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

CONTENTS

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

MONITORING REPORT
Version 01; 24/11/2011
TITLE: Project for the catalytic reduction of N2O emissions with a secondary catalyst inside the ammonia reactor of the nitric acid plant at Dongbu Hannong Chemicals Ltd., Ulsan, Korea ("Dongbu")
Reference Number: 1443
Monitoring period: Nr. 05, 21/10/2010 - 07/11/2011

SECTION A. General description of the project activity

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

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

The sole purpose of the project activity is to significantly reduce former levels of N_2O emissions from the production of nitric acid at the Ulsan fertiliser factorys'nitric acid plant owned by Dongbu HiTek Co., Ltd. in Ulsan, South Korea, by implementation of a secondary N_2O abatement catalyst.

Brief description of the installed technology and equipments

The employed secondary N_2O abatement catalyst technology is supplied by Johnson Matthey PLC. Continuous monitoring of emission reductions is assured by a state of the art Automated Measuring System (AMS), consisting of stack gas volume flow meter, N_2O Analyzer, and respective data logging facilities. The AMS as well as its installation complies with the requirements of the European Norm EN 14181 as required by the methodology.

Relevant dates for the project activity

Registration Date:	01/04/2008	
Crediting Period:	10 years fixed (01/04/2008 – 31/03/2018)	
Installation of AMS:	29/01/2007	
Baseline Campaign:	06/04/2007 – 14/06/2007	
Starting Date of Project Activity:	29/01/2007	
Starting Date of Crediting Period:	01//04/2008	
Earlier Project Campaigns:	PC 1	26/02/2008 – 15/05/2008
	PC 2	26/05/2008 – 24/08/2008
	PC 3	28/08/2008 – 07/01/2009
	PC 4	18/01/2009 – 23/04/2009
	PC 5	26/04/2009 – 05/08/2009
	PC 6	07/08/2009 – 15/10/2009
	PC 7	16/10/2009 – 04/01/2010
	PC 8	05/01/2010 – 20/04/2010
	PC 9	21/04/2010 – 26/07/2010
	PC 10	27/07/2010 – 20/10/2010

Project Campaigns covered by current Monitoring/Verification Period:

PC 11 21/10/2010 – 04/01/2011
PC 12 05/01/2011 – 19/03/2011
PC 13 20/03/2011 – 07/06/2011
PC 14 08/06/2011 – 12/08/2011
PC 15 13/08/2011 – 08/11/2011[1]

Total emission reductions achieved in this monitoring period

The total amount of emission reductions achieved in this monitoring period is ***167,775*** t CO_2e.

A.2. Project Participants

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Name of Party involved	Project Participants	Party involved considered as project participant
Republic of Korea (host)	UPC Corporation Ltd. (Private)	No
Republic of Korea (host)	Dongbu Hitek Co., Ltd.	No
United Kingdom of Great Britain and Northern Ireland	Johnson Matthey PLC)	No
United Kingdom of Great Britain and Northern Ireland	N.serve Environmental Services GmbH	No
United Kingdom	Electrabel NV/SA	No
Switzerland	Dongbu HiTek Co., Ltd.[2]	No
Switzerland	UPC Corporation Ltd.	No
Switzerland	N.serve Environmental Services GmbH	No

A.3. Location of the project activity:

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The nitric acid plant is physically located at #523, Maeam-dong, Nam-ku, Ulsan, 680-050, Korea. The exact coordinates are: 35°31°09.33 N; 129°21°59.13 E.

A.4. Technical description of the project

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

1.) state-of-the art secondary N_2O abatement technology
2.) state-of-the-art Automated Monitoring System (AMS) for continuous N_2O measurement which is fully in compliance with European standard EN 14181
3.) training of local staff on installation, operation and maintenance of catalyst and monitoring equipment, etc. as well as implementation of quality check and quality assurance measures

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[1] The campaign was completed (time of shut-down of the plant) at 02:00 in the morning of 08/11/2011 and will be regarded completely for determination of the campaign specific emission factor, however, generated emission reductions will only be regarded until 07/11/2011 in order to be able starting the next monitoring period from 08/11/2011. .

[2] Please note that this is the correct form of spelling the name “HiTek”. The spelling “Hitek” 4 lines up (Republic of Korea) has been chosen in order to use the same spelling as on the UNFCCC homepage.

Catalyst Technology

Dongbu has contracted with Johnson Matthey Plc to install a secondary catalyst system that consists of a standard precious metal gauze pack with an additional base metal catalyst.

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, composition and weight of that gauze pack remain unchanged during the crediting period of the project.

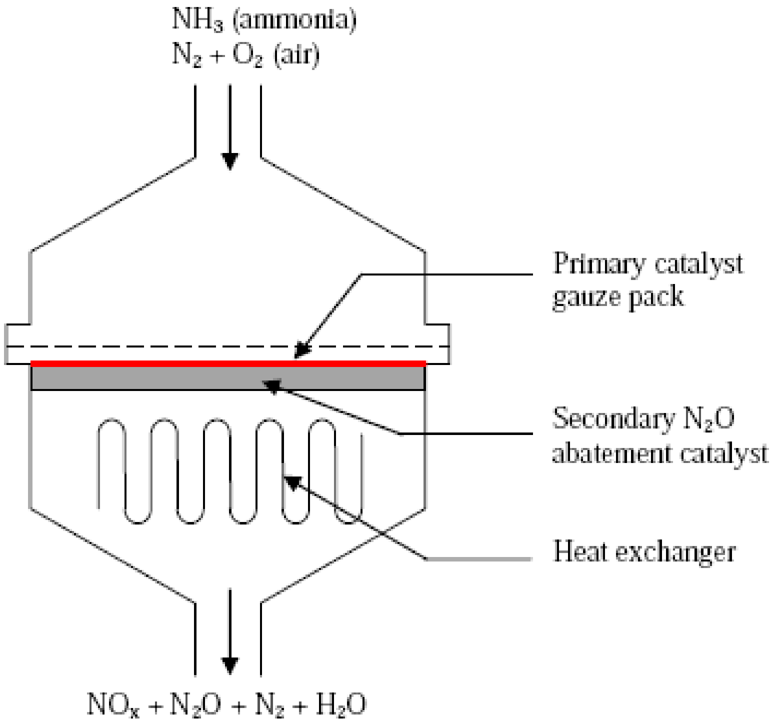
The secondary catalyst reduces N_2O levels in the gas mix resulting from the primary ammonia oxidation reaction based on the following reaction:

$2N_2O \rightarrow 2N_2 + O_2$

The secondary abatement catalyst does not contaminate the nitric acid produced in the respective nitric acid plant and 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.

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 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 150 mm 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.

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

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This project activity 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 (Version 4.2) for the baseline scenario selection and employs the “Tool for the demonstration and assessment of additionality” (Version 03).

A.6. Registration date of the project activity:

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Registration Date of project activity: 01/04/2008

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

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The 10 years crediting period option was chosen with starting date upon registration of the CDM project activity on 01/04/2008.

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

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SECTION B. Implementation of the project activity

B.1. Implementation status of the project activity

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1. After installation of the AMS (January 2007) and successfully having carried out the baseline campaign the secondary N_2O abatement catalyst was installed and the project started regular operation on 26/02/2008. Since the project activity was only registered April 1st 2008 this date is the starting date for the 10 years crediting period. However, the full commissioning of the complete AMS which took place on 29/01/2007 is considered the starting date of the project activity. So far 15 project campaigns have been conducted out of which the last 15 campaigns are covered by this Monitoring Report.

According to the registered PDD Dongbu has contracted with Johnson Matthey to install its Amoxis Hybrid® RN20/101 N_2O reduction catalyst from the start of the project. In order to optimize the abatement performance of the secondary catalyst Johnson Matthey recommended changing to a different type of secondary catalyst.

In a stepwise procedure the Amoxis Hybrid® RN20/101 catalyst was exchanged against a different type of N_2O abatement catalyst (YARA 58-Y1 catalyst). The change was performed in three steps:

18/01/2009:	6%	of YARA and	94 %	of Amoxis
02/03/2009:	31%	of YARA and	69 %	of Amoxis
09/04/2009:	100%	of YARA and	0 %	of Amoxis

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. Moreover, as the costs for the new

secondary catalyst are the same as for the previous type of secondary catalyst the change has also no effect on the additionality test of the project[3].

2. As to the characteristics of this specific project type certain production related events and incidents may affect the performance of the project or influence the monitoring of emission reductions in addition to possible failure of the installed monitoring equipment.

The below table lists all relevant events and incidents related to production and/or emission monitoring which have occurred during actual operation within this specific monitoring period.

TIME	EVENT / ACTION
Campaign PC 12	
20/10/2010 - 21/10/2010	change primary catalyst (start of new campaign)
24/11/2010 - 25/11/2010	Power failure work and catalyst cleaning (shut-down)
25/11/2010 - 27/11/2010	Boiler leak repair
20/12/2010 - 21/12/2010	tail gas heater tube leak repair
25/12/2010	inpulse line freeze
04/01/2011 - 05/01/2011	change primary catalyst (end of campaign)
Campaign PC 12	
04/01/2011 - 05/01/2011	change primary catalyst (start of new campaign)
08/01/2011 - 09/01/2011	boiler leak repair
12/01/2011	Motor Power failure
19/01/2011	catalyst cleaning (shut-down)
26/01/2011	interlock shut down by reactor temperature increase (trip)
29/01/2011	tail gas heater tube leak repair
05/03/2011 - 06/03/2011	reactor problem (shut-down)
11/03/2011	interlock shut down by air compressor (expander) temperature increase (trip)
19/03/2011 - 20/03/2011	change primary catalyst (end of campaign)
Campaign PC 13	
19/03/2011 - 20/03/2011	change primary catalyst (start of new campaign)
15/04/2011 - 16/05/2011	catalyst cleaning (shut-down)
28/04/2011	tail gas heater tube leak repair (shut-down)
09/05/2011 - 11/05/2011	boiler leak repair (shut-down)
11/05/2011 - 13/05/2011	air compressor motor was not running
07/06/2011 - 08/06/2011	change primary catalyst (end of campaign)
Campaign PC 14	
07/06/2011 - 08/06/2011	change primary catalyst (start of new campaign)
09/07/2011	catalyst cleaning (shut-down)
12/08/2011 - 16/08/2011	full of storage tank (shut-down)
16/08/2011 - 19/08/2011	change primary catalyst (end of campaign)
Campaign PC 15	
16/08/2011 - 19/08/2011	change primary catalyst (start of new campaign)
14/09/2011 - 15/09/2011	catalyst cleaning (shut-down)
20/10/2011	full of storage tank (shut-down)
22/10/2011	nitric acid heater tube leak (shut-down)
23/10/2011	nitric acid heater tube leak (shut-down)
25/10/2011	nitric acid heater tube leak (shut-down)
08/11/2011	change primary catalyst (start of new campaign)

[3] This change of secondary catalyst was accepted by the EB. Please refer to B.4. Notification or request of approval changes.

3. No events or incidents of any relevance in regard to impacting the applicability of the methodology occurred during this 5th monitoring period.

B.2. Revision of the monitoring plan

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A change of the monitoring plan for this monitoring/verification period will be applied for regarding the measurement of Nitric Acid Production (NAP). In the past (for the previous four monitoring periods and verifications) NAP has been determined following a rather complicated multi-source-mass-balance approach which has shown to require a lot of efforts for providing evidence of accurate measurement and resulting in discussions and difficulties in the cause of the respective verifications. Thus Dongbu HiTek Co., Ltd. has decided to install a new coriolis mass flow meter (was installed 05/07/2010) in order to provide for a more transparent and more accurate means of measurement of generated Nitric Acid. By this it is thought to be able easing the verification of NAP measurements and prevent from any problems in this respect for this and any future verification. However, as mentioned before so far this change (revision) of the monitoring plant has not yet been submitted to nor accepted by the UNFCCC (in the process of application).

