Monitoring report form

(Version 05.0)

Complete this form in accordance with the Attachment "Instructions for filling out the monitoring report form" at the end of this form.

MONITORING REPORT		
Title of the project activity	Reduction of N2O emissions from the new nitric acid plant #5 of Hu-Chems Fine Chemical Corp.	
UNFCCC reference number of the project activity	6637	
Version number of the monitoring report	Version 1	
Completion date of the monitoring report	11/04/2015	
Monitoring period number and duration of this monitoring period	Monitoring period number: 2 Duration: 01/09/2013 – 31/12/2014	
Project participant(s)	Carbon CDM Korea Ltd. Hu-Chems Fine Chemical Corp. Carbon Climate Protection GmbH	
Host Party	Republic of Korea	
Sectoral scope(s)	Sectoral scope 5: Chemical industries	
Selected methodology(ies)	Applied methodology: ACM0019 Version 1 ("N2O abatement from nitric acid production")	
Selected standardized baseline(s)	No standardized baseline(s) applicable	
Estimated amount of GHG emission reductions or net GHG removals by sinks for this monitoring period in the registered PDD	Amount estimated in PDD for 2013: 421,789 tCO_2e Amount estimated in PDD for 2014: 397,191 tCO_2e → Corresponding estimated amount for the duration of monitoring period (122 days in 2013 + whole year 2014): 538,172 tCO_2e	
Total amount of GHG emission reductions or net GHG removals by sinks achieved in this monitoring period	GHG emission reductions or net GHG removals by sinks reported up to 31 December 2012	GHG emission reductions or net GHG removals by sinks reported from 1 January 2013 onwards
	Not applicable (Start of period is after 31 December 2012)	556,070 tCO_2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

>>

(a) Hu-Chems has implemented the project activity for the purpose of GHG emission reduction by catalytic N_2O destruction in its Nitric Acid Plant #5 in Yeosu, Republic of Korea. The project is categorized as large scale project under sectoral scope 5: "Chemical Industry". The Host Party for the project activity is the Republic of Korea. The Project Activity includes development, design, engineering, procurement, finance, construction, operation and maintenance of a system for catalytic decomposition of N_2O in the Nitric Acid Plant #5 at Hu-Chems Fine Chemical Corp.

(b) In this project, Hu-Chems installed an EnviNOx® system for catalytic decomposition of NO_x and N_2O additionally to the equipment at the nitric acid manufacturing plant. The project activity reduces the GHG emissions, which would otherwise be released to the atmosphere, if the project was not implemented.
The EnviNOx® process used in the #5 nitric acid plant is based on the catalytic decomposition of nitrous oxide (N_2O) and the catalytic reduction of NO_x (NO and NO_2) with ammonia (NH_3). This process works very well at temperatures above about 425°C. The reactions take place over two iron zeolite catalyst beds.

(c) The EnviNOx® system at Hu-Chems #5 nitric acid plant was installed in February 2013 and the catalytic reduction process of N_2O started in the end of February 2013.

(d) Total emission reductions achieved in this monitoring period: **556,070 tCO_2e**

A.2. Location of project activity

>>

Country (Host Party): Republic of Korea
Province: Jeollanam-do
Town: Yeosu, 7-6, Wollae-dong

Unique geographic coordinates:

- Longitude: 127.74158 E
- Latitude: 34.84583 N

A.3. Parties and project participant(s)

Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate whether the Party involved wishes to be considered as project participant (yes/no)
Republic of Korea (Host)	Carbon CDM Korea Ltd. Hu-Chems Fine Chemical Corp.	No
Austria	Carbon Climate Protection GmbH	No

Hu-Chems Fine Chemical Corp. (furthermore called "Hu-Chems"), an entity registered under the laws of the Republic of Korea. Hu-Chems was established by separating from Nam-Hae chemical corporation in 2002 and is listed on the Korean Stock Exchange, KOSPI200, item code 069260, since September 17, 2002. Hu-Chems operates several production units which produce fine chemical products in it industrial complex in Yeosu whereas the company's headquarter is in Seoul. Hu-Chems is active in major business areas, which are fine chemical products (Nitric acid, Dinitrotoluene, Mononitrobenzene, Ammonium nitrate, etc.). The products are provided to major-chemical companies in the Republic of Korea as well as to world-wide major chemical companies like BASF and Rhodia on long term off-take contract basis.
Hu-Chems is ISO 9002 and ISO 14001 certified and received the Korean safety and health management system certificate (KGS18001 & OHSHAS18001). The company has received the Grand Prize of Korea Valuable Management Award in 2005, the President of Korea's medal in Energy Saving Promote Contest as well as the Korean Marketing Best Award (KMAC) in 2004, as well as other awards.
The project activity has been implemented in the nitric acid plant #5 and, along with the CDM monitoring equipment it has been included in the established quality management system.

Carbon CDM Korea Ltd. is registered under the laws of the Republic of Korea. **CARBON Climate Protection GmbH** is registered under the laws of Austria. Both companies, jointly referred to as CARBON, are subsidiaries of CARBON Projektentwicklung GmbH, Austria, and RWE Power AG, Germany. CARBON Projektentwicklung GmbH was founded as a limited liability company located and registered in Austria under Austrian law in order to develop, finance and operate high quality JI/CDM Projects. CARBON Projektentwicklung GmbH has vast experience with CDM-Project development in Africa, Latin America and Asia and is specialized on the catalytic N_2O destruction in the tail gas of nitric acid plants. It has initially developed the methodology for destruction of N_2O in the tail gas of nitric acid plants (AM0028) and has implemented such projects in Egypt, the Republic of Korea and the Republic of Chile. Furthermore, it has contributed to the consolidated methodology for N_2O abatement in from nitric acid production (ACM0019).

Host Country is the Republic of Korea. The Republic of Korea ratified the Kyoto Protocol in November 2002.

A.4. Reference of applied methodology and standardized baseline

>>
Applied methodology: ACM0019, Version 1: "N2O abatement from nitric acid production"[1]

The methodology also refers to the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" in its latest version, thus the tool is applied in this project activity (Version 2.0.0).[2]

[1] http://cdm.unfccc.int/methodologies/DB/MNMFNF10VUEOJACEIRX3EHYC9QXGDC

[2] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v2.0.0.pdf/history_view

Furthermore, the applied methodology refers to the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" in its latest version, however since no fossil fuels are used in the project activity, it is neglected and not anymore mentioned.

No standardized baselines are used.

A.5. Crediting period of project activity

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Type of crediting period:	Fixed
Starting date of the crediting period:	25/02/2013 (changed from 01/09/2012)
End date of the crediting period:	24/02/2023 (changed from 31/08/2022)
Length of the fixed crediting period:	10 years

A.6. Contact information of responsible persons/ entities

>>

Andreas Moser-Rammelmüller
Carbon Climate Protection GmbH
Am Südblick 5
3550 Langenlois
Austria

Tel.: +43 2734 32 270 60
Email: rammelmueller@carbon-austria.com

Carbon Climate Protection GmbH is a project participant. For further information please refer to Appendix 1.

SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

>>

(a) Description of the installed technology, technical processes and equipment

General Introduction

Nitrous oxide (N_2O) is an unwanted, invisible and previously neglected by-product of the manufacture of nitric acid. It is formed alongside the main, desired product nitric oxide (NO) during the catalytic oxidation of ammonia in air over noble metal gauzes. The production of nitric acid takes place in three main process steps as indicated by the following reactions:

1. Ammonia (NH_3) combustion to form nitric oxide (NO)[3]:

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

   Simultaneously nitrous oxide (N_2O), nitrogen (N) and water (H_2O) are formed as well, in accordance with the following equations:

   $4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$ (side reaction 1)
   $4\ NH_3 + 4\ O_2 \rightarrow 2\ N_2O + 6\ H_2O$ (side reaction 2)

   NO yield mainly depends on pressure and temperature in the ammonia oxidation process and is usually in a range of 95% to 97%.

[3] Ammonia is reacted with air on noble metal catalyst in the oxidation section of nitric acid plants. Nitric oxide and water are formed in this process according to the above mentioned main equation.

2. NO is oxidised to nitrogen dioxide (NO_2):

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

3. (According to the technical process) Absorption of NO_2 in water to form nitric acid (HNO_3):

   $3\ NO_2 + H_2O \rightarrow 2\ HNO_3 + NO$ (main reaction 3)
   (NO is oxidised to NO_2 according to main reaction 2)

When leaving the ammonia oxidation reactor, there is no relevant loss of N_2O in the tail gas section unless a N_2O destruction facility is installed. N_2O that leaves the ammonia oxidation reactor is thus discharged to atmosphere in the tail gas and has no economic value.

Project Specific description:

Principles of the EnviNOx® process in plant Hu-Chems #5:
The EnviNOx® process used in the Hu-Chems #5 nitric acid plant is based on the catalytic decomposition of nitrous oxide (N_2O) and the catalytic reduction of NO_x (NO and NO_2) with ammonia (NH_3). Catalytic decomposition of N_2O occurs when the N_2O is split into its constituent elements by contact with a catalyst. A catalyst is a material which accelerates the speed of the reaction without itself being transformed or consumed by the reaction. This process works well at temperatures above about 425°C.

