance with AM0034 the project length (CL_n) has to be compared to the established average historic campaign length (CL_{normal}); and If the length of each individual project campaign CL_n is longer than or equal to the average historic campaign length CL_{normal}, then all N_2O values measured during the baseline campaign can be used for the calculation of EF (subject to the elimination of data from the Ammonia/Air analysis). If $CL_n < CL_{normal}$, recalculate EF_{BL} by eliminating those N_2O values that were obtained during the production of tonnes of nitric acid beyond the CL_n (i.e. the last tonnes produced) from the calculation of EF_n.
QA/QC procedures to be applied:	See comments for NAP.
Any comment:	None.

Data / Parameter:	**P.13 EF_p**
Data unit:	$tN_2O/tHNO_3$
Description:	Emissions factor used for the specific campaign n to determine the emission reductions of that campaign
Source of data to be used:	Calculation of EF_n and $EF_{ma,n}$.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	To be determined during project campaigns.
Description of measurement methods and procedures to be applied:	To calculate the total emission reductions achieved in a campaign, the higher of the two values $EF_{ma,n}$ and EF_n shall be applied as the emission factor relevant for the particular campaign to be used to calculate emissions reductions (EF_P). Thus: If $EF_{ma,n} > EF_n$ then $EF_P = EF_{ma,n}$ If $EF_{ma,n} < EF_n$ then $EF_P = EF_n$
QA/QC procedures to be applied:	Not applicable.
Any comment:	None

Data / Parameter:	**P.14 EF_{min}**
Data unit:	$tN_2O/tHNO_3$
Description:	EF_{min} is equal to the lowest EF_n observed during the first 10 campaigns of the project crediting period.
Source of data to be used:	Calculations of $EF_{ma,n}$.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not available yet.
Description of measurement methods and procedures to be applied:	A campaign-specific emissions factor shall be used to cap any potential long-term trend towards decreasing N_2O emissions that may result from a potential built up of platinum deposits. After the first ten campaigns of the crediting period of the project, the lowest EF_n observed during those campaigns will be adopted as a minimum (EF_{min}). 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 used EF_{min} and not EF_n.
QA/QC procedures to be applied:	Not applicable.
Any comment:	None.

Data / Parameter:	**P.15 OPh**
Data unit:	Bar (gauge)
Description:	Oxidation Pressure for each hour during each project campaign.

Source of data to be used:	Monitored by pressure transmitter.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not applicable. Used to determine when plant is operating outside of permitted range (OP_{normal})
Description of measurement methods and procedures to be applied:	AM0034 requires the monitoring of the oxidation pressure in the ammonia oxidation reactor. In Dongbu's nitric acid plant, the pressure is measured after the air compressor discharge and not inside the ammonia oxidation reactor. However, since the location of this pressure probe remains the same during the historic campaigns, the baseline period and the project campaigns, it is appropriate to use this value for comparison of OP_h between these campaigns. 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 OPh was above or below OP_{normal} has to be eliminated from the calculation of EF_{BL}. The design level of OPh is 1188 Kpa.
QA/QC procedures to be applied:	Subject to ISO 9001 procedures.
Any comment:	None.

Data / Parameter:	**P.16 OTh**
Data unit:	°C
Description:	Oxidation temperature in the ammonia oxidation reactor (AOR).
Source of data to be used:	2 thermocouples inside Ammonia Oxidation Reactor (AOR)
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Not applicable. Used to determine when plant is operating outside of permitted range.
Description of measurement methods and procedures to be applied:	In accordance with AM0034 the oxidation temperature in the ammonia oxidation reactor (OTh) has to be monitored and compared to the Normal range for oxidation temperature (OT_{normal}). VSG and NCSG data obtained during times when OTh was above or below OT_{normal} has to be eliminated from the calculation of EF_n.
QA/QC procedures to be applied:	Subject to ISO 9001 procedures.
Any comment:	None.

Data / Parameter:	**P.17 GS_{PC}**
Data unit:	Name of supplier.
Description:	Gauze supplier for the project campaign

Source of data used:	Monitored / Invoices
Value applied:	Not available yet.
Justification of the choice of data or description of measurement methods and procedures actually applied :	See B.20.
Any comment:	Dongbu expects to continue to source its gauzes from Johnson Matthey in the foreseeable future.

Data / Parameter:	**P.18 $GC_{project}$**
Data unit:	%
Description:	Gauze composition during each project campaign expressed as percentage by weight of the precious metals Platinum, Rhodium and, if applicable, Palladium comprising the Ammonia Oxidation Catalyst gauzes.
Source of data used:	Monitored / Invoices
Value applied:	To be obtained during the project campaigns.
Justification of the choice of data or description of measurement methods and procedures actually applied :	The gauze composition during the project needs to be monitored and compared to GC_{BL}. If the operator has changed the gauze composition during a project campaign to a composition not used during the baseline campaign, the baseline campaign may have to be repeated or a conservative IPCC default emissions factor applied.
Any comment:	None.