B.3. Request for deviation applied to this monitoring period

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NO request for deviation was applied to this monitoring period.

B.4. Notification or request of approval of changes

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A notification of approval of change to the project activity described in the original registered CDM-PDD has been made and was accepted by the EB on 07/07/2010 (date for acceptance of “new” approved PDD). The approved change was made related to using a different type of secondary N_2O abatement catalyst, which is also supplied by the original supplier Johnson Matthey.

SECTION C. Description of the monitoring system

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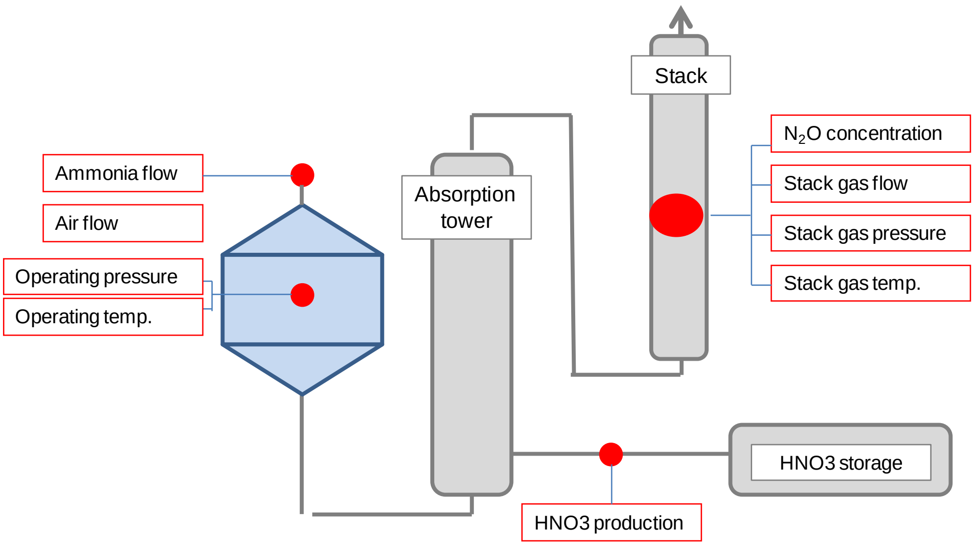
The monitoring System includes parts of monitoring equipment that is used for regular process control as well as the AMS (Automated Monitoring System) which had been installed on the sole purpose of emission (reduction) monitoring under this CDM project. The below diagram indicates the main measurement points, whereas Ammonia flow, Air flow, Operating Pressure and Temperature as well as the Nitric Acid (HNO_3) production are regular process parameter while N_2O concentration (NCSG), Stack Gas Flow (VSG), Stack Gas Temperature (TSG) and Stack Gas Pressure (PSG) are the parameters measured by the AMS.



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. N_2O Gas Analyser

Baseline Campaign: ***ADC MGA3000 NDIR Gas Analyser***

At the time of conducting the baseline campaign (06/04/2007 – 14/06/2007) an ADC *MGA3000 NDIR Gas Analyser* for the measurement of N_2O concentration in the stack gas was installed as part of the AMS.

***Project Campaigns:	ABB AO2000 URAS 26 gas analyser***

A new N_2O analyzer type ABB AO2000 URAS 26[4] was installed in February 2008 before the start of the first project campaign. This new gas analyser also incorporates the NDIR measurement technology and is in full compliance with the requirements of the QAL1, which was successfully tested by TÜV SÜD Industrie Service, Germany[5].

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 dew point
- 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 temp. 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 installed *delta-flow 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 with 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 measurement results are converted from operating to standard conditions by taking temperature and pressure at the sample point into account.

The *delta-flow DF 25* measurement device is approved in Germany for use in large combustion waste incineration plants (equivalent to QAL1 test[6]), which was confirmed during the AST conducted by Müller-BBM in May 2009.

6. Monitoring Plan

General description of the monitoring plan

The emission reductions achieved by the project activity are monitored based on the approved monitoring methodology AM0034 (Version 2). 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.

Methodology AM0034 requires the use of the European Norm EN14181 (2004) *"Stationary source emissions - Quality assurance of automated measuring systems"*[7] as a guidance[8] for installing and

[4] AO2000 is the Analyzer type, however, the actual name is AO2020 indicating horizontal installation

[5] TÜV Süd Industrie Service GmbH, München (Report number 821029) June 2006

[6] TÜV Umwelttechnik GmbH, Unternehmensgruppe TÜV Bayern, Nr. 24013115, date: 01/03/1996)

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's nitric acid plant was commissioned in 2006 and installed before start of the baseline campaign. In February 2008 the initially installed N_2O analyzer was replaced by a different type.

As an operator of nitric acid plants for many years, Dongbu staff in general and its Instrument Department in particular is accustomed to operating technical equipment to a high level of quality standards.

The plant manager is responsible for the ongoing operation and maintenance of the 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). In addition the supplier of the N_2O analyzer (I&A) company provides service and maintenance for the analyzer at regular intervals.

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

The monitoring software connected to the AMS at Dongbu derives hourly averages for all of the monitored parameters and delivers these data to N.serve, who is responsible for the correct analysis of the delivered data in accordance with the methodology.

Application of EN 14181 procedures to the project

The procedures as given in EN14181 related to QAL1, QAL2 and QAL3 are practically applied at Dongbu nitric acid plant by the following means:

<u>QAL 1</u>

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.

The AMS consisting of the ABB AO2000 URAS 26 gas analyser[9] and the delta-flow DF 25 volume flow meter fulfil the requirements of QAL1[10/11]. Moreover was the analyzer provided by the local ABB distributer company I&A (Instrument & Analyzer), Ulsan, a local company, thus being able of providing service and maintenance for the analyzer at regular intervals.

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[7] 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.

[8] See page 8, last paragraph of AM0034 version 2: "The monitoring system is to be installed using the guidance document EN 14181 …"

[9] AO2000 is Analyzer type, however, the actual name is AO2020 indicating horizontal installation

[10] TÜV Umwelttechnik GmbH, Unternehmensgruppe TÜV Bayern, Nr. 24013115, date: 01/03/1996)

[11] TÜV Süd Industrie Service GmbH, München (Report number 821029) June 2006

QAL2 and Standard Reference Measurements (SRM)

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

A calibration function is established from the results of a number of parallel measurements performed with a Standard Reference Method (SRM). The variability of the measured values obtained with the AMS is then evaluated against the required uncertainty. According to EN14181, both the QAL2 procedures and the SRM need to be conducted by an independent "testing house" or laboratory accredited to EN ISO/IEC 17025.

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

After the installation of the new N_2O analyzer in February 2008, a new QAL2 test was performed for the analyzer by Müller-BBM GmbH, Germany (accredited testing laboratory according to ISO/IEC 17025) in March 2008 and again in May 2010. The tests were performed according to EN 14181 in order to ensure the AMS' suitability, establishing the calibration curve and test the variability of the measurements. The results were applied in the respective calculations of EF_n.

Annual Surveillance Tests (AST) have successfully been performed by an accredited testing house in years between QAL2 tests. The tests were performed in accordance with EN14181. The AST is a series of measurements that need to be conducted by independent measurement equipment in parallel to the existing AMS.

AMS calibration and QA/QC procedures

Dongbu is certified according to ISO 9001 standards for quality management. The procedures for monitoring, regular calibrations and QA/QC are fully embedded into the procedures required by ISO 9001 and documented in the applicable ISO handbooks.

Calibration Gas

A certified N_2O Calibration gas (balance being N_2) with a precision of ± 2% is used in the span calibrations. The calibration gas is certified by the manufacturer.

Analyser Zero and Span Calibrations

Zero and span calibrations are conducted manually at least every 3 weeks. For the zero calibration pure nitrogen is used, for the span calibration a certified calibration gas is used. The results of the calibrations are recorded according to the related CDM procedure.

Flow meter calibration procedures

The flow meter is tested once per year during the AST test according to EN 14181. If the flow meter fails to pass the AST test, the pressure transmitter of the instrument needs to be recalibrated by the manufacturer or by the plant operator.

The probe of the flow meter itself does not need to be calibrated since it is a physical device which will not have drift. Therefore, it is sufficient to regularly inspect the physical condition of the probe.

Training

Operations staff at the nitric acid plant who are responsible for the operation of the AMS and regular calibrations, visual and physical checks have been trained appropriately by the AMS vendors and Dongbu's' own instrumentation engineers.

QAL 3

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

This is achieved by conducting periodic zero and span checks on the AMS and then evaluating the results obtained using control charts. Zero and span adjustments or maintenance of the AMS, may be necessary depending on the results of this evaluation. The periodic zero and span calibration checks are conducted by Dongbu personnel. Results of periodic calibrations are analyzed graphically with the aid of simplified Shewart charts. The documentation of the above mentioned periodic calibrations show that the analyser was operating within the requirements on the drift evaluation as included in the QAL2 test.

A specific procedure was developed according to which in case of unusual calibration observations an investigation on the reason for that event is triggered and an increased calibration frequency is used until the problem is solved. In addition, Annual Surveillance Tests (AST) are conducted in accordance with EN14181, these are a series of measurements that need to be conducted by independent measurement equipment in parallel to the existing AMS.

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 (OT_h, OP_h, AFR, Air Flow, and AIFR). The analyser unit contains its own CPU which receives the NCSG and VSG data (all converted from 4-20 mA analogue data into digital signal). This CPU will store the 2 second raw data of up to 5 years of operation. Then the CPU generates minute-by-minute average values from this raw data which are sent via Ethernet cable to a PC in the control room that also records the plant operating data.

Also from the plant operating data (OT_h, OP_h, AFR, Air Flow, and AIFR) minute-by-minute average values are generated in order to match the per minute average data records for NCSG and VSG.
To obtain the results for stack gas flow VSG (Nm^3/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 (PSG) and temperature (TSG) correction. During the QAL2 and AST test the correct implementation of the correction function of VSG measurements to standard conditions was audited by independent testing laboratories (accredited to EN ISO/IEC 17025; SGS and Müller-BBM). During the test VSG values were compared to the results obtained from measurements by the standard reference method.

As a result, there are now two sets of records on minute-by-minute average basis:

- Plant operation data (OT_h, OP_h, AFR, Air Flow, AIFR)
- Emissions Data (NCSG, VSG)

From these two files the hourly average values are extracted and converted into EXCEL format to get a complete data set which is then imported into the N.serve Database Management System (N.DBMS).

The production of final Nitric Acid at 100% concentration is determined on a daily basis separately recorded and reported.

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

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

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

After data inspection and plausibility check, the provided monitoring data is transferred from the received excel files into the N.DBMS (Microsoft Access Program) for the analysis in accordance with AM0034. The results of this analysis are then exported into excel again where the final calculations are undertaken to derive EF_{BL} and EF_P which will then be used in the Monitoring Reports prepared by N.serve.

Prior to the start of the CDM project activity at Dongbu, the plant operating parameters were only recorded in handwritten log-books as spot values taken every two hours. As described in the PDD, the historic campaigns' operating parameters have been derived from these log-books.

The handwritten log is still continued as a back-up in case of any disturbance of the electronic monitoring and recording systems.