The reactions take place over two iron zeolite catalyst beds. In the first bed N_2O is catalytically decomposed into its elements:

$2\ N_2O \rightarrow 2\ N_2 + O_2$

This rate of this reaction is enhanced by high concentrations of NO_X. Before the tail gas enters the second catalyst bed, a small quantity of ammonia vapour is added. In the second bed a large part of the NO_x is reduced with ammonia according to such reactions as:

$6\ NO_2 + 8\ NH_3 \rightarrow 7\ N_2 + 12\ H_2O$
$6\ NO + 4\ NH_3 \rightarrow 5\ N_2 + 6\ H_2O$
$NO + NO_2 + 2\ NH_3 \rightarrow 2\ N_2 + 3\ H_2O$
$4\ NO + O_2 + 4\ NH_3 \rightarrow 4\ N_2 + 6\ H_2O$

Some further destruction of N_2O also occurs. All the above reactions are exothermic and cause a temperature rise over the EnviNOx® reactor. The consumption of ammonia corresponds to the stoichiometric ratio given in the reaction equations above and does not differ significantly from the consumption of a conventional DeNOx unit.

Technology employed by the project activity:
In this project, Hu-Chems installed an EnviNOx® system for catalytic decomposition of NOx and N2O additionally to the equipment at the #5 nitric acid manufacturing plant. The project activity reduces the GHG emissions, which would otherwise be released to the atmosphere, if the project was not implemented.

Location of the EnviNOx®-System:
The EnviNOx® system is located in the tail gas stream at the position with the highest tail gas temperature in the nitric acid production process.

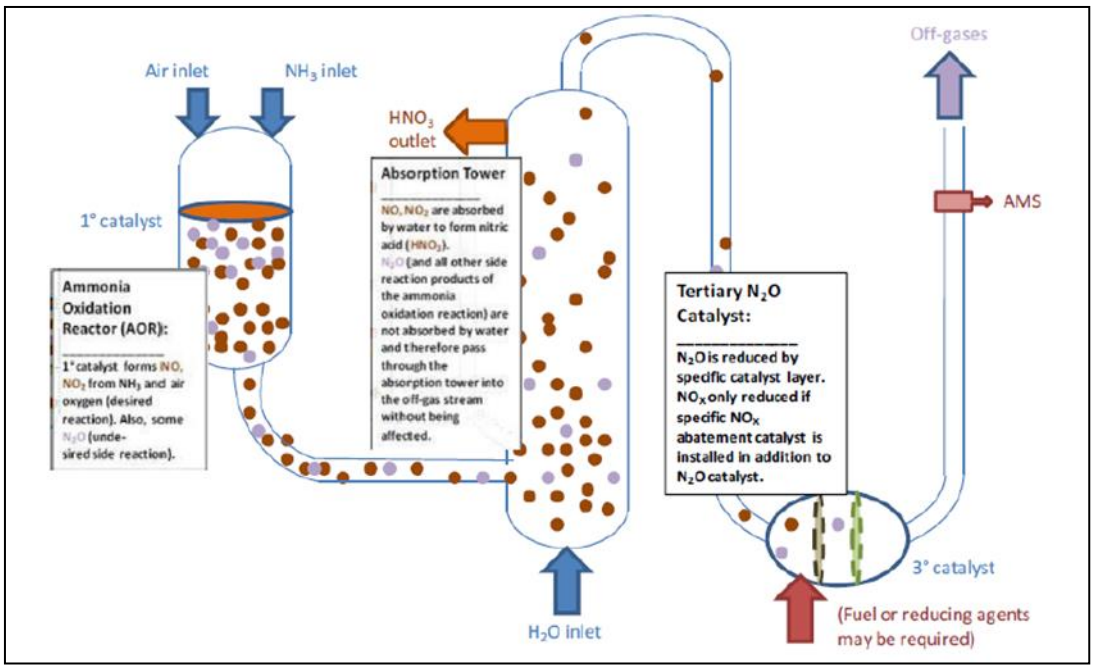

Figure 1: Project boundary

(b) Implementation status of the project activity during this monitoring period

The project has been fully implemented and is operated as per the registered PDD with all physical features (technology, project equipment, and monitoring and metering equipment) in place, monitoring is done according to the applied methodology (ACM0019v1) and the monitoring plan.

The EnviNOx® system at the nitric acid plant Hu-Chems#5 was installed in February 2013 and the starting date of normal operation of the project activity was 25/02/2013.

(c) Actual operation of the Project Activity during the covered monitoring period

Downtimes of the Nitric Acidp plant (and EnviNOx® System)
During the below mentioned periods, the EnviNOx® System was out of operation due to the given reasons. No Emission Reduction is claimed during these downtimes.

Downtime - Start		Downtime - End		Downtime Reason
Date	**Time**	**Date**	**Time**	**Description**
02/10/2013	02:00	05/10/2013	03:00	Nitric acid plant shutdown (Exchange of AOR catalyst)
13/11/2013	21:00	15/11/2013	01:00	Nitric acid plant shutdown (Power failure)
22/04/2014	01:00	26/04/2014	09:00	Nitric acid plant shutdown (Plant maintenance and Exchange of AOR catalyst)
21/05/2014	11:00	21/05/2014	21:00	Nitric acid plant shutdown (Work in the tail gas turbine 1)
04/07/2014	09:00	04/07/2014	19:00	Nitric acid plant shutdown (Plant trip during maintenance)
04/07/2014	22:00	05/07/2014	01:00	Nitric acid plant shutdown (Plant trip during maintenance)
20/11/2014	02:00	21/11/2014	08:00	Nitric acid plant shutdown (Maintenance of electric facility)

Relevant observations during the monitoring period

During the below mentioned periods, observations related to the operation of the EnviNOx® system and the AMS have been made.

Date	Time	Date	Time	Observation, Reason & Conservative Action
01/11/2013	10:00	01/11/2013	17:00	Observation: Fluctuation of stack gas pressure & stack gas flow concentration
				Reason: Preliminary instrument check in respect to the following regular annual extended general inspection by EMERSON Germany
				Conservative action: Recalculation of stack gas pressure & flow based on maximum value in monitoring period (in accordance with ACM0019v1 & PDD)
06/11/2013	09:00	13/11/2013	09:00	Observation: Fluctuation of N2O concentration
				Reason: Regular extended general inspection by EMERSON Germany
				Conservative action: Recalculation of N2O concentration based on maximum value in monitoring period (in accordance with ACM0019v1 & the PDD)
15/11/2013	01:00	15/11/2013	05:00	Observation: Non-availability of N2O concentration measurement immediately after nitric acid plant start-up
				Reason: Analyser deactivation during previous nitric acid plant-shutdown
				Conservative action: Recalculation of N2O concentration based on maximum value in monitoring period (in accordance with ACM0019v1 & the PDD)
03/12/2013	09:00	03/12/2013	15:00	Observation: Fluctuation of stack gas pressure & stack gas flow concentration
				Reason: Instrument check by Hu-Chems engineers
				Conservative action: Recalculation of stack gas pressure & flow based on maximum value in monitoring period (in accordance with ACM0019v1 & PDD)
30/12/2013	13:00	30/12/2013	16:00	Observation: Fluctuation of stack gas pressure & stack gas flow concentration
				Reason: Instrument check by Hu-Chems engineers
				Conservative action: Recalculation of stack gas pressure & flow based on maximum value in monitoring period (in accordance with ACM0019v1 & PDD)
10/03/2014	10:00	10/03/2014	14:00	Observation: Fluctuation of N2O concentration
				Reason: Repair works in Nox sampling system has influenced also the N2O measurements.
				Conservative action: Recalculation of N2O concentration based on maximum value in monitoring period (in accordance with ACM0019v1 & the PDD)
11/03/2014	09:00	11/03/2014	18:00	Observation: Fluctuation of N2O concentration
				Reason: Regular Analyser Certification per national Korean Standards by Korean Testing Laboratory (KTL)
				Conservative action: Recalculation of N2O concentration based on maximum value in monitoring period (in accordance with ACM0019v1 & the PDD)
12/03/2014	13:00	18/03/2014	14:00	Observation: Fluctuation of N2O concentration
				Reason: Defect in one isolated part of the analyser & respective repair works by EMERSON.
				Conservative action: Recalculation of N2O concentration based on maximum value in monitoring period (in accordance with ACM0019v1 & the PDD)
21/05/2014	21:00	22/05/2014	11:00	Observation: Fluctuation of N2O concentration
				Reason: Checks & works in the sampling system by Hu-Chems engineers directly after plant shutdown
				Conservative action: Recalculation of N2O concentration based on maximum value in monitoring period (in accordance with ACM0019v1 & the PDD)
14/07/2014	09:00	14/07/2014	16:00	Observation: Fluctuation of N2O concentration
				Reason: Regular monthly Health Check by EMERSON
				Conservative action: Recalculation of N2O concentration based on maximum value in monitoring period (in accordance with ACM0019v1 & the PDD)
22/08/2014	09:00	22/08/2014	16:00	Observation: Fluctuation of N2O concentration
				Reason: Regular extended general inspection by EMERSON Korea
				Conservative action: Recalculation of N2O concentration based on maximum value in monitoring period (in accordance with ACM0019v1 & the PDD)
13/10/2014	10:00	13/10/2014	14:00	Observation: Fluctuation of N2O concentration
				Reason: Regular monthly Health Check by EMERSON
				Conservative action: Recalculation of N2O concentration based on maximum value in monitoring period (in accordance with ACM0019v1 & the PDD)
15/12/2014	10:00	15/12/2014	16:00	Observation: Fluctuation of N2O concentration
				Reason: Regular monthly Health Check by EMERSON
				Conservative action: Recalculation of N2O concentration based on maximum value in monitoring period (in accordance with ACM0019v1 & the PDD)

During the mentioned periods, the nitric acid plant as well as the EnviNOx® system were in normal operation and emission reductions have been conservatively determined as described in section C - 4 (Systematic Measures) of this Monitoring Report, fully in line with the applied methodology and the registered monitoring plan.