B.7.2 Description of the monitoring plan:

The emission reductions achieved by the project activity will be monitored using the approved monitoring methodology AM0034 as prepared by N.serve Environmental Services GmbH. It is the appropriate monitoring methodology to be used in conjunction with the baseline methodology AM0034, "Catalytic reduction of N_2O 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"*[17] as a guidance for installing and operating the Automated Monitoring System (AMS) in the nitric acid plants for the monitoring of N_2O emissions.

A complete Automated Monitoring System (AMS) to monitor the mass emissions of N_2O at the stack of Dongbu' nitric acid plant was installed and commissioned on 29 January. As an operator of the nitric acid plants for many years and of dedicated NO_X and other emissions monitoring equipment, Dongbu staff in general and its Instrument Department in particular is accustomed to operating technical equipment to a high level of quality standards.

[17] 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 plant manager is responsible for the ongoing operation and maintenance of the N_2O monitoring system. Operation, maintenance, calibration and service intervals are being carried out by staff from the instrumentation department according to the vendor's specifications and under the guidance of internationally relevant environmental standards, in particular EN 14181 (2004) and EN ISO 14956 (2002).

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

Please see Annex 4 for a detailed description of the Automated Monitoring System (AMS) installed at Dongbu' nitric acid plant and for background information on EN 14181 and the practical implications for using this standard for guidance in the implementation of this CDM project activity.

In the following, it is described how the procedures given in EN14181 for QAL1, 2 and 3 have been practically applied at Dongbu' 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 commissioning of the AMS by Dongbu in January 2007, only one analyser was available that has been certified suitable for N_2O monitoring under QAL 1 of EN 14181 and ISO 14956. However, the ADC MGA 3000 is currently undergoing the necessary procedures under QAL 1 and it is expected that the testing series is successfully completed and certification obtained before the end of 2007.

The flow meter has been tested and certified by TÜV Nord under 17. BImSchV and therefore does not require an additional QAL1 certification.

The Analyser and Flow Meter were calibrated by the vendors (ADC and Systec) prior to shipment and installation in the nitric acid plant.

QAL2 and Standard Reference Measurements (SRM)

QAL2 is a procedure for the determination of the calibration function and its variability, and a test of the variability of the measured values of the AMS compared with the uncertainty given by legislation. The QAL2 tests are performed on suitable AMS that have been correctly installed and commissioned on-site (as opposed to QAL 1 which is conducted off-site). QAL 2 tests are to be performed at least every 5 years according to EN 14181 but also after major changes to the plant or changes or repairs to the AMS.

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

The difficulty again with fully complying with EN14181 again is the lack of a regulatory N_2O emissions level and lack of a testing house or laboratory in Korea that would meet the accreditation requirements of EN14181.

However, a series of QAL2 specific reference measurements using a the SRM method as per EN 14181 has been carried out at the plant in March and June 2007 by an accredited testing house to ensure the AMS' suitability, establish the calibration curve and test the variability of the measurements. The results of these SRM and QAL2 are available to the DOE as part of the validation process. The AMS calibration function as well as the total uncertainty of the AMS was determined. The results were applied in the calculation of EF_{BL}.

AMS calibration and QA/QC procedures

The calibration procedures for the complete AMS are an integral part of the company's ISO 9001 QA system, certified to and audited by an accredited ISO 9001 auditing company.

Zero Calibration

Zero calibration gas is pure N2 with a certified accuracy of +/- 2% is supplied by MS General Gas Co. in Korea (analytical report available on site for DOE to inspect). The zero gas cylinder must always be open and connected to the analyser.

Analyser is set to automatic zero calibration every 24 hours. At the end of the zero calibration, the zero point is reset automatically by the analyser.

Span Calibration

The analyser range is 3000ppmv. Span calibration gas is 2096 µmol/mol (i.e. 2096ppm) N_2O in Air with a certified accuracy of +/- 2% is supplied by Research Institute of Gas Analytical Science (RIGAS) (analytical report available on site for DOE to inspect).

Before the beginning of the first project campaign the analyser will be re-ranged to 1000 or 1500 ppmv and a new bottle of calibration gas should be purchased with an N_2O concentration of between 60% and 80% of the new range of the analyser.