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 Annex1 and Annex2 of this monitoring report: OT_h, OP_h, AFR, AIFR, NAP, GS, GC, CL, incoming N_2O regulation and changes in the NO_X regulations.

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

SECTION D. Data and parameters

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

Data / Parameter:	$NCSG_{BC}$
Data unit:	**mg/Nm^3**
Description:	N_2O concentration in the stack gas during the baseline campaign.
Source of data used:	NDIR N_2O gas analyser (ADC MGA 3000 gas analyser)
Value(s) :	Value applicable for **regular project campaigns** exceeding CL_{normal} CL_{BL}: **3,282** Value applicable for **Project Campaign PC 14: 3,255**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations
Additional comment:	None.

Data / Parameter:	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:	Gas Volume Flow meter, Systec Controls, Deltaflow DF25
Value(s) :	**41,585**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	The stack gas volume measurements are normalized to standard conditions by parallel measurement of temperature (TSG) and pressure (PSG) of the stack gas.

Data / Parameter:	**TSG**
Data unit:	**°C**
Description:	Temperature in the stack gas
Source of data used:	Integrated Stack temperature probe (KDS 2000'S / FT - PT 100 sensor) as part of the stack gas volume flow meter (Systec Controls, Deltaflow DF 25);
Value(s) :	**Not applicable**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	Used for normalization of stack gas volume flow.

Data / Parameter:	PSG
Data unit:	**bar**
Description:	Pressure in the stack
Source of data used:	Stack gas pressure probe integrated in the volume flow meter (Systec Controls, Deltaflow DF 25).
Value(s) :	**Not applicable**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	Used for normalization of stack gas volume flow to standard conditions.

Data / Parameter:	OH_{BC}
Data unit:	**hours**
Description:	Operating hours
Source of data used:	Production log
Value(s) :	**1,506**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	NAP_{BC}
Data unit:	$tHNO_3$
Description:	Metric tonnes of 100% concentrated nitric acid produced during the baseline campaign.
Source of data used:	Tank level measurements
Value(s) :	**19,026.6**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	Please refer to table NAP under section D.2 below for a more detailed description of NAP determination.

Data / Parameter:	UNC
Data unit:	**%**
Description:	Calculated uncertainty of the overall Automated Monitoring System (AMS)
Source of data used:	Calculation of combined uncertainty of the applied monitoring equipment
Value(s) :	**5.0**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline / Project emission calculations.
Additional comment:	None.

Data / Parameter:	AFR
Data unit:	**tNH_3/h**
Description:	Mean Ammonia gas flow rate to the ammonia oxidation reactor
Source of data used:	Orifice plate – Differential pressure measurement principle
Value(s) :	**Not applicable, monitored data of AFR will be used to determine if plant was operating outside of AFR_{max}.**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	AFR_{max}
Data unit:	**tNH_3/h**
Description:	Maximum Ammonia gas flow rate to the ammonia oxidation reactor
Source of data used:	AFR data from historic campaigns
Value(s) :	**3.797**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None.

Data / Parameter:	AIFR
Data unit:	**$t NH_3/h$ / t Air/h**
Description:	Mean Ammonia to air ratio into the ammonia oxidation reactor
Source of data used:	Measurements of AFR and primary air flow rates
Value(s) :	**Not applicable, monitored data of AIFR will be used to determine if plant was operating outside of $AIFR_{max}$.**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	$AIFR_{max}$
Data unit:	**$t NH_3/h$ / t Air/h**
Description:	Maximum Ammonia to air ratio into the ammonia oxidation reactor.
Source of data used:	AIFR
Value(s) :	**0.08**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	CL_{BL}
Data unit:	**$tHNO_3$**
Description:	Length of the baseline campaign measured in metric tonnes of 100% concentrated nitric acid produced during the baseline campaign.
Source of data used:	NAP_{BC}
Value(s) :	**19,026.6**

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

Data / Parameter:	**CL_{normal}**
Data unit:	**$tHNO_3$**
Description:	Average length of the historic campaigns measured in metric tonnes of 100% concentrated nitric acid produced during that baseline campaign.
Source of data used:	Production logs
Value(s) :	**20,672**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline / Project emission calculations.
Additional comment:	None.

Data / Parameter:	**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(s) :	**Used to determine whether OT_h during baseline campaign falls outside OT_{normal}.**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	**OT_{normal}**
Data unit:	**°C (min and max)**
Description:	Normal range operating temperature during the 5 historic campaigns
Source of data used:	Thermocouples inside Ammonia Oxidation Reactor (AOR).
Value(s) :	**907.3°C (min.) and 932.0°C (max.)**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	**OP_h**
Data unit:	**kPa**
Description:	Oxidation Pressure for each hour.
Source of data used:	Monitored by pressure transmitter.
Value(s) :	**Used to determine whether OP_h during baseline campaign falls outside OP_{normal}.**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	**OP_{normal}**
Data unit:	**kPa**
Description:	Oxidation Pressure for each hour during the five historic campaigns.
Source of data used:	Monitored by pressure transmitter
Value(s) :	**1087.5 kPa – 1283.9 kPa**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	**GS_{normal}**
Data unit:	**Name of Supplier**
Description:	Gauze supplier for the five historic campaigns
Source of data used:	Monitored / Invoices
Value(s) :	**Johnson Matthey plc.**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	**GS_{BL}**
Data unit:	**Name of Supplier**
Description:	Gauze supplier for the baseline condition campaign
Source of data used:	Monitored / Invoices
Value(s) :	**Johnson Matthey plc.**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	**GC_{normal}**
Data unit:	**%**
Description:	Gauze composition during the 5 historic operating campaigns expressed as percentage by weight of the precious metals Platinum, Rhodium and, if applicable, Palladium comprising the Ammonia Oxidation Catalyst gauzes.
Source of data used:	Monitored / Gauze supplier invoices
Value(s) :	**Platinum (Pt) 90%, Rhodium (Rh) 5%, Palladium (Pd) 5%**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	**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.
Source of data used:	Monitored / Gauze supplier invoices
Value(s) :	**Platinum (Pt) 90%; Rhodium (Rh) 5%; Palladium (Pd) 5%**

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

Data / Parameter:	$\mathbf{EF_{reg}}$
Data unit:	$\mathbf{tN_2O/tHNO_3}$
Description:	N_2O Emissions cap for N_2O from nitric acid production set by national government regulation.
Source of data used:	Ministry of Environment
Value(s) :	**None**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline / Project emission calculations.
Additional comment:	There is currently no regulation in Korea that limits the emissions of N_2O from nitric acid production.

Data / Parameter:	$\mathbf{BE_{BC}}$
Data unit:	$\mathbf{tN_2O}$
Description:	Total N_2O mass flow during baseline campaign.
Source of data used:	Calculation from measured data.
Value(s) :	Value applicable for **regular project campaigns** exceeding CL_{normal} or CL_{BL}: **212.9** Value applicable for **Project Campaign PC 6: 210.9**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

Data / Parameter:	$\mathbf{EF_{BL}}$
Data unit:	$\mathbf{tN_2O / tHNO_3}$ $\mathbf{(kgN_2O / tHNO_3)}$
Description:	N_2O Emission factor for baseline period
Source of data used:	Calculated from measured data (tons of N_2O emitted / tons of nitric acid produced)
Value(s) :	Value applicable for **regular project campaigns** exceeding CL_{normal} and CL_{BL}: **0.01063 (10.63)**[12] Value applicable for **Project Campaign PC14: 0.01054 (10.54)**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Baseline emission calculations.
Additional comment:	None

[12] This value is different from the value as stated in the PDD (0.01078) as to some corrections done after publication of the PDD. These changes and the baseline emission factor of 0.01063 $tN_2O/tHNO_3$ have been verified by DNV during the first verification.

D.2. Data and parameters monitored

Data / Parameter:	**NCSG**
Data unit:	**mg / m³**
Description:	N_2O concentration in the stack gas during each project campaign.
Measured /Calculated /Default:	Measured/Calculated - every 2 sec. used for calculation of campaign mean (average, after exclusion of extreme values and outliers)
Source of data:	NDIR N_2O gas analyser (ABB AO2020 Uras-26)
Value(s) of monitored parameter:	**Project Campaign PC 11: 1,096** **Project Campaign PC 12: 1,518** **Project Campaign PC 13: 1,783** **Project Campaign PC 14: 1,160** **Project Campaign PC 15: 1,162**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: *NDIR N_2O gas analyzer (ABB AO2020 Uras-26)* Overall measurement accuracy: *±1%* Serial Number*:* *3.358769.7* Calibration frequency: *Manual zero and span calibrations are carried out every three weeks at minimum by external company (local representative of manufacturer of the N_2O Analyzer).* *In addition determination or validation of calibration function is performed once every year*[13]*: QAL2 test (determination) at least every 5 years + AST (validation) in years in between.* Date of last calibration: *QAL2 test according to EN 14181 performed by external laboratory with ISO/IEC 17025 accreditation (Müller BBM) 12/05 - 14/05/2010, last AST according to EN 14181 performed by external laboratory with ISO/IEC 17025 accreditation (Müller BBM) 18/05 - 19/05/2011*[14] valid until: *next AST in 2012, next QAL2: 2013*
Measuring/ Reading/ Recording frequency:	Continuously (every 2 seconds).
Calculation method (if applicable):	NCSG is continuously monitored and recorded every 2 seconds. Hourly mean values for NCSG are derived from the collected data. NCSG data taken during times when the respective plant was out of operation are eliminated. The analyser reads ppmv (parts per million in volume); in order to obtain mg/Nm^3 the values are transferred by application of the

[13]Due to the fact that conducting the QAL2 and AST both require the plant being in operation some flexibility in regard to actual date of test performance is required. Events such as plant shut-down along with the aspects of availability and required planning time (the test is to be carried out by an independent 3rd party holding respective accreditation, which usually comes from overseas) as well as customs check of the equipment can easily delay execution of the test. This means that although once every year either QAL2 or AST shall be conducted the actual time period between 2 consecutive performances is not mandatorily bound to strictly one year (365 days) but allows for some tolerance. Nevertheless, under consideration of operating conditions and practical reasons it is generally aimed on performing the tests one to another as close to one year as possible.