Calibration and Maintenance

The maintenance methods and procedures as well as the calibration scheme for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 procedures, and form an integral part of the systems and procedures of HU-CHEMS. QA/QC of monitoring equipment is in full compliance with the monitoring methodology and the monitoring plan of the registered PDD. Detailed information on exchange and/or calibration of instruments is mentioned under section D – 2.

As further pointed out in section C – 3, the project participants have contracted Emerson Process Management Korea to execute monthly on-site **Health Checks** and quarterly on-site **Inspection Visits**. System components, sampling system, analysers/measurement devices and the automated monitoring system required for the monitoring of the CDM project are covered by these contracts.
Regular health check and inspection visit services, respectively, have been conducted by Emerson Process Management Korea in September 2013, October 2013, November 2013, December 2013, January 2014, February 2014, March 2014, April 2014, May 2014, June 2014, July 2014, August 2014, September 2014, October 2014, November 2014 and December 2014 and attest good condition and availability of the system (i.e. Sampling system, analyser as well as AMS hard- and software and total DeltaV DCS System). Extended general instrument inspections were performed by Emerson Germany in November 2013 and by Emerson Germany in August 2014.

Records of conducted maintenance activities and other performed services related to calibration and maintenance are available and submitted to the DOE for verification.

(d) Situations with impact on the applicability of the methodology

No such situations occurred during the covered monitoring period.

B.2. Post-registration changes

B.2.1. Temporary deviations from registered monitoring plan, applied methodology or applied standardized baseline

>>
No such temporary deviations have applied to this monitoring period neither to any previous monitoring periods.

B.2.2. Corrections

>>
No such corrections have applied to this monitoring period neither to any previous monitoring periods.

B.2.3. Changes to start date of crediting period

>>
The start date of the crediting period has been changed from 01/09/2012 (indicated date in the PDD) to 25/02/2013 (start of regular operation of the EnviNOx® system). This change to the start date of the crediting period was approved by the UNFCCC Secretariat via Email and made visible on the relevant project view page (CDM Project reference number: 6637) on 11/09/2013.

B.2.4. Inclusion of a monitoring plan to the registered PDD that was not included at registration

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No such inclusion has applied to this monitoring period.

B.2.5. Permanent changes from registered monitoring plan, applied methodology or applied standardized baseline

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No such permanent changes have applied to this monitoring period.

B.2.6. Changes to project design of registered project activity

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No such changes have applied to this monitoring period neither to any previous monitoring periods.

B.2.7. Types of changes specific to afforestation or reforestation project activity

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Not applicable to this project activity

SECTION C. Description of monitoring system

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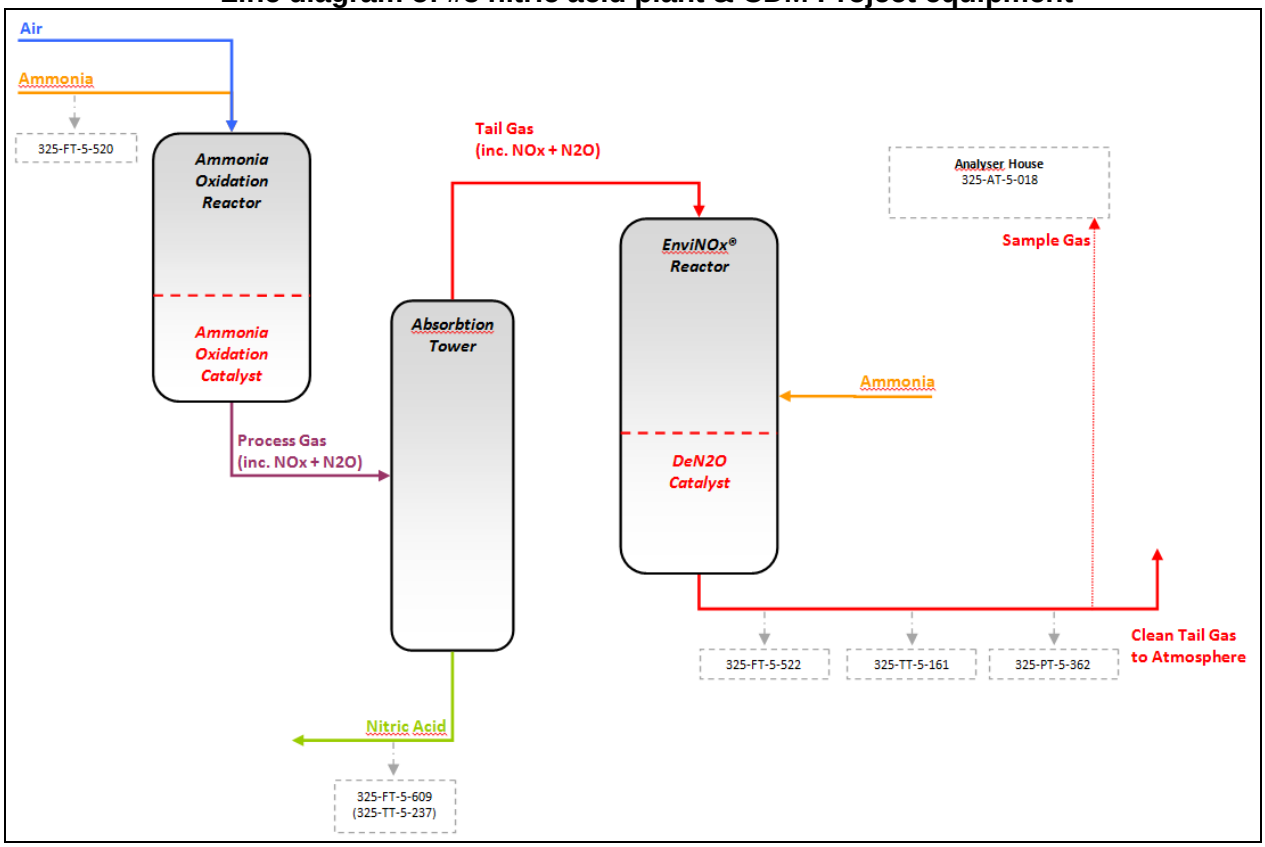
1. Information flow

The instruments transmitters continuously provide a 4 - 20 mA analogue signal according to range and units configured. These signals are transmitted to I/O cards (analogue input/output cards) and collected by the DeltaV Processor. Resulting digital values are made available in the network to be further processed (e.g. in controller blocks, calculation of other variables) and are stored as raw data in the protected continuous historian server (CHS).

Modifications of the Delta V, which are protected by security levels by the supplier, are tracked by a Version Control Tool.