Dongbu plant staff conduct a span calibration once per week. At the end of the span calibration, the measuring output of the analyser has to be reset manually by the person conducting the span calibration. The person conducting the calibration has to fill out the calibration log-sheet with the following information:

Date, Time, Name, Reading of analyser with span calibration gas, confirm resetting of analyser.

Alarm settings & corresponding analyser output

The following alarm conditions are programmed in the analyser and CEM-Suite software

1. Analyser Calibration: OK / Alarm
2. Analyser Flow: OK / Alarm
3. Dryer Temperature: OK / Alarm
4. Dryer Flow: OK / Alarm

Alarm procedures:

→ 2. + 4. means that there is no compressed air flow ("purge air")

→ 2. + 3. Dryer Temperature too low, which is likely to be a failure of the heater-dryer system. If the failure is permanent, the heater will have to be replaced. Korins will have spare heater available to be delivered on site.

→ 2. means that the flow to the analyser is too high or too low. Since the Dryer flow is not showing up, the problem is not with the Dryer but either with the sample line (e.g. blockage) or with the flow directly into the analyser.

a) turn off the flow of the sample pump in the cabinet (red button at front of cabinet)

b) investigate the problem (e.g. the sample pipes etc.)

Minigas Dryer and Pump

The operating condition data readings of the Minigas Dryer at the stack should be visually checked once per day by a person climbing up the stack. The correct operating conditions are as follows:

- Sample Flow: approximately 20 litres / minute
- Pressure: approximately 15 PSI
- Temperature: approximately 80 - 90 °C

Also, the filter in the Minigas Dryer need to be visually checked once per week (no need to open and unscrew, simply look at the visible filter). The filter should be white at the start, getting browner over time. After between 3 to 6 months, when the filter has a dirty brown colour, it needs to be replaced with a new one.

Flow Meter

After each campaign the flow meter probe and the thermocouple need to be taken out of the stack and inspected for physical condition. The person doing this has to fill out the flow meter inspection log-sheet with the following information:

Date, Time, Name, confirmation that flow meter probe and thermocouple were taken out of the stack, general description of the condition of the probes, confirmation that both were re-installed correctly.

Once per year (max. after 14 months of continuous operation), the pressure transducer on the flow meter has to be taken off the flow meter and sent away for recalibration. The recalibration can either be carried out by the manufacturer of the pressure transducer or by Foxbrow at their local workshop in Korea.

QAL 3

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

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

In essence, Dongbu staff performs QAL 3 procedures through the established calibration procedures described above. However, similarly to QAL2, there is no independent, qualified and certified entity in Korea that could conduct the QAL 3 procedures and particularly the AST in accordance with EN14181. Therefore, a sufficiently qualified (but not certified in accordance with EN14181) technical surveillance company or laboratory will have to be identified who could perform the independent QAL 3 procedures.

Data acquisition system

Dongbu operates one data acquisition system that accumulates the analogue plant operating data from the Process Control System (PCS) into a PC (OTh, OPh, AFR, Air Flow, AIFR, NAP)

The analyser unit contains its own CPU which receives the NCSG and VSG data as well as O_2 concentration (all converted from 4-20 mA analogue data into digital signal). This CPU will store the raw data of up to 5 years of operation. This CPU generates minute-by-minute average values from the raw data which are sent via Ethernet cable to a PC in the control room that already collects the plant operating data.

Donbgu staff will generate minute-by-minute averages from the plant operating data (OTh, OPh, AFR, Air Flow, AIFR, NAP) to match the minute average data for NCSG and VSG.

As a result, there are now two sets of minute-by-minute average reports:
- Operations Data (OTh, OPh, AFR, Air Flow, AIFR, NAP)
- Emissions Data (N_2O, Flow, O_2, Errors)

The two files are then merged to get a complete data set which is then imported into the N.serve Database Management System (N.DBMS) as described in section B.6.3 above.

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 N_2O regulation and changes in the NO_X regulations.

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

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

05. April 2007

Dongbu Hannong Chemicals Ltd. (Project Participant)

Mr. Jin Ho Lee (jhleedb@dongbuchem.com)

N.serve Environmental Services GmbH (Project Participant)

Mr. Albrecht von Ruffer (ruffer@nserve.net) (N.DBMS by Dr. Helmuth Groscurth)

Mr. D K Seo of UPC Corporation Ltd., Partner of N.serve in Korea (upcdkseo@unitel.co.kr)

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

29. January 2007 (the date of commissioning of the complete Automated Monitoring System to monitor the mass emissions of N_2O at the stack of Dongbu's nitric acid plant)

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

25 years

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

C.2.1. Renewable crediting period

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

Not selected

C.2.1.2. Length of the first crediting period:

Not selected

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

31. March 2008 or the date of registration of the project activity, whichever occurs later[18]. In addition, the crediting period shall commence after the date of registration or the completion of the baseline campaign of the project, whatever occurs later.