[14] Due to organisational reasons the AST 2011 was conducted about 1 year and 4 days after the previous QAL2 test in 2010. Although actual practice as normally seen throughout European countries and in accordance with EN14181 (as required by AM0034) this kind of delay would be accepted without any doubt, it was decided to apply the maximum acceptable error (accuracy) as stated by equipment vendor for the N_2O concentration measurements (NCSG = 1%) as a conservative correction factor during the critical time period from 15/05/ – 18/05/2011. This measure presents the correct application of EB52, Annex 60 as the 2011 AST resulted in confirmation of the established QAL2 calibration function for NCSG.

	following 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. Subsequently the following statistical analysis is applied: 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 Before using the resulting new sample mean for calculation of emission reductions a correction factor as determined during the latest QAL2 test is applied. The relevant QAL2 correction factor for this monitoring period for NCSG is ***1.017.***
QA/QC procedures applied:	Manual zero and span calibrations, AST and QAL2 test according to EN 14181. *QAL3 procedures according to EN 14181 applied through documentation and evaluation by Shewart charts.*

Data / Parameter:	**VSG**
Data unit:	**Nm^3/h**
Description:	Normal gas volume flow rate of the stack gas during each project campaign.
Measured /Calculated /Default:	Measured/Calculated - every 2 sec. used for calculation of campaign mean (average, after exclusion of extreme values and outliers)
Source of data:	Gas Volume Flow meter, Systec Controls, Deltaflow DF25
Value(s) of monitored parameter:	**Project Campaign PC 11: 47,051** **Project Campaign PC 12: 47,394** **Project Campaign PC 13: 46,651** **Project Campaign PC 14: 45,761** **Project Campaign PC 15: 46,552**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: *Tail Gas Volume Flow meter, Systec Controls, Deltaflow DF 25 with integrated temperature and pressure measurement, transmitter: Foxboro/Invensys, Annubar, model IVM 30* Overall measurement accuracy: *1.5%* Serial Number: *06460586/10546-01* Calibration frequency: D*etermination or validation of calibration function is performed once every year[15]: QAL2 test (determination) at least every 5 years + AST (validation) in years in between.*

[15]Due to the fact that conducting the QAL2 and AST both require the plant being in operation some flexibility in regard to actual date of test performance is required. Events such as plant shut-down along with the aspects of

	Date of last calibration: *QAL2 test according to EN 14181 performed by external laboratory with ISO/IEC 17025 accreditation (Müller BBM) 12/05 - 14/05/2010, last AST according to EN 14181 performed by external laboratory with ISO/IEC 17025 accreditation (Müller BBM) 18/05 - 19/05/2011*[16] valid until: *next AST in 2012, next QAL2: 2013*
Measuring/ Reading/ Recording frequency:	Continuously (every 2 seconds).
Calculation method (if applicable):	VSG is continuously monitored with a flow meter and monitoring results are recorded continuously (every 2 seconds). The *SYSTEC Controls, Deltaflow DF 25* with integrated Foxboro/ Invensys IMV30 multivariable transmitter/calculator, (annubar probe with multifunctional transmitter for pressure and temperature correction) combines differential pressure, static pressure and temperature measurement with an integral flow calculator to dynamically and continuously calculate all of the dp flow coefficients for fully compensated flow. The dp, stack temperature and stack pressure are measured and the normalized flow in standard conditions (273.15 K, 1013.25 hPa) calculated directly in the instrument. The normalized flow measurements are recorded in the data acquisition system. Hourly means for VSG are derived by the data acquisition system. VSG data taken during times when the plant was operating outside the permitted operating range were eliminated. The resulting hourly average values for VSG are now expressed in Nm^3/h as required by AM0034 and are subjected to the following statistical analysis: 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 Before using the resulting new sample mean for calculation of emission reductions a correction factor as determined during the latest QAL2 test is applied. The relevant QAL2 correction factor for this

availability and required planning time (the test is to be carried out by an independent 3rd party holding respective accreditation, which usually comes from overseas) as well as customs check of the equipment can easily delay execution of the test. This means that although once every year either QAL2 or AST shall be conducted the actual time period between 2 consecutive performances is not mandatorily bound to strictly one year (365 days) but allows for some tolerance. Nevertheless, under consideration of operating conditions and practical reasons it is generally aimed on performing the tests one to another as close to one year as possible.

[16] Due to organisational reasons the AST 2011 was conducted about 1 year and 4 days after the previous QAL2 test in 2010. Although actual practice as normally seen throughout European countries and in accordance with EN14181 (as required by AM0034) this kind of delay would be accepted without any doubt, it was decided to apply the maximum acceptable error (accuracy) as stated by equipment vendor for the tail gas volume flow (VSG = 1.5%) as a conservative correction factor during the critical time period from 15/05/ – 18/05/2011. This measure presents the correct application of EB52, Annex 60 as the 2011 AST resulted in confirmation of the established QAL2 calibration function for VSG.

	monitoring period for VSG is ***1.11***.
QA/QC procedures applied:	AST and QAL2 according to EN 14181.

Data / Parameter:	**TSG**
Data unit:	**°C**
Description:	Temperature in the stack gas
Measured /Calculated /Default:	Measured.
Source of data:	Integrated Stack temperature probe (KDS 2000'S / FT - PT 100 sensor) as part of the stack gas volume flow meter (Systec Controls, Deltaflow DF 25)
Value(s) of monitored parameter:	Not applicable, directly used for normalization of tail gas volume flow measurement.
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: *Tail Gas Volume Flow meter, Systec Controls, Deltaflow DF 25 with integrated temperature (temperature probe KDS 2000'S / FT - PT 100 sensor) and pressure measurement, transmitter: Foxboro/Invensys, Annubar, model IVM 30* Overall measurement accuracy: *1.5%* Serial Number: *06460586/10546-01* Calibration frequency: D*etermination or validation of calibration function is performed once every year*[17]*: QAL2 test (determination) at least every 5 years + AST (validation) in years in between.* Date of last calibration: *QAL2 test according to EN 14181 performed by external laboratory with ISO/IEC 17025 accreditation (Müller BBM) 12/05 - 14/05/2010, last AST according to EN 14181 performed by external laboratory with ISO/IEC 17025 accreditation (Müller BBM) 18/05 - 19/05/2011*[18] valid until: *next AST in 2012, next QAL2: 2013*
Measuring/ Reading/ Recording frequency:	Continuously (every 2 seconds).
Calculation method (if applicable):	Not applicable.
QA/QC procedures applied:	ISO9001 procedures and documented in the applicable ISO handbooks. The QAL2 test as well as the AST test, performed by an independent 3rd party laboratory with EN ISO/IEC 17025 accreditation, include the test of the correct measurement of stack gas temperature and stack gas

[17]Due to the fact that conducting the QAL2 and AST both require the plant being in operation some flexibility in regard to actual date of test performance is required. Events such as plant shut-down along with the aspects of availability and required planning time (the test is to be carried out by an independent 3rd party holding respective accreditation, which usually comes from overseas) as well as customs check of the equipment can easily delay execution of the test. This means that although once every year either QAL2 or AST shall be conducted the actual time period between 2 consecutive performances is not mandatorily bound to strictly one year (365 days) but allows for some tolerance. Nevertheless, under consideration of operating conditions and practical reasons it is generally aimed on performing the tests one to another as close to one year as possible.

[18] Due to organisational reasons the AST 2011 was conducted about 1 year and 4 days after the previous QAL2 test in 2010. Although actual practice as normally seen throughout European countries and in accordance with EN14181 (as required by AM0034) this kind of delay would be accepted without any doubt, it was decided to apply the maximum acceptable error (accuracy) as stated by equipment vendor for the tail gas volume flow (VSG = 1.5%) as a conservative correction factor during the critical time period from 15/05/ – 18/05/2011. As TSG is directly used for generating normalized measurements this parameter (TSG) is covered by the applied correction for VSG (same instrument).The described correction for VSG This measure presents the correct application of EB52, Annex 60 as the 2011 AST resulted in confirmation of the established QAL2 calibration function for VSG.

	pressure by comparison of the AMS results of these parameters (as displayed by the flow meter transmitter at the stack) with the results of the reference measurement instruments of the testing laboratory. Moreover during the QAL2 and AST tests the correct normalization of the stack gas flow (VSG) to standard conditions is verified by comparison of the AMS results for normalized flow with the reference measurement results for normalized flow. As TSG is the internal temperature measurement of the volume flow meter directly utilized by the device for displaying the measured volume flow at normalized conditions regular calibration is covered by QAL2/AST for VSG.

Data / Parameter:	**PSG**
Data unit:	**Bar**
Description:	Pressure in the stack
Measured /Calculated /Default:	Measured.
Source of data:	Stack gas pressure probe integrated in the volume flow meter (Systec Controls, Deltaflow DF 25).
Value(s) of monitored parameter:	Not applicable, directly used for normalization of tail gas volume flow measurement.
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: *Tail Gas Volume Flow meter, Systec Controls, Deltaflow DF 25 with integrated temperature and pressure measurement, transmitter: Foxboro/Invensys, Annubar, model IVM 30* Overall measurement accuracy: *1.5%* Serial Number: *06460586/10546-01* Calibration frequency: D*etermination or validation of calibration function is performed once every year*[19]*: QAL2 test (determination) at least every 5 years + AST (validation) in years in between.* Date of last calibration: *QAL2 test according to EN 14181 performed by external laboratory with ISO/IEC 17025 accreditation (Müller BBM) 12/05 - 14/05/2010, last AST according to EN 14181 performed by external laboratory with ISO/IEC 17025 accreditation (Müller BBM) 18/05 - 19/05/2011*[20] valid until: *next AST in 2012, next QAL2: 2013*
Measuring/ Reading/ Recording frequency:	Continuously (every 2 seconds).

[19]Due to the fact that conducting the QAL2 and AST both require the plant being in operation some flexibility in regard to actual date of test performance is required. Events such as plant shut-down along with the aspects of availability and required planning time (the test is to be carried out by an independent 3rd party holding respective accreditation, which usually comes from overseas) as well as customs check of the equipment can easily delay execution of the test. This means that although once every year either QAL2 or AST shall be conducted the actual time period between 2 consecutive performances is not mandatorily bound to strictly one year (365 days) but allows for some tolerance. Nevertheless, under consideration of operating conditions and practical reasons it is generally aimed on performing the tests one to another as close to one year as possible.

[20] Due to organisational reasons the AST 2011 was conducted about 1 year and 4 days after the previous QAL2 test in 2010. Although actual practice as normally seen throughout European countries and in accordance with EN14181 (as required by AM0034) this kind of delay would be accepted without any doubt, it was decided to apply the maximum acceptable error (accuracy) as stated by equipment vendor for the tail gas volume flow (VSG = 1.5%) as a conservative correction factor during the critical time period from 15/05/ – 18/05/2011. As PSG is directly used for generating normalized measurements this parameter (PSG) is covered by the applied correction for VSG (same instrument).The described correction for VSG This measure presents the correct application of EB52, Annex 60 as the 2011 AST resulted in confirmation of the established QAL2 calibration function for VSG.

Calculation method (if applicable):	Not applicable.
QA/QC procedures applied:	ISO9001procedures and documented in the applicable ISO handbooks. The QAL2 test as well as the AST test, performed by an independent 3rd party laboratory with EN ISO/IEC 17025 accreditation, include the test of the correct measurement of stack gas temperature and stack gas pressure by comparison of the AMS results of these parameters (as displayed by the flow meter transmitter at the stack) with the results of the reference measurement instruments of the testing laboratory. Moreover during the QAL2 and AST tests the correct normalization of the stack gas flow (VSG) to standard conditions is verified by comparison of the AMS results for normalized flow with the reference measurement results for normalized flow. As TSG is the internal pressure measurement of the volume flow meter directly utilized by the device for displaying the measured volume flow at normalized conditions regular calibration is covered by QAL2/AST for VSG.

Data / Parameter:	**PE_n**
Data unit:	**tN_2O**
Description:	Total mass N_2O emissions in each project campaign.
Measured /Calculated /Default:	Calculated.
Source of data:	Calculated from measured values.
Value(s) of monitored parameter:	**Project Campaign PC 11: 87.4** **Project Campaign PC 12: 121.3** **Project Campaign PC 13: 143.8** **Project Campaign PC 14: 81.9** **Project Campaign PC 15: 110.8**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if applicable):	$PE_n = VSG * NCSG * 10^{-9} * OH$
QA/QC procedures applied:	Not applicable.

Data / Parameter:	**OH_n**
Data unit:	**Hours**
Description:	Total operating hours during each project campaign
Measured /Calculated /Default:	Measured.
Source of data:	Production log.
Value(s) of monitored parameter:	**Project Campaign PC 11: 1,695** **Project Campaign PC 12: 1,686** **Project Campaign PC 13: 1,729** **Project Campaign PC 14: 1,543** **Project Campaign PC 15: 1,862**
Indicate what the data are used for (Baseline/ Project/	Project emission calculations.