Line diagram of #5 nitric acid plant & CDM Project equipment

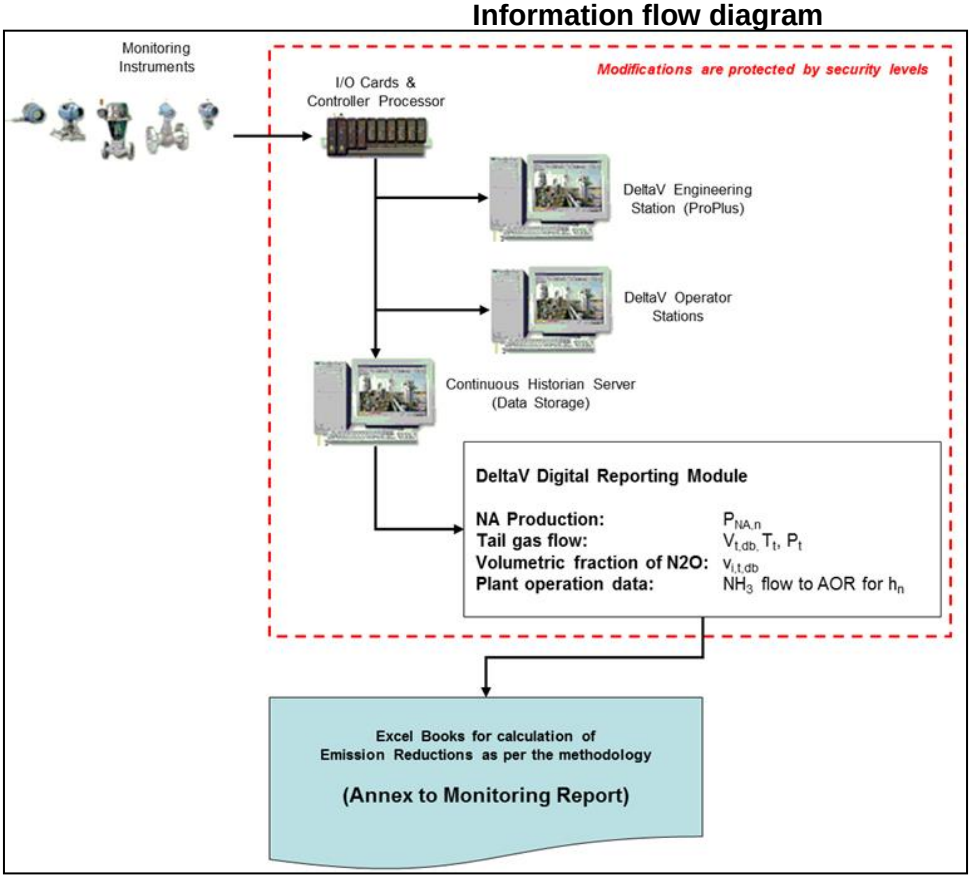


The reporting module of the DeltaV system automatically generates aggregated daily reports based on the stored raw data from the continuous historian server. Daily reports contain following kinds of data relevant for calculation of claimed emission reductions (hourly values):

- Nitric acid production ($P_{NA,n}$)
- Operating parameter of the nitric acid plant (NH_3 flow to AOR for determining h_n)
- Volumetric flow, temperature and pressure of the tail gas stream ($V_{t,db}$, T_t, P_t)
- Volumetric fraction of N_2O in the tail gas stream ($v_{i,t,db}$)

Relevant parameters as mentioned above are exported from the digitally available daily reports to an excel book (available as *Appendix 2* to this monitoring report) for presentation of required parameters and calculation of baseline emissions, project emissions and emission reductions according to formulae as required. Details on source of data of all relevant parameters can be found directly in the respective parameter tables in *Section D*.

Information flow diagram



The description of the information flow (including data generation, aggregation, recording, calculation and reporting) fully complies with the applied methodology (ACM0019, Version 1), the registered PDD and the Monitoring Plan.

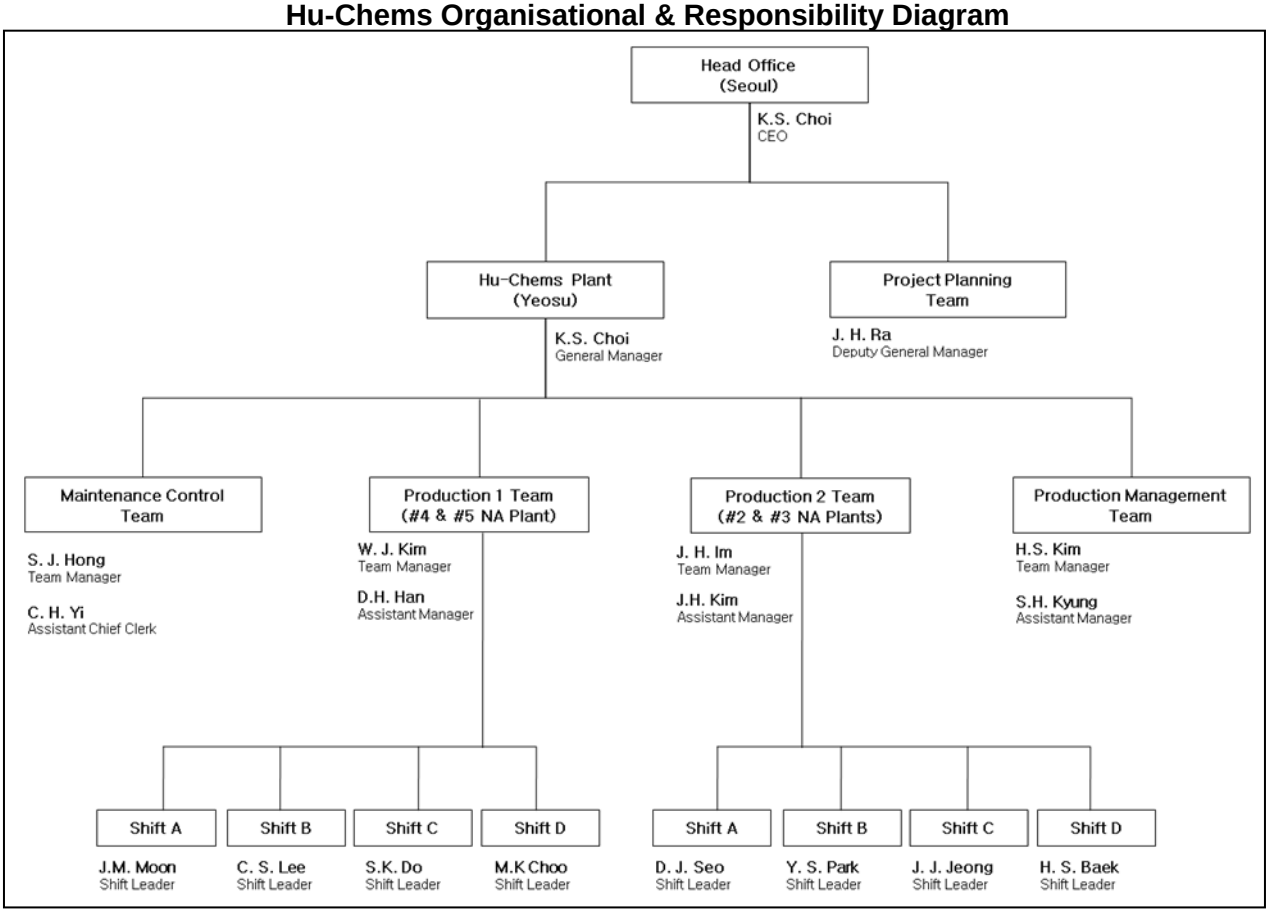
2. Roles and responsibilities of personnel

Project Operator is Hu-Chems Fine Chemical Corp. (HU-CHEMS). HU-CHEMS operates several production units which produce fine chemical products. HU-CHEMS is ISO 9001 and 14001 certified and received the Korean safety and health management system certificate (KGS18001 & OHSAS18001). The company has received the Grand Prize of Korea Valuable Management Award in 2005, the President of Korea's medal in an Energy Saving Promote Contest as well as the Korean Marketing Best Award (KMAC) in 2004 as well as other awards.

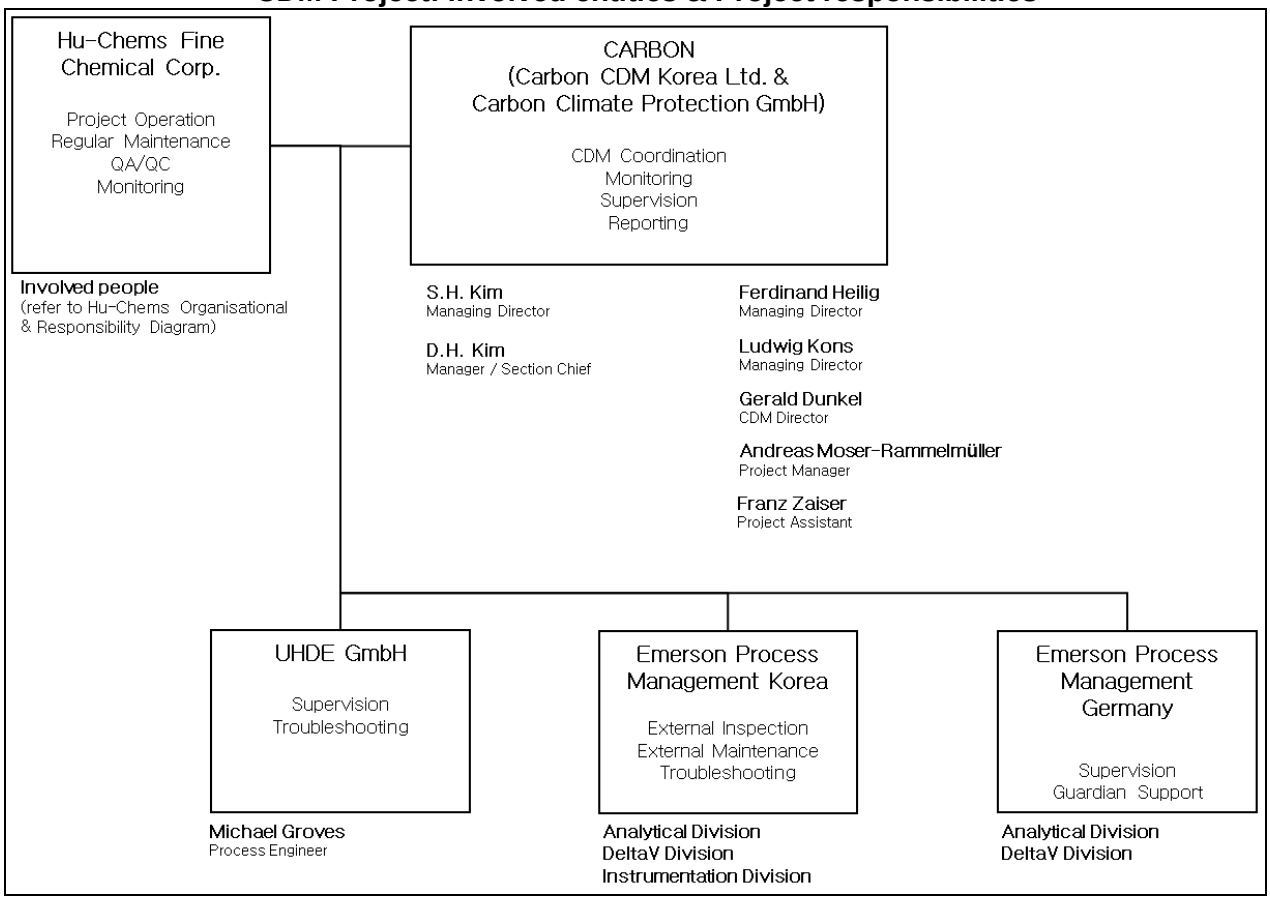
The operating and maintenance personal of the EnviNOx® system have been trained by the technology provider UHDE and the supplier of the digital process control system (Delta V, M/s. process management), further Hu-Chems has established internal training plans on the CDM procedures, operation of the EnviNOx® system and the monitoring system to train staffs who are assigned to the project during the crediting period. Training records are available and submitted to the DOE for verification.