C.2.2.2. Length:

10 years

SECTION D. Environmental impacts

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

The project will reduce gaseous emissions of nitrous oxide (N_2O) 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.

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[18] Indicating a variable date fort he commencement of the Crediting Period is necessary due to the ex-ante uncertain timeline of the registration procedure. This approach has been found acceptable for several other CDM-projects successfully registered in the recent past. Some examples are the CDM-projects with Abonos Colombianos S.A. (UNFCCC reference no. 1119, registered on 16th Nov 07), Haifa N1&2 and N4 (UNFCCC reference no. 1369, 1370, both registered on 13th Januar 2008) and AEL No. 11 (UNFCCC reference no. 1364, registered 8th February 2008).

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 N_2O abatement catalyst will be leased from an overseas supplier. The catalyst will be replaced from time to time and the spent catalyst returned to the supplier for recycling, if possible.

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

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

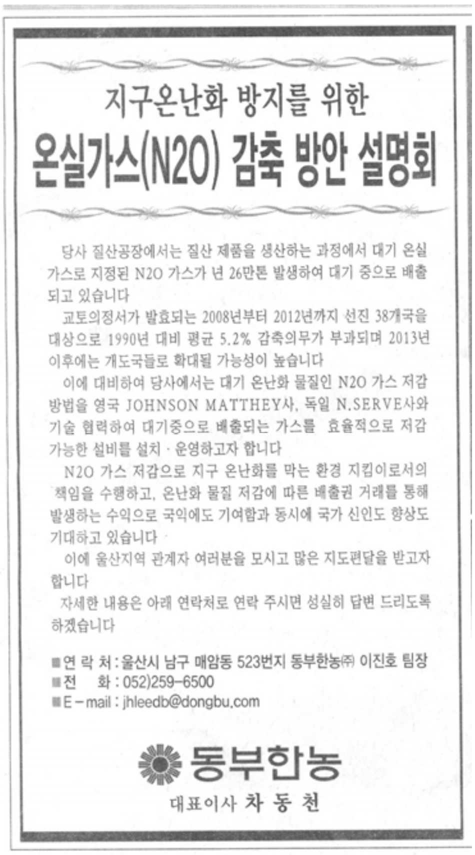
Not applicable.

SECTION E. Stakeholders' comments

E.1. Brief description how comments by local stakeholders have been invited and compiled:

The stakeholder consultation procedure was organised and conducted by UPC Corp. Ltd., N.serve's partner in Korea, with assistance from Dongbu staff..

For the purpose of inviting comments from public and stakeholders, the publication has been made on Kyungsang Daily Newspaper of Feb. 28th, 2007 as following attachment.



지구온난화 방지를 위한

온실가스(N2O) 감축 방안 설명회

당사 질산공장에서는 질산 제품을 생산하는 과정에서 대기 온실가스로 지정된 N2O 가스가 년 26만톤 발생하여 대기 중으로 배출되고 있습니다

교토의정서가 발효되는 2008년부터 2012년까지 선진 38개국을 대상으로 1990년 대비 평균 5.2% 감축의무가 부과되며 2013년 이후에는 개도국들로 확대될 가능성이 높습니다

이에 대비하여 당사에서는 대기 온난화 물질인 N2O 가스 저감 방법을 영국 JOHNSON MATTHEY사, 독일 N.SERVE사와 기술 협력하여 대기중으로 배출되는 가스를 효율적으로 저감 가능한 설비를 설치 · 운영하고자 합니다

N2O 가스 저감으로 지구 온난화를 막는 환경 지킴이로서의 책임을 수행하고, 온난화 물질 저감에 따른 배출권 거래를 통해 발생하는 수익으로 국익에도 기여함과 동시에 국가 신인도 향상도 기대하고 있습니다

이에 울산지역 관계자 여러분을 모시고 많은 지도편달을 받고자 합니다

자세한 내용은 아래 연락처로 연락 주시면 성실히 답변 드리도록 하겠습니다

■ 연 락 처 : 울산시 남구 매암동 523번지 동부한농㈜ 이진호 팀장
■ 전 화 : 052)259-6500
■ E-mail : jhleedb@dongbu.com

동부한농

대표이사 차 동 천

Translation Summary :

TITLE :GHG (N2O) REDUCTION SEMINAR FOR GLOBAL WARMING PROTECTION

N2O, one of the green house gases, is being come out from our Nitric Acid plant and they are currently being emitted into the atmosphere. About 38 countries will have responsibility to reduce GHG by in average of 5.2% during 2008-2012 because of Kyoto Protocol and it is possible that the responsibility is to be expanded to developing countries from 2013.