Leakage emission calculations)	
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Hourly.
Calculation method (if applicable):	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 PE calculation. 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 are recorded outside the "trip" limits as determined by the plant manuals: AIFR > 0.081 (i.e. if the Ammonia concentration in Air is higher than 8.1%, the plant shuts itself off automatically. The trip value for AIFR given as 0.075 in the manual is actually representative of 0.075 units Ammonia in 1 unit of Air. Therefore, the trip value has to be recalculated as 0.075 / (1 - 0.075) = 0.081 in order for it to be comparable with the AFR/Air calculation) OPh > 1500 kPa The following additional criteria were applied to exclude any obviously nonsensical values and the corresponding operating hours (OH) eliminated: OTh < 550°C AFR = 10 t NH3/h (These values were chosen arbitrarily with a view to capture and exclude such values that where obviously not valid or nonsensical)
QA/QC procedures applied:	Not applicable.

Data / Parameter:	**NAP**
Data unit:	**$tHNO_3$**
Description:	Metric tonnes of 100% concentrated nitric acid during each project campaign.
Measured /Calculated /Default:	Measured
Source of data:	Flow Meter
Value(s) of monitored parameter:	**Project Campaign PC 11: 21,109** **Project Campaign PC 12: 20,281** **Project Campaign PC 13: 20,536** **Project Campaign PC 14: 18,213** **Project Campaign PC 15: 21,596**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Type: ***Coriolis Mass Flow Meter*** *(Tag-Nr. FQI-1303)* Overall measurement accuracy: *± 0.1%* Serial Number: *14175882* Calibration frequency: *every three years* Date of last calibration: *the new coriolis flow meter was installed*

	05/07/2010;first periodic calibration relevant for this monitoring period was carried out: 07/06/2011 valid until: *06/06/2014*
Measuring/ Reading/ Recording frequency:	see below calculation method
Calculation method (if applicable):	NAP flow at actual concentration (as measured by the coriolis mass flow meter) * nitric acid concentration (also measured by this same coriolis flow meter) results in NAP at 100%.
QA/QC procedures applied:	Regular calibration

Data / Parameter:	**EF_n**
Data unit:	**tN_2O / $tHNO_3$ (kgN_2O / $tHNO_3$)**
Description:	Emissions factor for campaign n.
Measured /Calculated /Default:	Calculated.
Source of data:	Calculation from total mass N_2O emissions of campaign n (PE_n) and total nitric acid production (NAP_n).
Value(s) of monitored parameter:	**Project Campaign PC 11: 0.00414 (4.14)** **Project Campaign PC 12: 0.00598 (5.98)** **Project Campaign PC 13: 0.00700 (7.00)** **Project Campaign PC 14: 0.00450 (4.50)** **Project Campaign PC 15: 0.00466 (4.66)**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if applicable):	The campaign specific emissions factor for each campaign during the project's crediting period is calculated by dividing the total mass of N_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 is: $EF_n = PE_n / NAP_n$
QA/QC procedures applied:	Not applicable.

Data / Parameter:	**$EF_{ma,n}$**
Data unit:	**tN_2O / $tHNO_3$ (kgN_2O / $tHNO_3$)**
Description:	Moving average emissions factor derived over time from campaign specific emissions factors.
Measured /Calculated /Default:	Calculated.
Source of data:	Calculation from project emission factors of all project campaigns.
Value(s) of monitored parameter:	**Project Campaign PC 11: 0.00424 (4.24)** **Project Campaign PC 12: 0.00439 (4.39)** **Project Campaign PC 13: 0.00459 (4.59)** **Project Campaign PC 14: 0.00458 (4.58)** **Project Campaign PC 15: 0.00459 (4.59)**
Indicate what the data are	Project emission calculations.

used for (Baseline/ Project/ Leakage emission calculations)	
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if applicable):	In order to take into account possible long-term emissions trends over the duration of the project activity and to take a conservative approach the moving average emission factor is determined as follows: $EF_{ma,n} = (EF_1 + EF_2 + \ldots + EF_n) / n$ 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.
QA/QC procedures applied:	Not applicable.

Data / Parameter:	**EF_p**
Data unit:	**tN_2O / $tHNO_3$ (kgN_2O / $tHNO_3$)**
Description:	Emissions factor used for the specific campaign n to determine the emission reductions of that campaign
Measured /Calculated /Default:	Calculated.
Source of data:	Calculation of EF_n and $EF_{ma,n}$.
Value(s) of monitored parameter:	**Project Campaign PC 11: 0.00424 (4.24)** **Project Campaign PC 12: 0.00598 (5.98)** **Project Campaign PC 13: 0.00699 (6.99)** **Project Campaign PC 14: 0.00458 (4.58)** **Project Campaign PC 15: 0.00466 (4.66)**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if applicable):	To calculate the total emission reductions achieved in a campaign, the higher of the two values $EF_{ma,n}$ 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 applied:	Not applicable.

Data / Parameter:	**EF_{min}**
Data unit:	**tN_2O / $tHNO_3$ (kgN_2O / $tHNO_3$)**
Description:	EF_{min} is equal to the lowest EF_n observed during the first 10 campaigns

	of the project crediting period.
Measured /Calculated /Default:	Calculated.
Source of data:	Calculation of EF_n.
Value(s) of monitored parameter:	**0.0028 (2.98)**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if applicable):	A campaign-specific emissions factor shall be used to cap any potential long-term trend towards decreasing N_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 applied:	Not applicable.

Data / Parameter:	**CL_n**
Data unit:	**$tHNO_3$**
Description:	Length of each project campaign measured in metric tonnes of 100% concentrated nitric acid produced during that campaign.
Measured /Calculated /Default:	Measured.
Source of data:	Calculation from project emission factors of all project campaigns.
Value(s) of monitored parameter:	**Project Campaign PC 11: 21,109** **Project Campaign PC 12: 20,281** **Project Campaign PC 13: 20,536** **Project Campaign PC 14: 18,213** **Project Campaign PC 15: 21,618**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Project emission calculations.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	See description for NAP measurement!
Measuring/ Reading/ Recording frequency:	See description for NAP measurement!
Calculation method (if applicable):	See description for NAP measurement!
QA/QC procedures applied:	See description for NAP measurement!

Data / Parameter:	**OP_h**
Data unit:	**Bar**

Description:	Oxidation Pressure for each hour
Measured /Calculated /Default:	Measured.
Source of data:	Monitored by pressure transmitter.
Value(s) of monitored parameter:	**Not applicable. Eventually used to determine whether the plant is in operation or not.**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if applicable):	Not applicable.
QA/QC procedures applied:	Not applicable.

Data / Parameter:	**OTh**
Data unit:	**°C**
Description:	Oxidation temperature in the ammonia oxidation reactor (AOR).
Measured /Calculated /Default:	Measured.
Source of data:	Thermocouple inside Ammonia Oxidation Reactor (AOR)
Value(s) of monitored parameter:	**Not applicable. Eventually used to determine whether the plant is in operation or not.**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if applicable):	Not applicable.
QA/QC procedures applied:	Not applicable.

Data / Parameter:	**AFR**
Data unit:	**tNH_3/h**
Description:	Ammonia gas flow rate to the ammonia oxidation reactor.
Measured /Calculated /Default:	Measured.
Source of data:	Continuously measured by orifice plate.
Value(s) of monitored parameter:	**Not applicable. Eventually used to determine whether the plant is in operation or not.**
Indicate what the data are used for (Baseline/ Project/ Leakage emission	Not applicable.

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

Data / Parameter:	**AIFR**
Data unit:	**% v/v**
Description:	Ammonia to air ratio into the ammonia oxidation reactor
Measured /Calculated /Default:	Calculated.
Source of data:	Calculation for each hour of plant operation based on measurements of AFR and primary air flow rates.
Value(s) of monitored parameter:	**Not applicable. Eventually used to determine whether the plant is in operation or not.**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if applicable):	Not applicable.
QA/QC procedures applied:	Not applicable.

Data / Parameter:	$\mathbf{GS_{project}}$
Data unit:	**Name of Supplier**
Description:	Gauze supplier for the project campaign
Measured /Calculated /Default:	Not applicable.
Source of data:	Monitored / Invoices
Value(s) of monitored parameter:	**Johnson Matthey plc**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if	Not applicable.

applicable):	
QA/QC procedures applied:	Not applicable.

Data / Parameter:	**$GC_{project}$**
Data unit:	**%**
Description:	Gauze composition during the project campaign expressed as % by weight of the precious metals Platinum, Rhodium and, if applicable, Palladium comprising the Ammonia Oxidation Catalyst gauzes.
Measured /Calculated /Default:	Not applicable.
Source of data:	Monitored / Gauze supplier invoices
Value(s) of monitored parameter:	**Platinum (Pt) 90%** **Rhodium (Rh) 5%** **Palladium (Pd) 5%**
Indicate what the data are used for (Baseline/ Project/ Leakage emission calculations)	Not applicable.
Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity)	Not applicable.
Measuring/ Reading/ Recording frequency:	Not applicable.
Calculation method (if applicable):	Not applicable.
QA/QC procedures applied:	Not applicable.

SECTION E. Emission reductions calculation

E.1. Baseline emissions calculation

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

It should be noted that all values presented in excel tables are displayed (in the tables) as rounded values due to the function of excel as a program. However, actual calculations have been conducted using the exact values, which explains possible differences compared to calculating with the rounded parameter values as displayed in the tables. This applies to all presented excel tables not only those related to baseline emission calculations.

The Baseline Campaign was conducted 06/04/2007 – 14/06/2007.

<u>**Analysis of Historical campaign data and determination of permitted operating ranges**</u>

Historical Query 1 (Raw data): Analysis of historical campaign data

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

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

The resulting MS Access table shows the following numbers:

Query 1: Without parameter limits

ProjId	CampType	Count(DT)	Count(AFR)	Max(AFR)	Max(AIFR)	Min(Oph)	Max(Oph)	Min(OTh)	Max(OTh)	Sum(NAP)
11	H	4148	4148	333,284	6,691106204	0	12458	0	941	103360,429

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

N.DBMS		**Dongbu (Ulsan, Korea)**								
Historical campaigns		**Query 1: Without parameter limits**								
	Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**		**VSG**	**NAP**
	Unit	h	t NH3 / h	ratio	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count		4.148	4.148	4.126	4.148	4.142				
Minimum			0	0,006	0,00	0				
Maximum			333	6,691	12.458,0	941				
Mean			3,37	0,068	1.201,6	915				
Standard deviation			5,15	0,105	307,5	64				
95% Confidence Interval			10,10	0,206	602,8	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}. The result for CL_{normal} is ***20,672*** tons of 100% HNO_3.

Historical Query 2: Analysis of the raw historical campaign data

This second query includes elimination of incomplete and obviously implausible monitoring data sets. For the reason of making this more systematic, the following exclusion criteria according to plant operation trip values were applied:

AFR < 10 tNH3/h

OPh < 1500 kPa (i.e. if the ammonia oxidation pressure in the raw data log for a particular point in time is higher than 1500 kPa, the whole data set was excluded from further analysis as to exclude extreme and nonsensical values (exclusion of only 3 values)

AIFR < 0.12 (exclusion of only one single value)

OTh > 550°C (chosen to be consistent with the trip criteria applied during the baseline campaign)

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	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	4.105	4.105	4.105	4.105	4.105				
Remaining share of data set	99%	99%	99%	99%	99%				
Minimum		0,32	0,006	117,0	817				
Maximum		3,80	0,080	1.301,0	941				
Mean		3,30	0,066	1.200,6	919				
Standard deviation		0,09	0,003	58,7	7				
95% Confidence Interval		0,17	0,005	115,1	13				
Sum									
Limits acc. to consistency check		not blank	not blank	not blank	not blank				
Lower limit					550				
Upper limit		10	0,081	1.500					

As a result from this query the AFR_{max} is ***3.8 t NH_3/h*** and $AIFR_{max}$ is ***8 %.***
The remaining historical data were analysed in excel in order to determine the upper and lower 2.5% percentiles for OPh and OTh (Query 3 and 4).