CARBON is responsible for supervision and checks of monitoring and reporting data. Furthermore, CARBON prepares the CDM-MR and supporting documents and arranges additional double-checking of data and information. CARBON gives its approval on the supporting documents as well as the CDM-MR before submitting to the respective DOE for verification.

Hu-Chems Organisational & Responsibility Diagram



CDM Project: Involved entities & Project responsibilities



3. Back up plans / Emergency procedures for monitoring system

Back Up Plans for measuring systems / Periodically observation of the automated monitoring system

EnviNOx® – Automatic DCS system:
The EnviNOx® system is designed for automatic operation, so that activities by the operation personnel are not required during normal operation. However, all alarms and any action taken by the operating personnel (events) are automatically logged at the computer station (Alarm & Event List) of the DCS system. All log sheets for **Alarm & Events** are exported and therefore digital available (Excel Files) and can be analysed and evaluated.
Malfunction of system components is indicated on the operator console in the control room as an alarm. Occurrence of such an alarm requires the operator to immediately take measures to remedy the problem. This is done by informing Hu-Chems instrument department and CARBON. It is then deciding whether the problem can be fixed immediately by themselves, or whether external support from Emerson Korea/Emerson Germany/Uhde is required.

Back Up – Regular on-site inspection:
In addition to the automatic error indication by the automatic DCS system, the project operator Hu-Chems is carrying out visual **on-site analyser cabinet inspections** as well as related installations on a shift basis (3 times daily). Relevant data related to the analyser and sampling system are logged on the ISO Document HCSEF-448-1 “CDM Analyzer/Reactor Check List”. Actions are defined in case of abnormal observations.

Further, Hu-Chems is carrying out a **visual on-site check of the EnviNOx® reactor and tail gas line** as well as related installations once per day. Relevant data are logged on the ISO Document HCSEF-448-1 “CDM Analyzer/Reactor Check List”. Actions are defined in case of abnormal observations.

Back Up – System support & Preventive maintenance: DeltaV
The DeltaV automatic measuring system (AMS) used for plant operation & CDM Monitoring was designed by the company Emerson, the main supplier of components related to the monitoring system.
In order to ensure maximum availability of the DeltaV automatic measuring system and to prevent deficient handling of data, Hu-Chems has contracted Emerson Process Management Korea to execute **monthly** on-site **Health Checks** and **quarterly** on-site **Inspection Visits**. Furthermore a **24 hours emergency service** and the **24 hours DeltaV Guardian Support** are covered by the contract. The contracted services comprise error diagnostics, measures for system stability, updates as well as preventive maintenance for the DeltaV System and related technical components. Health check reports and inspection visit reports are available and submitted to the DOE for verification.

Back Up – Support & Preventive maintenance: EnviNOx®-System/Analyser, Instruments
Main instruments for CDM Monitoring (i.e. Sampling system and the continuously measuring non-dispersive-infrared (NDIR) analyser used for N_2O detection as well as further instruments) were designed and supplied by the company Emerson Process Management, the main supplier of components related to the monitoring system.

In order to enable high levels of availability and accuracy of instruments, Hu-Chems has contracted Emerson Process Management Korea to execute **monthly** on-site **Health Checks** and **quarterly** on-site **Inspection Visits**. Furthermore a **24 hours emergency service** is covered by the contract. The contracted regular, services comprise error diagnostics of analysers, component updates of the analysers and the sampling system, in-depth inspections of analysers and the sampling system as well as preventive maintenance services for the analysers, the sampling system and technical components/instruments of the CDM Monitoring System. The contract was coming into force after the start-up period of the project activity. Exception handling for CDM Monitoring Instruments is covered by the 24 hours emergency service with guaranteed short-term on-site availability of

Emerson experts. Health check reports and inspection visit reports are available and submitted to the DOE for verification.

Supervision is done based on the daily reports by the technology provider Uhde and Emerson.

Back Up – Calibration and General Maintenance: Instruments

In order to safeguard availability and accuracy of instruments, the project participants have mandated Emerson Process Management Korea to execute **regular calibration services** and **regular general maintenance services** for all related monitoring instruments on a regular basis (adapted to the annual shut-down and maintenance schedule of the nitric acid plant). The service inter alia consists, besides calibrations, of hardware and connection maintenance as well as software checks and error diagnostics. Service reports of performed services and calibration records are submitted to the DOE for verification.

Back Up – On-site spare part stock:

As further important contribution to the availability of the monitoring system (e.g. in the event of failure of the measuring equipment), Hu-Chems stores a comprehensive range of spare parts at the project site. The types and amount of stored spare parts meet the recommendations of the supplier. The majority of spare part types are re-purchased after consumption, some other spare part types are re-purchased after their stock has reached a defined reorder level, in both cases Hu-Chems is following the recommendation of the supplier. The spare part stock includes inter alia filter elements, valves and pressure controllers for the sample handling system and filter elements, analysis cells (crucial part for analyzers), flow sensors and several electrical parts for the analyzers. An overview on available parts is made available to the DOE for verification.

Back Up – Certified standard gases

Pressure levels of standard gases used for the regular, automatic calibration of the analyser are constantly monitored during the regular on-site inspection. Spare bottles of test gases are purchased in proper time. Specifications and certification of test gases are made available to the DOE for verification.

Back Up – Procedures:

In addition to the quality control and quality assurance procedures according to the Hu-Chems quality management system and in order to avoid possible failures of the automated monitoring system, procedures are implemented for the project activity. The approach was to ensure immediate response to such special events in the system.

The following table summarizes the periodical observations of the AMS.

Periodical observation of the AMS

Organization	Action	Frequency	Output
DeltaV	Events & Alarm List	Continuously	Txt-files, Excel files
Hu-Chems	Shift Inspection	3 times per day	Protocol/Check List
Hu-Chems	Daily Inspection	Daily	Protocol/Check List
UHDE	Supervision	Daily	Plausibility check of daily reporting
Emerson Process Management Korea (EPMK)	Health check of AMS System (Hardware & Software)	Monthly	Health Check Report
EPMK	Health Check of Sampling & Analyser system	Monthly	Health Check Report
EPMK	Inspection check of AMS System	Quarterly	Inspection Check Report

	(Hardware & Software)		
EPMK	Inspection check of Sampling & Analyser system	Quarterly	Inspection Check Report
EPMK	General Maintenance & Calibration Service of instruments	Regularly, adopted to annual shut-down schedule of the plant	Service Reports & Calibration records

All resulting documents are analysed and evaluated by Hu-Chems under support of CARBON. In case of any upcoming problem or failure of the EnviNOx® system and/or the automated monitoring system Hu-Chems immediately takes measure to remedy the problem. The provider of the automated monitoring system is available 24 hours a day via Hotline. Furthermore Emerson Korea is committed to be onsite within 24 hours.

4. Systematic measures for QA for monitoring data during AMS down times

In order to ensure data quality, back up plans (see above) are in place. In case of (scheduled or unscheduled) AMS down times (or parts thereof, such as analyser, etc.), demonstration of normal plant operation and estimation of emission reductions are conservatively conducted according to the methodology and the monitoring plan. Related data and documents are provided to the DOE for verification, if applicable in the covered monitoring period.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante or at renewal of crediting period

Data/parameter:	**$EF_{default,y}$**
Unit	$kgN_2O/tHNO_3$
Description	Default N_2O baseline emissions factor in the calendar year y of the monitoring period n
Source of data	According to the PDD / ACM0019 (Version 1)
Value(s) applied)	**3.70 $kgN_2O/tHNO_3$ (for the year 2013)** **3.50 $kgN_2O/tHNO_3$ (for the year 2014)**
Choice of data or measurement methods and procedures	Specified in the methodology
Purpose of data	Calculation of baseline emissions
Additional comments	The default N_2O baseline emission factor will vary every year. For the year 2005 the emission factor has been 5.1 and since then decrease every year until it reaches a final value of 2.5 in the year 2020. The value of 2.5 will remain constant after 2020.