We plan to install and operate facilities to reduce the N2O gas by the technical co-operation with Johnson Matthey (U.K.) and N. Serve (Germany).

By reducing N2O gas, we are expecting that we will be able to implement the environmental protector role and contribute to the country by profits from CERs as well as for the country credibility improvement in environment.

With the plan and purpose in above, we welcome any comments from people outside and invite related people who are interested in this project.

We will sincerely reply if you can contact below address for any further information or questions on our project.

Contact : Mr. Lee Jin-Ho, Manager, Dongbu Hannong

Chemicals Ltd.

Tel : 052) 259-6500 E-mail : jhleedb@dongbu.com

Dongbu Hannong Chemicals Ltd., President Cha Dong Chun

The Stakeholder meeting took place on 2nd March 2007 at the Dongbu Hannong Plant in Ulsan. 16 people attended the meeting. Of these 15 were from neighbouring companies and one person from the Ulsan District Environmental Preservation Association (an NGO). Also, five people from Dongbu were present at the meeting.

List of Attendees of the Local Stakeholder Meeting

NO	Organization & Company	Name
1	UPC CORPORATION LTD	MR. SEO DONG KYUN
2	TAEWON MULSAN CO.LTD	MR. KIM BYEONG NYEON
3	INSUNG INDUSTRY	MR. JOO JAE YEONG
4	KOREA POLYOL CO.LTD	MR. JEONG YEONG TAEK
5	TAEWON MULSAN CO.LTD	MR. BAEK SONG HAK
6	ULSAN DISTRICT ENVIRONMENTAL PRESERVATION ASSOCIATION	MR. BYEON YUN HWAN
7	NOVELIS KOREA LIMITED	MR. KIM DAE IL
8	DAIHAN SWISS CHEMICAL	MR. KONG TAE HYEON
9	HYOSUNG	MR. IM JU WON
10	SAMYANG CORPORATION	MR. KIM KYEONG SOO
11	MIWON COMMERCIAL CO.LTD	MR. CHO YUN HYANG
12	YONGJIN FINE CHEMICAL CO. LTD	MR. JUNG YEONG MO
13	HANWHA CHEMICAL CORPORATION	MR. GWON SAM CHEOL
14	SAMYANG GENEX CORPORATION	MR. LEE SEUNG YONG
15	SAMSUNG FINE CHEMICAL CO. LTD	MR. KO SANG HYEON
16	SONGWON INDUSTRIAL CO. LTD	MR. JUNG WOO CHAN

Dongbu also invited Ulsan City Environment Policy Dept by phone and by e-mail but no one came to attend the meeting. However, the CDM project was explained in some detail to them over the phone. No comments were received.

Agenda of the Meeting

Welcoming Address & Introduction of Dongbu: Mr. Kim Kwang-Chul, Plant Manager of Dongbu

Detailed Presentation of the Project: Mr. Lee Jin-Ho, Manager of Dongbu

1) Background of CDM

2) CDM Summary

3) Dongbu and CDM Project

4) Nitric Acid De-N2O Technology (Methodology)

5) CDM Project Development by Dongbu

6) Project Plan

7) Registered CDM Projects

8) Environmental & Social Effects

9) Questions & Answers

Picture of the Local Stakeholder Meeting:

E.2. Summary of the comments received:

The following brief question and answer session followed the presentation

Q) How would project participants share the CERs? Do Annexe 1 countries take most of them?

> A) There is no specific rule of CER share of the project participants and no rule that Annex 1 countries can take more CERs than Non-Annexe countries. All project participants including Dongbu have agreed to CER share ratio. In our case, Annex 1 country participants take less share than Dongbu.

Q) In some other CDM cases, Annexe 1 countries take the most of the CER share which shouldn't be recommendable from our (Non-Annexe country) point of view?

> A) We know there are some CDM projects whose Korean partners share are less than those of Annexe 1 countries partners. We can not inform the exact share ratio but Dongbu have the largest share by the project participants agreement.

Q) What is the expectation from the economic view, profit?

> A) It depends on CER price in the market. The current price level is around 5 Euro – 12 Euro.

Q) Where is the technology coming from for Dongbu De-N2O CDM business?

> A) In case of measuring system and CDM process consulting, N.serve Environmental Services (Germany) is co-operating and leading the role and in case of De-N2O catalyst, Johnson Matthey PLC (U.K.) is going to supply the catalyst.

Q) In the reduction process of N2O, LNG can be used which can create NOx, is this fits Korean regulation?