The statistical analysis reveals that the plant operated under very stable conditions resulting in fairly narrow "permitted operating ranges" based on the analysed historical data:

OP_h range: ***1,087.5 - 1,283.9 kPa***
OT_h range: ***907.3 - 932.0 °C***

These permitted ranges were then applied in Query 5 below.

Analysis of Baseline campaign data

Baseline Query 1 (Raw data): Analysis of raw baseline data without application of operating limits

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	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,512	1,507	1,507	1,507	1,507	1,507		1,507	
Minimum		1.86	0.060	234.65	661	139	*273*	3,198	
Maximum		3.36	0.143	1,263.00	932	2,300	*4,519*	43,683	
Mean		3.21	0.068	1,185.76	920	1,682	*3,304*	41,297	
Standard deviation		0.09	0.003	72.72	11	198	*390*	2,313	
Sum	1,512								19,027
Baseline emissions	**BE**	*= VSG * NCSG * OH * 10^{-9}*						t N2O	**206.3**
Emission factor	**EF**	*= BE / NAP*10^{3}*						kg N2O / t HNO3	**10.84**

Baseline Campaign period: 06/04/2007 – 14/06/2007. The above table shows the raw results for NAP, OH, NCSG, VSG and EF_{BL}.
According to this Query 1, the NAP value of the baseline campaign is ***19,027*** t of nitric acid. The total number of operating hours for this campaign is ***1,507*** h according to the production log.

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	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,483	1,483	1,483	1,483	1,483	1,483		1,483	
Remaining share of data sets	98%	98%	98%	98%	98%	98%		98%	
Minimum		3.08	0.062	1,092.0	907	139	*273*	38,680	
Maximum		3.36	0.075	1,263.0	932	2,262	*4,444*	43,683	
Mean		3.22	0.068	1,191	921	1,680.48	*3,302*	41,447	
Standard deviation		0.05	0.003	33.1	5	193	*379*	984	
95% Confidence Interval		0.10	0.006	64.9	9	378	*742*	1,928	
Sum	1,506								19,026.6
Limits acc. to consistency check									
Lower limit				1,087	907.3				
Upper limit		3.797	0.080	1,284	932.0				
Baseline emissions	**BE**	*= VSG * NCSG * OH * 10^{-9}*						t N2O	**206.1**
Emission factor	**EF**	*= BE / NAP * 10^3*						kg N2O / t HNO3	**10.83**

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 all parameters (AFR, AIFR, OPh and OTh) were within the determined "permitted operating ranges".

The remaining share of the operating data after Query 5 is 98% of the raw data and therefore fully complies with the requirement of methodology AM0034 that plant operation must lay within the permitted range for 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). These 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	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count						1,417		1,345	
Minimum		3.080	0.062	1,092.0	907	1,305	2,565	40,078	
Maximum		3.357	0.075	1,263.0	932	2,055	4,038	43,288	
Mean		3.217	0.068	1,191.0	921	1,671	3,282	41,585	
Standard deviation						162	319	839	
95% Confidence Interval									
Sum	1,506								19,026.6
Limits acc. to consistency check									
Lower limit				1,087	907.3	1,303		39,518	
Upper limit		3.797	0.080	1,284	932.0	2,058		43,375	
	Correction factors resulting from QAL2					**0.945**		**1.096**	
Baseline emissions	**BE**	*= VSG * NCSG * OH*						t N2O	**212.9**
Emission factor	**EF**	*= BE * 10^3 / NAP * (1 - UNC/100)*						kg N2O / t HNO3	**10.63**
Uncertainty	UNC								**5.00**

By applying a 95% confidence interval on the remaining NCSG and VSG values again mavericks and outliers are excluded. The resulting mean values for NCSG and VSG are applied for calculation of the

Baseline N_2O emissions (BE) taking into account respective correction factors for NCSG and VSG as were determined during the QAL2 test.

Resulting EF_{BL}

The EF_{BL} derived from this analysis of historic and baseline data is ***10.63*** kg N_2O/tHNO_3.

<u>Statistical test if the baseline is representative of a normal campaign</u>

Compare BL campaign with Historic Campaigns

Historic campaigns:		AFR	AIFR	OPh	OTh
Historic upper 95% CI level	3.46	0.071	1315.7	932.5	
Baseline mean values	***3.22***	***0.068***	***1191.0***	***920.1***	
Historic lower 95% CI level	3.13	0.060	1085.5	905.9	

The values appearing in fat 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.

<u>Adjustment of Baseline Emission Factor if $CL_n < CL_{normal}$</u>

If the length of an individual project campaign CL_n is longer than or equal to the average historic campaign length CL_{normal} (20,672 tHNO_3), then all N_2O values measured during the baseline campaign can be used for the calculation of EF_{BL}. If $CL_n < CL_{normal}$, EF_{BL} has to be recalculated 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_{BL}. However, since the campaign length of the baseline campaign (CL_{BL}) was below CL_{normal} the actual threshold for factual adjustment of EF_{BL} is not presented by CL_{normal} but CL_{BL} at 19,026.6 tHNO_3.

Since for campaigns PC11 and PC15 $CL_n > CL_{normal}$ applies the above determined EF_{BL} is valid and was used for the calculation of respective emission reductions. In addition for PC12 and PC13 $CL_{normal} > CL_n > CL_{BL}$ applies, thus effectively no N_2O values can be removed. Again the above determined EF_{BL} is valid and was used for the calculation of respective emission reductions.

Only for campaigns PC14 $CL_n < CL_{normal}$ and at the same time $CL_n < CL_{BL}$ applies. Consequently individual recalculation of the EF_{BL} is carried out for this project campaign.

<u>Recalculation of Baseline Emissions Factor due to $CL_n < CL_{normal}$</u>

Since for campaign PC14 $CL_n < CL_{normal}$ (and at the same time $CL_n < CL_{BL}$) applies, the EF_{BL} is individually recalculated by eliminating those N_2O values that were obtained during the production of tonnes of nitric acid beyond the respective CL_n value (i.e. the last tonnes produced) within the calculation of EF_{BL}. As a result of this recalculation the following new value applies:

- EF_{BL} to be applied for the project campaign (PC 14) is 10.54 kg N_2O /t HNO_3.

N.DBMS Baseline Calculation P14				**Project:**	**Dongbu (Ulsan, Korea)**				
Baseline campaign calculation for Project campaign 14	**Query 6a+b: Confidence levels for NCSG and VSG**					**117**		**121**	
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	ratio	kPa	°C	ppm	mg N2O /	Nm3 / h	t HNO3
Count	1,483	1,483	1,483	1,483	1,483	1,352		1,345	
Minimum		3.08	0.062	1,092	907	1,305	2,563	40,078	
Maximum		3.36	0.075	1,263	932	2,033	3,994	43,288	
Mean		3.22	0.068	1,191	921	1,657	3,255	41,585	
Standard deviation		0.05	0.003	33	5	153	301	839	
95% confidence level *(1.96 * Std.dev.)*									
Sum	1,506								19,026.6
Limits acc. to consistency check						9/6/07 5:00			
Lower limit				1,087	907.3	1,304		39,518	
Upper limit		3.797	0.080	1,284	932.0	2,036		43,375	
	Correction factors resulting from QAL2					**0.945**		**1.096**	
Baseline emissions		**BE_{BC}**	$= VSG * NCSG * 10^{-9} * Oh$					t N2O	**211.2**
Emission factor		**EF_{BL}**	$= BE * 10^{3} / NAP * (1 - UNC/100)$					kg N2O / t HNO3	**10.54**
Uncertainty		UNC							**5.00**

Adjustment of Baseline emissions factor due to EF_{reg}

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

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

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

where:

Variable Definition

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

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

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

E.2. Project emissions calculation

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Project emissions are calculated according to the following formula:

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

Variable	Definition
VSG	Mean stack gas volume flow rate for the project campaign (m^3/h)
NCSG	Mean concentration of N_2O in the stack gas for the project campaign (mgN_2O/m^3)
PEn	Total N_2O emissions of the n^{th} project campaign (tN_2O)
OH	Is the number of hours of operation in the specific monitoring period (h)

Based on the total N_2O emissions of each project campaign the specific project campaign emission factor is calculated as:

$EF_n = PE_n / NAP_n$

Where:

Variable	Definition
EF_n	Project Emission Factor for n^{th} project campaign (kg N_2O/t HNO_3)
PE_n	Total N_2O emissions of the n^{th} project campaign (tN_2O or kg N_2O)
NAP_n	Campaign length of the n^{th} project campaign ($tHNO_3$)

Before calculation of the Project Emissions (PE) the same statistical analysis as for the calculation of the baseline emission factor (EF_{BL}) is applied to the monitoring raw data (hourly average values) of each project campaign.

The respective correction factors for NCSG and VSG as determined during the relevant QAL2 test have been applied to the monitoring data (hourly values) before application of the statistical analysis.

Analysis of Project campaign data

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

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

It should be noted that longer plant shut down times und obvious implausible data are subject to exclusion before this step.

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 11:	21/10/2010 - 04/01/2011		
Project campaign 11		**Query 1: Without parameter limits**							208
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,696	1,696	1,696	1,696	1,696	1,696		1,696	
Minimum		0.37	3.80	80	613	51	*100*	735	
Maximum		3.50	9.8	1,307	937	2,071	*4,069*	47,929	
Mean		3.41	6.70	1,282	931	578	*1,135*	46,976	
Standard deviation		0.105	0.12	38	13	129	*253*	1,490	
95% confidence level *(1.96 * Std.dev.)*		*0.20*	*0.24*	*75*	*26*	*252*	*496*	*2,921*	
Sum	1,696								21,109
Limits acc. to consistency check									
Lower limit									
Upper limit									
Campaign emissions	**PE**[1]	*= VSG * NCSG * Oh * 10^-9*						t N2O	**90.4**
Emission factor	**EF_n**	*= PE / NAP * 10^3*						kg N2O / t HNO3	**4.28**
[1] **QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System**									

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 12:	05/01/2011 - 19/03/2011		
Project campaign 12		**Query 1: Without parameter limits**							228
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,688	1,688	1,688	1,688	1,688	1,688		1,688	
Minimum		0.33	2.43	216	590	3	*6*	3,002	
Maximum		3.45	9.9	1,307	937	2,307	*4,533*	48,454	
Mean		3.37	6.63	1,288	929	780	*1,532*	47,211	
Standard deviation		0.156	0.20	57	18	224	*440*	2,359	
95% confidence level *(1.96 * Std.dev.)*		*0.31*	*0.39*	*112*	*35*	*439*	*862*	*4,623*	
Sum	1,688								20,281
Limits acc. to consistency check									
Lower limit									
Upper limit									
Campaign emissions	**PE**[1]	*= VSG * NCSG * Oh * 10^-9*						t N2O	**122.1**
Emission factor	**EF_n**	*= PE / NAP * 10^3*						kg N2O / t HNO3	**6.02**
[1] **QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System**									