Year	**Emission factor (kgN_2O/HNO_3)**
2012	3.90
2013	3.70
2014	3.50
2015	3.40
2016	3.20
2017	3.00
2018	2.80
2019	2.70
2020	2.50
2021	2.50

2022	2.50
…	…
Year n	2.50

Data/parameter:	GWP_{N2O}
Unit	tCO_2e/tN_2O
Description	Global warming potential of N_2O valid for the commitment period
Source of data	According to the PDD / ACM0019 (Version 1)
Value(s) applied)	**298 tCO_2e/tN_2O**
Choice of data or measurement methods and procedures	None
Purpose of data	Calculation of project emissions
Additional comments	Valid from 01/01/2013 onwards, as per relevant CDM EB decisions. The value applicable before that date (310 tCO_2e/tN_2O) is not applicable to this project activity, since physical emission reduction has started in February 2013.

Data / Parameter:	R_u
Unit	$Pa.m^3/kmol.K$
Description	Universal ideal gases constant
Source of data	According to the PDD / "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 2.0.0)
Value(s) applied)	**8,314 $Pa.m^3/kmol.K$**
Choice of data or measurement methods and procedures	Specified in the tool
Purpose of data	Calculation of project emissions
Additional comments	-

Data/parameter:	MM_i
Unit	kg/kmol
Description	Molecular mass of greenhouse gas i
Source of data	According to the PDD / "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 2.0.0)
Value(s) applied)	**44.02 kg/kmol**
Choice of data or measurement methods and procedures	Specified in the tool
Purpose of data	Calculation of project emissions
Additional comments	Value is applicable for N_2O

D.2. Data and parameters monitored

Data/parameter:	$P_{NA,n}$
Unit	$tHNO_3$
Description	Nitric acid produced in the monitoring period n

Measured/calculated/default	Measured
Source of data	Production reports (based on measurements from project participants) The nitric acid flow and density are measured with a coriolis flow meter, temperature with a temperature measurement and concentration is determined based on measured parameters. Values are sent to the DCS (control room), and the nitric acid production (as 100% HNO3) is calculated based on mass flow and HNO_3 concentration. Final production values are exported in production reports through the DeltaV System. Please refer also to *Section C – 1 (Information Flow)* of this Monitoring Report.
Value(s) of monitored parameter	**547,431 tHNO_3** An excel book containing recorded hourly values (covered by this monitoring period), is attached as *Appendix 2* to this Monitoring Report.
Monitoring equipment	Meter location: Located in the nitric acid line, downstream of the absorption tower. **325-FT-5-609** Type: Coriolis flow meter Accuracy class: ± 0.35% Serial number: 14290236 Calibration frequency: 60 Months Date of penultimate calibration: 17/05/2012 (Validity 16/05/2017) Date of last calibration: 22/04/2014 (Validity 21/04/2019) **325-TT-5-237** Type: Temperature transmitter Accuracy class: ±0.5℃ + (±0.03% of span) Serial number: C2M408098 Calibration frequency: 24 Months Date of antepenultimate calibration: 12/04/2012 (Validity 11/04/2014) Date of penultimate calibration: 02/10/2013 (Validity 01/10/2015) Date of latest calibration: 22/04/2014 (Validity 21/04/2016)
Measuring/reading/recording frequency:	Measuring: Continuously Reading: Every 10 seconds Recording: Hourly
Calculation method (if applicable):	-
QA/QC procedures:	The maintenance methods and procedures for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 procedures of HU-CHEMS. Accordingly, calibration and maintenance are part of regular QA/QC of the nitric acid plant (please refer also to section C-3). Please refer also to *Section C – 3. Back Up plans / Emergency procedures for monitoring system* of this Monitoring Report and respective subitems *Back Up Plans for measuring systems / Periodically observation of the automated monitoring system*.
Purpose of data:	Calculation of baseline emissions
Additional comments:	Parameter is automatically monitored.

Data/parameter	h_n
Unit	-
Description	Number of hours of operation in a monitoring period n
Measured/calculated/default	Measured
Source of data	Measuring device (please refer to Monitoring equipment below) The flow of NH_3 to the ammonia oxidation reactor indicates the operational status. In case, the volume flow of NH3 to the ammonia oxidation reactor lies above the threshold of 500 Nm³/h during an hour, the reactor is considered in operation. This check is traceably incorporated in the excel books attached as an *Appendix 2* to this monitoring report. Please refer also to *Section C – 1 (Information Flow)* of this Monitoring Report.
Value(s) of monitored parameter	**11,430** An excel book containing recorded hourly values (covered by this monitoring period), is attached as *Appendix 2* to this Monitoring Report.
Monitoring equipment	Meter location: Located in the ammonia supply line, upstream of the ammonia oxidation reactor. **325-FT-5-520** Type: Coriolis flow meter Accuracy class: ± 0.35% Serial number: 14288859 Calibration frequency: 60 Months Date of latest calibration: 18/05/2012 (Validity 17/05/2017) Date of latest calibration: 22/04/2014 (Validity 21/04/2019)
Measuring/reading/recording frequency:	Measuring: Continuously Reading: Every 10 seconds Recording: Hourly
Calculation method (if applicable):	-
QA/QC procedures:	The maintenance methods and procedures for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 procedures of HU-CHEMS. Accordingly, calibration and maintenance are part of regular QA/QC of the nitric acid plant (please refer also to section C-3). Please refer also to *Section C – 3. Back Up plans / Emergency procedures for monitoring system* of this Monitoring Report and respective subitems *Back Up Plans for measuring systems / Periodically observation of the automated monitoring system*.
Purpose of data:	Calculation of baseline and project emissions
Additional comments:	-

Data/parameter	$V_{t,db}$
Unit	m³ dry gas/h
Description	Volumetric flow of the gaseous stream in time interval t on a dry basis
Measured/calculated/default	Measured

Source of data	Measuring device (please refer to Monitoring equipment below) Please refer also to *Section C – 1 (Information Flow)* of this Monitoring Report.
Value(s) of monitored parameter	**251,194 m³ dry gas / h** The value represents an average over the monitoring period. An excel book containing recorded hourly values (covered by this monitoring period), is attached as *Appendix 2* to this Monitoring Report.
Monitoring equipment	Meter location: Located in the stack at the end of the tail gas line. **325-FT-5-522** Type: Differential pressure transmitter Accuracy class: ± 2% of span Serial number: 1230726 Calibration frequency: 36 months (QAL2 reference measurement) Date of last calibration (QAL2): 25/02/2013 to 28/02/2013 (Validity: 24/02/2016)
Measuring/reading/recording frequency:	Measuring: Continuously Reading: Every 1 second Recording: Hourly
Calculation method (if applicable):	-
QA/QC procedures:	The maintenance methods and procedures for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 procedures of HU-CHEMS. Accordingly, calibration and maintenance are part of regular QA/QC of the nitric acid plant (please refer also to section C-3). QA/QC procedure consider requirements as per EN 14181 - Calibration against a primary device provided by an independent accredited laboratory follows EN 14181 requirements (QAL2 reference measurement). Latest such calibration has been performed by AIRTEC in February 2013. Latest Annual Surveillance Test (AST) per EN 14181 has been performed by AIRTEC in September 2014. Please refer also to *Section C – 3. Back Up plans / Emergency procedures for monitoring system* of this Monitoring Report and respective subitems *Back Up Plans for measuring systems / Periodically observation of the automated monitoring system*.
Purpose of data:	Calculation of project emissions
Additional comments:	-

Data/parameter	$v_{i,t,db}$
Unit	m³ gas i/m³ dry gas
Description	Volumetric fraction of greenhouse gas i in a time interval t on a dry basis
Measured/calculated/default	Measured
Source of data	Measuring device (please refer to Monitoring equipment below) Please refer also to *Section C – 1 (Information Flow)* of this Monitoring Report.
Value(s) of monitored parameter	**$2.13*10^{-5}$ m³ N_2O / m³ dry gas** The value represents an average over the monitoring period. An excel book containing recorded hourly values (covered by this monitoring period), is attached as *Appendix 2* to this Monitoring Report.