A) Dongbu have technically and environmentally investigated this matter, and all specifications from the project meet the Korean environmental regulation. No LNG will be used in the application of a secondary catalyst, which will be the case at Dongbu. LNG (or other fuels) may be applied when using a tertiary or tail gas catalyst.

No written or oral comments, questions or statements further to the meeting or the newspaper advert were received. Thus the local stakeholder consultation process was closed on April 5, 2007.

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

As a result, no changes had to be considered in the implementation of the project activity.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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FAX:	
E-Mail:	
URL:	
Represented by:	
Title:	President
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

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.

ANNEX 3

BASELINE INFORMATION

Excerpt from the hourly average measurement reports during the baseline period[19]:

		TI-1204 (R1001반응온도)	PT-1111 (NH3 PRESSURE)	FT-1201A (NH3 FEED)	FT-1201B (Air Flow)	FRI-1201 (Air/Amm' Ratio)	FT-1303 (Acid Prod)	ST0K GAS FLOW RATE	N2O EMISSION
		℃	bar	T NH3/H	T Air/h	%	TNO2/h	N㎥/h	ppm
05/02/2007	08:00:00	912.5	13.6682	2.4094	50.083	0.64	20.8368	33804.7193	1850.2
05/02/2007	08:00:01	912.5	13.6682	2.4106	50.083	0.6398	20.8116	33911.5739	1849.6001
05/02/2007	08:00:02	912.62	13.6682	2.4079	50.0775	0.64	20.8008	33911.5739	1848.2001
05/02/2007	08:00:03	912.62	13.6682	2.4044	50.0555	0.64	20.7936	33863.0046	1848
05/02/2007	08:00:04	912.68	13.6703	2.4028	50.0665	0.6396	20.7828	33804.7193	1845.3999
05/02/2007	08:00:05	912.68	13.6703	2.4121	50.061	0.64	20.772	33809.5773	1843.9999
05/02/2007	08:00:06	912.8	13.6744	2.4036	50.083	0.6393	20.7576	33809.5773	1843.4
05/02/2007	08:00:07	912.8	13.6765	2.4145	50.094	0.6391	20.7504	34504.1284	1842.5999
05/02/2007	08:00:08	912.8	13.6765	2.4215	50.0775	0.6411	20.7612	34504.1284	1842
05/02/2007	08:00:09	912.8	13.6785	2.4215	50.0555	0.6412	20.7612	34504.1284	1841.0001
05/02/2007	08:00:10	912.92	13.6785	2.4231	49.9675	0.6418	20.7756	34159.2819	1840.3999
05/02/2007	08:00:11	912.92	13.6765	2.427	49.8245	0.6431	20.7828	34149.5658	1839.8
05/02/2007	08:00:12	913.04	13.6765	2.434	49.7585	0.6443	20.7756	34159.2819	1838.2001
05/02/2007	08:00:13	913.22	13.6785	2.4281	49.731	0.6446	20.7612	33571.5853	1838.2001

[19] The complete data series is available for review and inspection by the DOE at any time.

Annex 4

MONITORING INFORMATION

A. 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 N_2O are not yet defined in EN14181;
- Only very limited experience exists with monitoring systems for N2O emissions;
- No applicable regulatory N_2O levels exist in the EU (or elsewhere) that are required to conduct some of the calculations and tests of EN14181; and

N_2O is expected to be regulated in the EU starting in 2008, the Council Directive 96/61/EC on integrated pollution prevention and control is under preparation under the lead of the European IPPC Bureau (http://eippcb.jrc.es/). Only once the regulatory limits and the framework for N_2O measurements have been established can and will AMS vendors finally conduct the suitability testing in accordance with EN14181. Therefore, it is currently not possible to fully comply with the letter of EN14181, neither in the EU, nor in a non-Annex 1 country to the Kyoto Protocol.

Despite all this, EN14181 provides a very useful guidance in conducting a logical, step-by-step approach to selecting, installing, adjusting and operating the N_2O AMS for CDM projects.

The monitoring procedures developed for this project under AM0034 aim at providing workable and practice orientated solutions that take into account national environmental standards and regulations, available monitoring and testing expertise in the country as well as the specific situation at each nitric acid plant. Wherever possible, EN14181 is applied as guidance for the development and implementation of the monitoring procedures for this CDM project in order to achieve highest possible measuring accuracy and to implement a quality control system that assures transparency and credibility.

Scope of EN 14181

This European Standard specifies procedures for establishing quality assurance levels (QAL) for automated measuring systems (AMS) installed on industrial plants for the determination of the flue gas components and other flue gas parameters.

This standard is designed to be used after the AMS has been accepted according to the procedures specified in EN ISO 14956 (QAL1).