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 13:	20/03/2011 - 07/06/2011		
Project campaign 13		**Query 1: Without parameter limits**							248
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,731	1,731	1,731	1,731	1,731	1,731		1,731	
Minimum		0.01	3.32	-2	598	37	*73*	17	
Maximum		3.45	10.6	1,310	937	1,547	*3,040*	48,093	
Mean		3.36	6.68	1,261	928	922	*1,811*	46,521	
Standard deviation		0.144	0.18	62	15	176	*346*	2,317	
95% confidence level *(1.96 * Std.dev.)*		*0.28*	*0.36*	*121*	*30*	*345*	*678*	*4,542*	
Sum	1,731								20,536
Limits acc. to consistency check									
Lower limit									
Upper limit									
Campaign emissions	**PE**[1]	*= VSG * NCSG * Oh * 10^-9*						t N2O	**145.9**
Emission factor	**EF_n**	*= PE / NAP * 10^3*						kg N2O / t HNO3	**7.10**
[1] **QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System**									

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 14:	08/06/2011 - 12/08/2011		
Project campaign 14		**Query 1: Without parameter limits**							268
Parameter	**OH**	**AFR**	**AIFR**	**OPh**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,546	1,546	1,546	1,546	1,546	1,546		1,546	
Minimum		0.01	4.50	-2	551	53	*104*	15	
Maximum		3.44	10.6	1,272	939	1,425	*2,801*	47,359	
Mean		3.33	6.71	1,222	924	625	*1,228*	45,643	
Standard deviation		0.145	0.19	54	15	196	*385*	2,063	
95% confidence level *(1.96 * Std.dev.)*		*0.28*	*0.36*	*107*	*29*	*384*	*754*	*4,044*	
Sum	1,546								18,213
Limits acc. to consistency check									
Lower limit									
Upper limit									
Campaign emissions	**PE[1]**	*= VSG * NCSG * Oh * 10^{-9}*						t N2O	**86.7**
Emission factor	**EF_n**	*= PE / NAP * 10^{3}*						kg N2O / t HNO3	**4.76**

[1] QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 15:	13/08/2011 - 07/11/2011		
Project campaign 15		**Query 1: Without parameter limits**							288
Parameter	**OH**	**AFR**	**AIFR**	**OPh**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,862	1,862	1,862	1,862	1,862	1,862		1,862	
Minimum		0.01	2.11	242	579	107	*210*	8,463	
Maximum		3.42	7.8	1,304	935	1,152	*2,263*	48,315	
Mean		3.34	6.69	1,252	927	600	*1,178*	46,428	
Standard deviation		0.140	0.21	53	19	220	*432*	1,949	
95% confidence level *(1.96 * Std.dev.)*		*0.28*	*0.42*	*105*	*37*	*431*	*847*	*3,821*	
Sum	1,862								21,618
Limits acc. to consistency check									
Lower limit									
Upper limit									
Campaign emissions	**PE[1]**	*= VSG * NCSG * Oh * 10^{-9}*						t N2O	**101.9**
Emission factor	**EF_n**	*= PE / NAP * 10^{3}*						kg N2O / t HNO3	**4.71**

[1] QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System

Query 2: Elimination of faulty data outside operational limits

In this query (Query 2) the operational limits of the plant are applied. Lines of data in which at least one value indicates that the plant is out of operation (trip values) are completely eliminated from further analysis.

The following "trip conditions" are used for determining those hours during which the plant was out of operation:

	AFR	**AIFR**	**Oph**	**OTh**
	t NH3 / h	%	kPa	°C
Lower limit	-	-	-	550
Upper limit	10	12	1500	-

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 11:	21/10/2010 - 04/01/2011		
Project campaign 11		**Query 2: With operational limits**							212
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,695	1,695	1,695	1,695	1,695	1,695		1,695	
Minimum		1.44	3.80	551	613	51	*100*	14,741	
Maximum		3.50	7.44	1,307	937	2,071	*4,069*	47,929	
Mean		3.42	6.70	1,283	931	577	*1,134*	47,003	
Standard deviation		0.074	0.099	25	11.8	128	*252*	979	
95% confidence level *(1.96 * Std.dev.)*		0.145	0.194	48	23.2	252	*495*	1,920	
Sum	1,695								21,109
Limits acc. to consistency check									
Lower limit					550				
Upper limit		10.0	8.10	1,500.0					
Campaign emissions	**PE[1]**	*= VSG * NCSG * Oh * 10^{-9}*						t N2O	**90.4**
Emission factor	**EF_n**	*= PE / NAP * 10^{3}*						kg N2O / t HNO3	**4.28**

[1] QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 12:	05/01/2011 - 19/03/2011		
Project campaign 12		**Query 2: With operational limits**							232
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,686	1,686	1,686	1,686	1,686	1,686		1,686	
Minimum		0.33	2.43	216	590	3	*6*	3,002	
Maximum		3.45	6.85	1,307	937	2,307	*4,533*	48,454	
Mean		3.37	6.63	1,289	929	780	*1,532*	47,256	
Standard deviation		0.126	0.166	45	17.5	224	*440*	1,966	
95% confidence level *(1.96 * Std.dev.)*		0.247	0.326	89	34.2	439	*862*	3,853	
Sum	1,686								20,281
Limits acc. to consistency check									
Lower limit					550				
Upper limit		10.0	8.10	1,500.0					
Campaign emissions	**PE**[1]	*= VSG * NCSG * Oh * 10^{-9}*						t N2O	**122.1**
Emission factor	**EF_n**	*= PE / NAP * 10^{3}*						kg N2O / t HNO3	**6.02**

[1] **QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System**

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 13:	20/03/2011 - 07/06/2011		
Project campaign 13		**Query 2: With operational limits**							252
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,729	1,729	1,729	1,729	1,729	1,729		1,729	
Minimum		1.42	3.32	338	598	468	*919*	7,131	
Maximum		3.45	6.84	1,310	937	1,547	*3,040*	48,093	
Mean		3.36	6.67	1,263	928	923	*1,813*	46,575	
Standard deviation		0.088	0.125	44	12.4	174	*342*	1,694	
95% confidence level *(1.96 * Std.dev.)*		0.173	0.245	87	24.2	341	*670*	3,321	
Sum	1,729								20,536
Limits acc. to consistency check									
Lower limit					550				
Upper limit		10.0	8.10	1,500.0					
Campaign emissions	**PE**[1]	*= VSG * NCSG * Oh * 10^{-9}*						t N2O	**146.0**
Emission factor	**EF_n**	*= PE / NAP * 10^{3}*						kg N2O / t HNO3	**7.11**

[1] **QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System**

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 14:	08/06/2011 - 12/08/2011		
Project campaign 14		**Query 2: With operational limits**							272
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,543	1,543	1,543	1,543	1,543	1,543		1,543	
Minimum		2.13	4.50	640	697	103	*203*	18,583	
Maximum		3.44	6.87	1,272	939	1,425	*2,801*	47,359	
Mean		3.33	6.70	1,224	925	626	*1,230*	45,723	
Standard deviation		0.058	0.099	24	9.3	195	*383*	962	
95% confidence level *(1.96 * Std.dev.)*		0.113	0.194	46	18.3	382	*751*	1,885	
Sum	1,543								18,213
Limits acc. to consistency check									
Lower limit					550				
Upper limit		10.0	8.10	1,500.0					
Campaign emissions	**PE**[1]	*= VSG * NCSG * Oh * 10^{-9}*						t N2O	**86.8**
Emission factor	**EF_n**	*= PE / NAP * 10^{3}*						kg N2O / t HNO3	**4.76**

[1] **QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System**

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 15:	13/08/2011 - 07/11/2011		
Project campaign 15		**Query 2: With operational limits**							292
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count	1,862	1,862	1,862	1,862	1,862	1,862		1,862	
Minimum		0.01	2.11	242	579	107	*210*	8,463	
Maximum		3.42	7.77	1,304	935	1,152	*2,263*	48,315	
Mean		3.34	6.69	1,252	927	600	*1,178*	46,428	
Standard deviation		0.140	0.214	53	18.9	220	*432*	1,949	
95% confidence level *(1.96 * Std.dev.)*		0.275	0.420	105	37.1	431	*847*	3,821	
Sum	1,862								21,618
Limits acc. to consistency check									
Lower limit					550				
Upper limit		10.0	8.10	1,500.0					
Campaign emissions	**PE[1]**	*= VSG * NCSG * Oh * 10^{-9}*						t N2O	**101.9**
Emission factor	**EF_n**	*= PE / NAP * 10^{3}*						kg N2O / t HNO3	**4.71**
[1] **QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System**									

Query 6: application of confidence interval to eliminate outliers

The 95% confidence interval for NCSG and VSG values is derived and the outliers excluded individually for VSG and NCSG. Hence, the remaining number of data sets may differ between NCSG and VSG.

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 11:	21/10/2010 - 04/01/2011		
Project campaign 11		**Q6: Q2 + confidence levels**				216		220	212
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count						1,611		1,687	
Minimum		1.442	3.80	551	613	364	*715*	45,207	
Maximum		3.50	7.44	1,307	937	827	*1,625*	47,929	
Mean		3.42	6.70	1,283	931	558	*1,096*	*47,051*	
Standard deviation		0.074	0.099	25	11.8	84	*165*	253	
95% confidence level *(1.96 * Std.dev.)*		0.145	0.194	48	23.2	165	*324*	495	
Sum	1,695								21,109
Limits acc. to consistency check									
Lower limit					550	326	640	45,084	
Upper limit		10.0	8.10	1,500.0		829	1,629	48,923	
Campaign emissions	**PE[1]**	*= VSG * NCSG * Oh * 10^{-9}*						t N2O	**87.4**
Emission factor	**EF_n**	*= PE / NAP * 10^{3}*						kg N2O / t HNO3	**4.14**
[1] **QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System**									

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)			Campaign:	PC 12:	05/01/2011 - 19/03/2011		
Project campaign 12		**Q6: Q2 + confidence levels**				236		240	232
Parameter	**OH**	**AFR**	**AIFR**	**Oph**	**OTh**	**NCSG**	**NCSG**	**VSG**	**NAP**
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count						1,615		1,673	
Minimum		0.334	2.43	216	590	347	*681*	43,675	
Maximum		3.45	6.85	1,307	937	1,216	*2,389*	48,454	
Mean		3.37	6.63	1,289	929	772	*1,518*	*47,394*	
Standard deviation		0.126	0.166	45	17.5	181	*356*	343	
95% confidence level *(1.96 * Std.dev.)*		0.247	0.326	89	34.2	355	*698*	673	
Sum	1,686								20,281
Limits acc. to consistency check									
Lower limit					550	341	670	43,402	
Upper limit		10.0	8.10	1,500.0		1,219	2,394	51,109	
Campaign emissions	**PE[1]**	*= VSG * NCSG * Oh * 10^{-9}*						t N2O	**121.3**
Emission factor	**EF_n**	*= PE / NAP * 10^{3}*						kg N2O / t HNO3	**5.98**
[1] **QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System**									

N.DBMS Project Campaign Calcula Project: Dongbu (Ulsan, Korea) Campaign: PC 13: 20/03/2011 - 07/06/2011