Monitoring equipment	Meter location: Sample take-off is located in the stack at the end of the tail gas line. and leads (via sample gas line) to the locked analyser house where analyser and standard gases for calibrations are installed. **325-AT-5-018** Type: NDIR Analyzer Accuracy class: ±1% (zero/span) Serial number: 393709203380368 Calibration frequency: 36 months (QAL2 reference measurement) Date of last calibration (QAL2): 25/02/2013 to 28/02/2013 (Validity: 24/02/2016)
Measuring/reading/recording frequency:	Measuring: Continuously Reading: Every 1 second Recording: Hourly
Calculation method (if applicable):	-
QA/QC procedures:	The maintenance methods and procedures for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 procedures of HU-CHEMS. Accordingly, calibration and maintenance are part of regular QA/QC of the nitric acid plant (please refer also to section C-3). QA/QC procedure consider requirements as per EN 14181 - Calibration against a primary device provided by an independent accredited laboratory follows EN 14181 requirements (QAL2 reference measurement). Latest such calibration has been performed by AIRTEC in February 2013. Latest Annual Surveillance Test (AST) per EN 14181 has been performed by AIRTEC in September 2014. Please refer also to *Section C – 3. Back Up plans / Emergency procedures for monitoring system* of this Monitoring Report and respective subitems *Back Up Plans for measuring systems / Periodically observation of the automated monitoring system*. Emerson Process Management Korea has been mandated to conduct monthly analyser health checks and quarterly inspection checks to ensure good instrument condition.
Purpose of data:	Calculation of project emissions
Additional comments:	-

Data/parameter	**T_t**
Unit	K
Description	Temperature of the gaseous stream in time interval t
Measured/calculated/default	Measured
Source of data	Measuring device (please refer to Monitoring equipment below) Please refer also to *Section C – 1 (Information Flow)* of this Monitoring Report.
Value(s) of monitored parameter	**405.56 K** The value represents an average over the monitoring period. An excel book containing recorded hourly values (covered by this monitoring period), is attached as *Appendix 2* to this Monitoring Report.

Monitoring equipment	Meter location: Located in the stack at the end of the tail gas line. **325-TT-5-161** Type: Temperature transmitter Accuracy class: ±0.5℃ + (±0.03% of span) Serial number: 1230727 Calibration frequency: 24 months Date of penultimate calibration: 25/02/2013 (Validity 24/02/2015) Date of latest calibration: 23/09/2014 (Validity 22/09/2016)
Measuring/reading/recording frequency:	Measuring: Continuously Reading: Every 1 second Recording: Hourly
Calculation method (if applicable):	-
QA/QC procedures:	The maintenance methods and procedures for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 procedures of HU-CHEMS. Accordingly, calibration and maintenance are part of regular QA/QC of the nitric acid plant (please refer also to section C-3). Please refer also to *Section C – 3. Back Up plans / Emergency procedures for monitoring system* of this Monitoring Report and respective subitems *Back Up Plans for measuring systems / Periodically observation of the automated monitoring system*.
Purpose of data:	Calculation of project emissions
Additional comments:	-

Data/parameter	**P_t**
Unit	Pa
Description	Pressure of the gaseous stream in time interval t
Measured/calculated/default	Measured
Source of data	Measuring device (please refer to Monitoring equipment below) Please refer also to *Section C – 1 (Information Flow)* of this Monitoring Report.
Value(s) of monitored parameter	**100,527 Pa** The value represents an average over the monitoring period. An excel book containing recorded hourly values (covered by this monitoring period), is attached as *Appendix 2* to this Monitoring Report.
Monitoring equipment	Meter location: Located in the stack at the end of the tail gas line**.** **325-PT-5-362** Type: Pressure transmitter Accuracy class: ± 0.1% of span Serial number: 1230980 Calibration frequency: Monthly Calibrations have been conducted month by month for this device, the first calibration touching this monitoring period was the calibration on 27/12/2013, as per requirements. Validity is always until the next month after calibration.
Measuring/reading/recording frequency:	Measuring: Continuously Reading: Every 1 second Recording: Hourly

Calculation method (if applicable):	-
QA/QC procedures:	The maintenance methods and procedures for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 procedures of HU-CHEMS. Accordingly, calibration and maintenance are part of regular QA/QC of the nitric acid plant (please refer also to section C-3). Please refer also to *Section C – 3. Back Up plans / Emergency procedures for monitoring system* of this Monitoring Report and respective subitems *Back Up Plans for measuring systems / Periodically observation of the automated monitoring system*.
Purpose of data:	Calculation of project emissions
Additional comments:	-

Data/parameter	**$C_{H2O,t,db,n}$**
Unit	mg H2O/m³ dry gas
Description	Moisture content of the gaseous stream at normal conditions, in time interval t
Measured/calculated/default	Measured
Source of data	Measurements according to the USEPA CF42 method 4 – Gravimetric determination of water content
Value(s) of monitored parameter	Below **$4*10^3$ mg H_2O/m³ dry gas** (equivalent to 0.004 kgH_2O/m³ dry gas).
Monitoring equipment	As per USEPA CF42 method 4 – Gravimetric determination of water content (performed by the qualified, external entity AIRTEC)
Measuring/reading/recording frequency:	As per the PDD, measurements coincide with the calibration of the flow meter (i.e. QAL 2 reference measurement). Repeated measurements were conducted by the company AIRTEC (which coincided with the QAL2 reference measurements) during 25/02/2013 to 28/02/2013 and during 23/09/2014.
Calculation method (if applicable):	-
QA/QC procedures:	According to standard USEPA CF42 method 4
Purpose of data:	Calculation of project emissions

Additional comments:	As per the applied "Tool to determine the mass flow of a greenhouse gas in a gaseous stream ", the flow and volumetric fraction may be measured on a dry basis or wet basis. The tool covers the possible measurement combinations, providing six different calculation options to determine the mass flow of a particular greenhouse gas (Option A to F). As described in the PDD, the option chosen for this project activity is Option A, requiring to demonstrate, that the gaseous stream is dry, whereas the tool suggests two ways to do this: (a) Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H2O/m³ dry gas; or (b) Demonstrate that the temperature of the gaseous stream (T_t) is less than 60°C (333.15 K) at the flow measurement point. In the case of this project activity, the first way (a) has been chosen. The measured values as described above ($4*10^3$ mg H2O/m³ dry gas, equivalent to 0.004 kgH2O / m³ dry gas) show that the moisture content of the gaseous stream is clearly below the threshold value of 0.05 kg H2O/m³ dry gas.

D.3. Implementation of sampling plan

>>

No sampling plan is applicable to this project activity.

SECTION E. Calculation of emission reductions or GHG removals by sinks

All references to formulae and methods used are in compliance with ACM0019 (Version 1), applicable tools and the project documentation (PDD, monitoring plan) and are transparently shown in the excel book (*Appendix 2* to this monitoring report). This excel book contains recorded monitored data, a comprehensive calculation of baseline emissions, project emissions and emission reductions with actual values (formulae of calculation are shown in the spreadsheet cells for ease of assessment).

E.1. Calculation of baseline emissions or baseline net GHG removals by sinks

>>

Baseline emissions are calculated by the following equation:

$$BE_n = P_{NA,n} * EF_{BL,N2O,n} * GWP_{N2O} * 10^{-3}$$

Where:

BE_n	=	Baseline emissions in monitoring period *n* (tCO_2e)
$P_{NA,n}$	=	Nitric acid produced in the monitoring period *n* ($tHNO_3$)
$EF_{BL,N2O,n}$	=	Baseline N_2O emission factor for nitric acid production in the monitoring period *n* (kgN_2O / $tHNO_3$)
GWP_{N2O}	=	Global Warming Potential of N_2O valid for the commitment period

Calculation result and parameters:

-	***BE_n**	$P_{NA,n}$	$EF_{BL,N2O,n}$	GWP_{N2O}
-	tCO_2e	$tHNO_3$	kgN_2O / $tHNO_3$	tCO_2e / tN2O
01/09/2013 – 31/12/2014	153,095	138,849	3.70	298
01/01/2014 – 31/12/2014	426,151	408,582	3.50	298
Total monitoring period 01/09/2013 – 31/12/2014	**579,246**	**547,431**	**-**	**298**

**Value is conservatively rounded DOWN*

Determination of the baseline N_2O emission factor

The baseline N_2O emission factor in the monitoring period n ($EF_{BL,N2O,n}$) is determined as a default emission factor $EF_{default,y}$ given for each calendar year y (and available from the PDD / Methodology):

$$EF_{BL,N2O,n} = EF_{default,y}$$

Since during this actual monitoring period two calendar years of physical emission reduction are involved (the year 2013 and the year 2014), also two values have to be considered for $EF_{default,y}$ which is 3.70 kgN_2O / $tHNO_3$ for the year 2013 and is 3.50 kgN_2O / $tHNO_3$ for the year 2014 (refer to the parameter tables under section D.1).

E.2. Calculation of project emissions or actual net GHG removals by sinks

>>

Project emissions are calculated by the following equation:

$$PE_n = PE_{N2O,n} + PE_{CO2,tertiary,n}$$

PE_n	=	Project emissions in monitoring period *n* (tCO_2e)
$PE_{N2O,n}$	=	Project emissions of N_2O from the project plant in monitoring period *n* (tCO_2e)
$PE_{CO2,tertiary,n}$	=	Project emissions of CO_2 from the operation of the tertiary N_2O abatement facility in monitoring period *n* (tCO_2)

As clearly described in the PDD, the project emissions of CO_2 from the operation of the tertiary N_2O abatement facility ($PE_{CO2,tertiary,n}$) are set to zero due to the absence of this emission source in the project activity.