EN14181 specifies:

- a procedure (QAL2) to calibrate the AMS and determine the variability of the measured values obtained by it, so as to demonstrate the suitability of the AMS for its application, following its installation;
- a procedure (QAL3) to maintain and demonstrate the required quality of the measurement results during the normal operation of an AMS, by checking that the zero and span characteristics are consistent with those determined during QAL1;
- a procedure for the annual surveillance tests (AST) of the AMS in order to evaluate (i) that it functions correctly and its performance remains valid and (ii) that its calibration function and variability remain as previously determined.

This standard is restricted to quality assurance (QA) of the AMS, and does not include the QA of the data collection and recording system of the plant.

B. Description of the AMS installed at Dongbu nitric acid plant

1. General Description of the AMS

Dongbu's nitric acid plant is equipped with a state of the art AMS consisting of an MGA3000 NDIR Continuous Emissions Analyser from ADC Ltd., Permapure Mini-GASS 1228 sample conditioning system and a custom made, multiple point pitot tube Systec DF25. The sample points were chosen in accordance with the AMS requirements and the plant design specifications to allow an optimum of data collecting quality.

2. Sample points

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 vertical section of the exit stack. At this point, the gas is still hot (above dew point) and well mixed. The sampling points for both the 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.

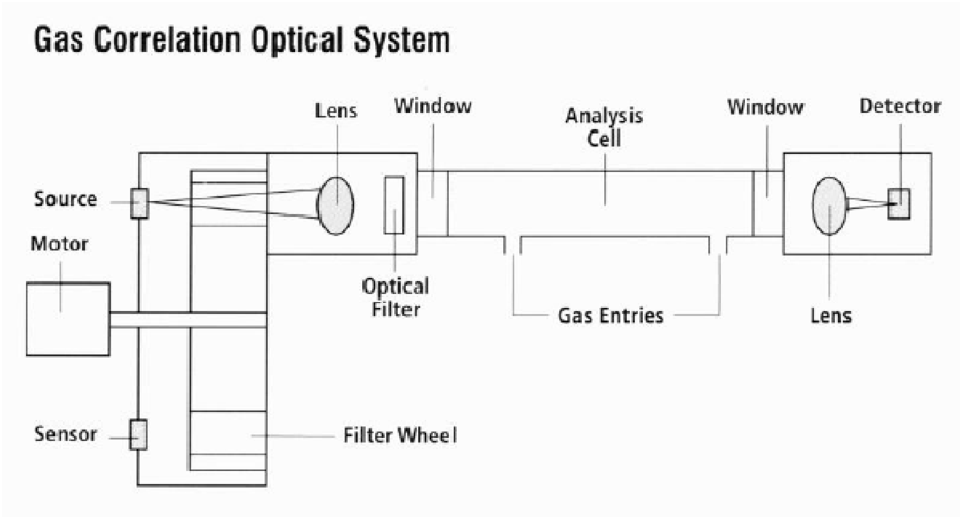
3. ADC MGA3000 NDIR Gas Analyser

MGA3000Series triple gas analyser using filter correlation infrared optics configured to measure nitrous oxide (N_2O) with a measurement range of 0 to 2000ppm or mg/m^3 and a display resolution of 1ppm. Zero and span solenoids for calibration gases, autozero function. Analogue output of 4 to 20 mA.

Criteria	Correlation Filter Technology
Gases Measured: (lowest detectable limits)	**Acetylene** C_2H_2 to 0.5ppm **Carbon Monoxide** CO to 0.1ppm **Hydrogen Chloride** HCl to 5.0ppm **Methane** CH_4 to 0.5ppm **Nitric Oxide** N_2O to 2.0ppm
Measurement Technique:	Non dispersive infrared absorption with solid state detector.
Measurement Range:	Up to 100% for gases and saturation concentration for vapours.
Resolution:	Display: 0.1% fsd Output: ≥0.1% fsd
Detection Limit	0.1% fsd
Intrinsic Accuracy:	≤ 1.0% of reading
Noise:	≤0.1% fsd
Zero Stability:	≤1% fsd over a week
Span Stability:	≤0.5% fsd over a week
Temperature Effect on Zero:	± 0.1% fsd per °C
Temperature Effect on Span:	± 0.2% fsd per °C
Cell Response:	Typically less than 30 secs
Flow Rate:	Typically 0.2 to 1 litre/minute

- Gas Filter Correlation Infrared Optics

The GC infrared bench is a non-dispersive single beam analyser in which the gas to be measured is passed through an optical cell, either continuously or as a static sample. Although the instrument output is in terms of gas concentration , this type of analyser acts as a comparator. That is its output is not absolute, but is established with a known gas mixture at a point on the calibrated scale.