Project campaign 13	Q6: Q2 + confidence levels					256		260	252
Parameter	OH	AFR	AIFR	Oph	OTh	NCSG	NCSG	VSG	NAP
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count						1,667		1,722	
Minimum		1.416	3.32	338	598	594	*1,167*	43,695	
Maximum		3.45	6.84	1,310	937	1,262	*2,480*	48,093	
Mean		3.36	6.67	1,263	928	907	*1,783*	*46,651*	
Standard deviation		0.088	0.125	44	12.4	154	*303*	826	
95% confidence level *(1.96 * Std.dev.)*		0.173	0.245	87	24.2	302	*594*	1,619	
Sum	1,729								20,536
Limits acc. to consistency check									
Lower limit					550	582	1,143	43,254	
Upper limit		10.0	8.10	1,500.0		1,264	2,484	49,895	
Campaign emissions	**PE**[1]	*= VSG * NCSG * Oh * 10^-9^*						t N2O	**143.8**
Emission factor	**EF_n**	*= PE / NAP * 10^3^*						kg N2O / t HNO3	**7.00**

[1] QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System

N.DBMS Project Campaign Calcula Project: Dongbu (Ulsan, Korea) Campaign: PC 14: 08/06/2011 - 12/08/2011

Project campaign 14	Q6: Q2 + confidence levels					276		280	272
Parameter	OH	AFR	AIFR	Oph	OTh	NCSG	NCSG	VSG	NAP
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count						1,473		1,536	
Minimum		2.127	4.50	640	697	343	*674*	43,930	
Maximum		3.44	6.87	1,272	939	1,001	*1,967*	47,359	
Mean		3.33	6.70	1,224	925	590	*1,160*	*45,761*	
Standard deviation		0.058	0.099	24	9.3	99	*194*	506	
95% confidence level *(1.96 * Std.dev.)*		0.113	0.194	46	18.3	193	*380*	993	
Sum	1,543								18,213
Limits acc. to consistency check									
Lower limit					550	244	479	43,838	
Upper limit		10.0	8.10	1,500.0		1,008	1,981	47,608	
Campaign emissions	**PE**[1]	*= VSG * NCSG * Oh * 10^-9^*						t N2O	**81.9**
Emission factor	**EF_n**	*= PE / NAP * 10^3^*						kg N2O / t HNO3	**4.50**

[1] QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System

N.DBMS Project Campaign Calcula Project: Dongbu (Ulsan, Korea) Campaign: PC 15: 13/08/2011 - 07/11/2011

Project campaign 15	Q6: Q2 + confidence levels					296		300	292
Parameter	OH	AFR	AIFR	Oph	OTh	NCSG	NCSG	VSG	NAP
Unit	h	t NH3 / h	%	kPa	°C	ppm	mg N2O / Nm3	Nm3 / h	t HNO3
Count						1,833		1,850	
Minimum		0.006	2.11	242	579	201	*395*	43,049	
Maximum		3.42	7.77	1,304	935	1,001	*1,967*	48,315	
Mean		3.34	6.69	1,252	927	592	*1,162*	*46,552*	
Standard deviation		0.140	0.214	53	18.9	211	*414*	906	
95% confidence level *(1.96 * Std.dev.)*		0.275	0.420	105	37.1	413	*811*	1,777	
Sum	1,862								21,618
Limits acc. to consistency check									
Lower limit					550	169	331	42,607	
Upper limit		10.0	8.10	1,500.0		1,031	2,026	50,249	
Campaign emissions	**PE**[1]	*= VSG * NCSG * Oh * 10^-9^*						t N2O	**100.8**
Emission factor	**EF_n**	*= PE / NAP * 10^3^*						kg N2O / t HNO3	**4.66**

[1] QAL2 correction factors for NCSG and VSG have been applied to raw data before beeing fed to the N_DMBS Access Data Base System

Relevant Project Emissions (PE_n) and respective Project Emission Factors (EF_n)

The resulting project emissions (PE_n) and project emission factor (EF_n) for the project campaigns covered by this monitoring report are:

Campaign	PE	EF_n
Campaign PC 11	87.4 tN_2O	4.14 $kgN_2O/tHNO_3$
Campaign PC 12	121.3 tN_2O	5.98 $kgN_2O/tHNO_3$
Campaign PC 13	143.8 tN_2O	7.00 $kgN_2O/tHNO_3$
Campaign PC 14	81.9 tN_2O	4.50 $kgN_2O/tHNO_3$
Campaign PC 15	100.8 tN_2O	4.66 $kgN_2O/tHNO_3$

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_{BL}, otherwise the baseline emission factor need to be recalculated. The later is the case for project campaign PC14 (see recalculation of EF_{BL} under E.1.)

E.3. Leakage calculation

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No leakage occurs under this project type.

E.4. Emission reductions calculation / table

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Emission reductions

A ***moving average emissions factor*** must be calculated at the end of a campaign "n" as follows:

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

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 $EF_p = EF_n$

In addition a campaign-specific ***Minimum Emission Factor*** (EF_{min}) 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 emission factor (EF_{min}). If any of the later project campaigns results in a EF_n that is lower than EF_{min}, the calculation of the emission reductions for that particular campaign shall use EF_{min} and not EF_n. As only 6 project campaigns were conducted so far consideration of EF_{min} (2.98 $kgN_2O/tHNO_3$) is not yet relevant.

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

$ER = (EF_{BL} – EF_P) * NAP * GWP\_N_2O \ (tCO_2e)$

Where:

Variable	Definition
ER	Emission reductions of the project for the specific campaign (tCO_2e)
NAP	Nitric acid production for the project campaign ($tHNO_3$). The maximum value of NAP shall not exceed the design capacity.
EF_{BL}	Baseline emissions factor ($kgN_2O/tHNO_3$)
EF_P	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of $EF_{ma,n}$ and $_{EFn}$) ($kgN_2O/tHNO_3$)
GWP_N_2O	Global Warming Potential of N_2O (310 tCO_2e/tN_2O)

The resulting emission reductions (ER) for each of the project campaigns covered by this monitoring report are as follows:

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)	Campaign: PC 11: 21/10/2010 - 04/01/2011	
Project campaign 11				
Emission factor Baseline	EF_BL		kg N2O / t HNO3	10.63
Emission factor nth Campaign	EF_n		kg N2O / t HNO3	4.14
Moving average emission factor	EF_ma,n		kg N2O / t HNO3	4.24
Minimum emission factor	EF_min		kg N2O / t HNO3	2.98
Emission factor Project Campaign	EF_P		kg N2O / t HNO3	4.24
NAP	NAP		t HNO3	21,109
Greenhouse warming potential N2O	GWP			310
Emission reduction	**ER**		**t CO2e**	**41,812**

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)	Campaign: PC 12: 05/01/2011 - 19/03/2011	
Project campaign 12				
Emission factor Baseline	EF_BL		kg N2O / t HNO3	10.63
Emission factor nth Campaign	EF_n		kg N2O / t HNO3	5.98
Moving average emission factor	EF_ma,n		kg N2O / t HNO3	4.39
Minimum emission factor	EF_min		kg N2O / t HNO3	2.98
Emission factor Project Campaign	EF_P		kg N2O / t HNO3	5.98
NAP	NAP		t HNO3	20,281
Greenhouse warming potential N2O	GWP			310
Emission reduction	**ER**		**t CO2e**	**29,244**

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)	Campaign: PC 13: 20/03/2011 - 07/06/2011	
Project campaign 13				
Emission factor Baseline	EF_BL		kg N2O / t HNO3	10.63
Emission factor nth Campaign	EF_n		kg N2O / t HNO3	7.00
Moving average emission factor	EF_ma,n		kg N2O / t HNO3	4.59
Minimum emission factor	EF_min		kg N2O / t HNO3	2.98
Emission factor Project Campaign	EF_P		kg N2O / t HNO3	7.00
NAP	NAP		t HNO3	20,536
Greenhouse warming potential N2O	GWP			310
Emission reduction	**ER**		**t CO2e**	**23,091**

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)	Campaign: PC 14: 08/06/2011 - 12/08/2011	
Project campaign 14				
Emission factor Baseline	EF_BL		kg N2O / t HNO3	10.54
Emission factor nth Campaign	EF_n		kg N2O / t HNO3	4.50
Moving average emission factor	EF_ma,n		kg N2O / t HNO3	4.58
Minimum emission factor	EF_min		kg N2O / t HNO3	2.98
Emission factor Project Campaign	EF_P		kg N2O / t HNO3	4.58
NAP	NAP		t HNO3	18,213
Greenhouse warming potential N2O	GWP			310
Emission reduction	**ER**		**t CO2e**	**33,660**

N.DBMS Project Campaign Calcula	Project:	Dongbu (Ulsan, Korea)	Campaign: PC 15: 13/08/2011 - 07/11/2011	
Project campaign 15				
Emission factor Baseline	EF_BL		kg N2O / t HNO3	10.63
Emission factor nth Campaign	EF_n		kg N2O / t HNO3	4.66
Moving average emission factor	EF_ma,n		kg N2O / t HNO3	4.59
Minimum emission factor	EF_min		kg N2O / t HNO3	2.98
Emission factor Project Campaign	EF_P		kg N2O / t HNO3	4.66
NAP Total - CL_n - (until 08/11/2011)	NAP_total		t HNO3	21,618
NAP (until 07/11/2011)	***NAP[1]***		***t HNO3***	***21,596***
NAP 08/11/2011 until 02:00	NAP		t HNO3	22
Greenhouse warming potential N2O	GWP			310
Total Emission reduction	ER		t CO2e	40,008
Emission Reductions in Monitoring period	***ER***		***t CO2e***	***39,968***

The campaign was concluded 08/11/2011 at 02:00. All emission data has been regarded as to determine the emission factor (EF_n) including the 2 hours on 08/11/2011. However, as the Monitoring Period is only until 07/11/2011 any NAP generated on 08/11/2011 has not been regarded for the calculation of emission reductions.

Campaign	Baseline Emissions	Project Emissions	Emission Reductions	NAP
Campaign PC 11	69,566	27,754	41,812	21,109
Campaign PC 12	66,838	37,594	29,244	20,281
Campaign PC 13	67,678	44,587	23,091	20,536
Campaign PC 14	59,525	25,865	33,660	18,213
Campaign PC 15	71,242	31,234	39,968	21,618
TOTAL	**334,849**	**167,034**	**167,775**	**101,757**

The total amount of emission reductions for the project activity of the "Project for the catalytic reduction of N2O emissions with a secondary catalyst inside the ammonia reactor of the nitric acid plant at Dongbu Hannong Chemicals Ltd, Ulsan, Republic of Korea ("Dongbu") during this 5th monitoring period is: 167,775 tCO_2e.

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

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Item	Values applied in ex-ante calculation of the registered CDM-PDD	Actual values reached during the monitoring period
Emission reductions (tCO_2e)	240,651 per year equal to 252,518 in 383 days.	167,775 in 383 days.
Nitric Acid Production ($tHNO_3$)	109,500 per year equal to 114,900 in 383 days.	101,757 in 383 days.

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

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The generated emission reductions during this 5th monitoring period are roundabout 35% lower than the expected emission reductions projected in the PDD for the same time period (383 days).

Without any doubt one reason for this short fall is to be seen in lower production of nitric acid (reduced demand for the product as well as some technical difficulties in the process.

In addition technical problems with the secondary catalyst resulted in a reduced N_2O abatement performance. Due to shifting of the secondary catalyst (pellets) caused by heat expansion during plant operation and subsequent cooling down (shut-down) passages (by-passes) can be formed between pieces of the pelletized catalyst. The process gas can now pass the reactor without being exposed to the secondary catalyst to the desired extend. This is a usual reason for reduced abatement performance, however, it should also be noted that at the time of writing the PDD only estimates on the expected abatement performance could be made. In this regard it should be noted that very specific and different conditions of different reactors and production plants make it impossible to exactly determine the later abatement performance beforehand.

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History of the document

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