The length of the cell is dependant upon the concentration of the sample to be measured, and may vary from 1mm (at high concentrations, (100%), to 250mm at low concentrations (ppm). Very low concentrations can also be accommodated using a “folded” path optical arrangement. Cells are usually constructed from stainless steel for corrosion resistance, however in some circumstances brass materials are used but are gold plated internally to improve performance. The principle of operation is identical for all variants and can be deduced from the drawing above. Infrared radiation from a small source is directed through a rotating filter wheel, a collimating lens, a thin film optical filter, the sample cell (s), a focussing lens and on to a solid state detector.

The wheel rotates at 1100RPM, giving a modulation frequency of 18.3 Hz. Each cell element is sealed at both ends by a transmitting window. The gas filled wheel is the heart of the analyser. The wheel has two or three “eyes” , one is filled with the reference gas, normally nitrogen, the other one or two with the target gas at low pressure. As the wheel rotates it provides a ratio of sample and reference signals, in a sequence detected by a wheel position sensor These signals together with the selective transmission of the optical filter sensitises the analyser to respond to the region of the infrared spectrum corresponding to the gas to be measured in the sample.

When sample gas is present the ratio of sample/reference energy detected is altered and is directly proportional to the concentration. The resulting signal is amplified to provide the concentration reading. The characteristics of the wheel, optical filter and other components can be affected by variations in temperature, but are minimised in the design using small heating elements with control.

Other areas of the optics may be purged with “clean” gas to reduce interference. To assist with service the optics may be stripped and cleaned, reassembled and recalibrated if found to be dirty.

- Cross Interferences

All cross intereferences in the MGA3000 are assumed to be more or less linear (i.e. effect on N_2O reading for different concentrations of other gasses can be extrapolated from this data table).

Example Cross Interferences provided by ADC

Gas	Example Stack	Effect on

Dongbu Stack gas composition

Gas	Dongbu Stack	Estimated Effect

	Concentration	N_2O reading
CO_2	3%	+1ppm
CO	10,000ppm	-10ppm
SO_2	5,000 ppm	0
NO	10,000 ppm	+70 ppm
CH_4		0
H_2O	2%	0.2ppm
NH_3	250ppm	0ppm

	Concentration	on N_2O reading
N_2	97.43 %	None
O_2	2.48 %	None
H_2O	0.07 % (700ppm)	0.07 / 2 * 0.2 = 0.007ppm
NO_X	0.02 % (200ppm)	200 / 10,000 * 70 = 1.4ppm

Resulting effect on N_2O measurements of 1200ppm: 1.4 / 1200 = 0.00117%. Even if the NO_X values are higher (e.g. 500ppm) the effect is less than 0.3%.

4. Sample Conditioning System Permapure Mini-GASS 1228

- Heated sample gas probe with downstream filter integrated with dryer
- Effective insulation and protection shield
- Self-regulating up to 180°C with low temperature alarm
- Dust concentration up to 2g/m³
- 24 inch heated permeation dryer assembly remove water to -10°C dewpoint
- requires either dry air or nitrogen 60 litres/min/70 psi
- full interlock to prevent sample pump damage

Technical Data:
- Material 1.4571
- Seals Graphite/1.4404 and see filter elements
- Operating temperature max. 200°C
- Maximum working pressure 6 bar
- Voltage 115/230 V, 50/60Hz
- Low temperature alarm contact is open at operating temperature, closes at < 140°C, current max. 4A
- Ambient temperature -20 to +80°C
- IP65 enclosure for weather protection

5. Flow Meter

The deltaflow DF25 is a dynamic pressure probe which measures the flow in conduits according to the differential pressure principle. The probe is a multiple point pitot tube and has two different chambers, between which a pressure difference, caused by the flow in the duct, builds up. The differential pressure resulting at the probe is proportional to the square of the gas speed. Due to the probe's special shape, a highest possible differential pressure is produced, whereby the linearity of the measuring signal is guaranteed.

The deltaflow DF25 and DF50 were successfully subjected to a three-month durability test conducted by the TÜV Compliance Board in accordance with clean air requirements identified in § 13 and 17 of the Federal Emission Control Ordinance and were included in the Environmental Control Agency's clean-air guidelines for watersteam saturated flue and exhaust gasses. During this test the deltaflow was neither heated nor cleaned throughout the entire test.

The measurement results are converted from operating to standard conditions by taking temperature and pressure at the sample point into account.

The following photographs show the monitoring equipment as it has been installed at the Dongbu plant for the baseline campaign and will be used for assessing the project emissions.

<u>**Dongbu Analyzer house**</u>	<u>**Probe Installation at Dongbu**</u>