Calculation result and parameters:

-	**PE_n**	**$PE_{N2O,n}$**	**$PE_{CO2,tertiary,n}$**
-	tCO_2e	tCO_2e	tCO_2e
01/09/2013 – 31/12/2014	4,888	4,888	0
01/01/2014 – 31/12/2014	18,288	18,288	0
Total monitoring period 01/09/2013 – 31/12/2014	**23,176**	**23,176**	**0**

Project emissions of N_2O from the project plant ($PE_{N2O,n}$) are calculated by the following equation:

$$PE_{N2O,n} = (Q_{N2O,tailgas,n} + Q_{N2O,by-pass,n}) * GWP_{N2O}$$

Where:

$PE_{N2O,n}$	=	Project emissions of N_2O from the project plant in monitoring period n (tCO_2e)
$Q_{N2O,tail\ gas,n}$	=	Amount of N_2O released through the tail gas of the project plant to the atmosphere in monitoring period n (tN_2O)
$Q_{N2O,by\text{-}pass,n}$	=	Amount of N_2O released through the by-pass to a tertiary N_2O abatement system to the atmosphere in monitoring period n (tN_2O)
GWP_{N2O}	=	Global Warming Potential of N_2O valid for the commitment period

As clearly described in the PDD, the amount of N_2O released through the by-pass to a tertiary N_2O abatement system to the atmosphere ($Q_{N2O,by\text{-}pass,n}$) is set to zero due to the absence of this emission source in the project activity.

Calculation result and parameters:

-	**$PE_{N2O,n}$	$Q_{N2O,tailgas,n}$	$Q_{N2O,by-pass,n}$	GWP_{N2O}
-	tCO_2e	tN_2O	tN_2O	tCO_2e / tN_2O
01/09/2013 – 31/12/2014	4,888	*16.40*	*0*	298
01/01/2014 – 31/12/2014	18,288	*61.37*	*0*	298
Total monitoring period 01/09/2013 – 31/12/2014	**23,176**	**77.77**	**0**	**298**

***Value is conservatively rounded UP*

Determination of $Q_{N2O,tail\ gas,n}$

The amount of N_2O released through the tail gas of the project plant to the atmosphere ($Q_{N2O,tail\ gas,n}$) is "Tool to determine the mass flow of a greenhouse gas in a gaseous stream", whereas following provisions apply:

- Throughout the crediting periods of the project activity, the N_2O concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is to be installed and maintained throughout the crediting period based on the European Norm 14181, or any more recent update of that standard;
- The monitoring system should provide separate hourly average values for the N_2O concentration and the volume or mass flow of the tail gas based on 2 seconds (or shorter) interval readings that are recorded and stored electronically. These N_2O data sets shall be identified by means of a unique time / date key indicating when exactly the values were observed;
- The correction factors derived from the calibration curve of the QAL2 audit for the monitoring components as determined during the QAL2-test in accordance with EN14181 must be applied to both the N_2O concentration and the volume or mass flow of the tail gas. This can either be applied automatically to the raw data recorded by the data storage system at the plant or it can be applied to the calculated hourly averages as part of the calculation of project emissions;
- If data for either the N_2O concentration or the volume or mass flow of the tail gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour shall be replaced with the maximum value of N_2O concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the N_2O concentration nor the volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of N_2O calculated during the monitoring period shall be applied to any such hour. Values observed during five operating hours before and after a plant start-up and shut-down shall not be used for the determination of the maximum values;

The monitoring system as well as calculations and consideration of QAL2 calibration curve are fully implemented, the monitoring system are in full compliance with these provisions.

As furthermore stated in the PDD, following the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" the mass flow of greenhouse gas i in the gaseous stream in time interval t ($F_{i,t}$) is calculated based on measurements of

(a) the total volume flow or mass flow of the gas stream;
(b) the volumetric fraction of the gas in the gaseous stream; and
(c) the gas composition and water content.

The flow and volumetric fraction may be measured on a dry basis or wet basis. The tool covers the possible measurement combinations, providing six different calculation options to determine the mass flow of a particular greenhouse gas (Option A to F).

As described in the PDD, the option chosen for this project activity is Option A, requiring to demonstrate, that the gaseous stream is dry, whereas the tool suggests two ways to do this:

(a) Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H2O/m³ dry gas; or

(b) Demonstrate that the temperature of the gaseous stream (T_t) is less than 60°C (333.15 K) at the flow measurement point.

In the case of this project activity, the first way has been chosen. Repeated measurements in line with the USEPA CF42 method 4 conducted by the company AIRTEC (which coincided with the QAL2 & AST reference measurements) during 25/02/2013 to 28/02/2013 (QAL2) and during 23/09/2014 (AST) clearly showed, that the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) is below 0.004 kgH2O / m³ dry gas, which is clearly below the threshold value of 0.05 kg H_2O/m³ dry gas.

Summarized ($Q_{N2O,tailgas,n}$) is calculated as per following equation, following Option A of the mentioned tool:

$$Q_{N2O,tailgas,n} = \sum_{h=1}^{h=h_n} F_{N2O,tailgas,h} * 10^{-3}$$

$Q_{N2O,tail\ gas,n}$ = Amount of N_2O released through the tail gas of the project plant to the atmosphere in monitoring period *n* (tN_2O)

$F_{N2O,tail\ gas,h}$[4] = Mass flow of N_2O in the gaseous stream of the tail gas in the hour *h* (kgN_2O/h)

h_n = Number of hours in monitoring period *n* during which the plant was in operation

The result of $Q_{N2O,tailgas,n}$ over the monitoring period is basically the sum over hourly values of calculated mass flow of N_2O ($F_{N2O,tailgas,h}$).

-	$Q_{N2O,tailgas,n}$	$\sum F_{N2O,tailgas,h}$
-	tN_2O	kgN_2O
01/09/2013 – 31/12/2014	*16.40*	16,401.65
01/01/2014 – 31/12/2014	*61.37*	61,367.39
Total monitoring period 01/09/2013 – 31/12/2014	**77.77**	**77,679.03**

The hourly values of $F_{N2O,tailgas,h}$ (which in the tool is stated as $F_{i,t}$ but represents the same parameter) are calculated as per following formulae:

$$F_{i,t} = V_{t,db} * v_{i,t,db} * \rho_{i,t}$$

With

$$\rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t}$$

Where:

$F_{i,t}$ = Mass flow of greenhouse gas i in the gaseous stream in time interval t (kg gas/h)

$V_{t,db}$ = Volumetric flow of the gaseous stream in time interval t on a dry basis (m³ dry gas/h)

$v_{i,t,db}$ = Volumetric fraction of greenhouse gas i in the gaseous stream in a time interval t on a dry basis (m³ gas i/m³ dry gas)

$\rho_{i,t}$ = Density of greenhouse gas i in the gaseous stream in time interval t (kg gas i/m³ gas i)

[4] $F_{N2O,tail\ gas,h}$ corresponds to the parameter $F_{i,t}$ of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0.0)".

P_t = Absolute pressure of the gaseous stream in time interval t (Pa)
MM_i = Molecular mass of greenhouse gas i (kg/kmol)
R_u = Universal ideal gases constant (Pa.m³/kmol.K)
T_t = Temperature of the gaseous stream in time interval t (K)

For calculation of $F_{N2O,tailgas,h}$, as well as application of calibration curves or corrections to data in case of observations & events (as described in section B.1. / (c)) on an hourly basis, please refer to the excel book which is available as *Appendix 2* to this monitoring report.

E.3. Calculation of leakage

>>
According to the methodology any leakage emissions sources are deemed to be negligible.

E.4. Summary of calculation of emission reductions or net GHG removals by sinks

Item	Baseline emissions or baseline net GHG removals by sinks (t CO_2e)	Project emissions or actual net GHG removals by sinks (t CO_2e)	Leakage (t CO_2e)	GHG emission reductions or net GHG removals by sinks (t CO_2e) achieved in the monitoring period		
				Up to 31/12/2012	From 01/01/2013	Total amount
Total	579,246	23,176	0	Not applicable (Start of period is after 31 December 2012)	556,070	556,070

The total emission reduction achieved by this project activity during the monitoring period is the difference between baseline emissions, project emissions and leakage emissions.

E.5. Comparison of actual emission reductions or net GHG removals by sinks with estimates in registered PDD

Item	Values estimated in ex-ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO_2e)	**Amount est.d in PDD for 2013: 421,789** **Amount est. in PDD for 2014: 397,191** **→ Corresponding estimated amount for the duration of monitoring period (122 days in 2013 + whole year 2014): 538,172**	**556,070 (487 days)**

Reason for the slight increase in actual emission reductions achieved during the current monitoring period compared to ex-ante calculation of the registered PDD is given in section E.6. below. It should be noted that the ex-ante estimation of emissions reductions in the PDD was generally based on conservative assumptions.

E.6. Remarks on difference from estimated value in registered PDD

>>
The slight increase of the actual emission reduction during the monitoring period compared to the corresponding ex-ante estimation according to the PDD is mainly because of the high efficiency of the EnviNOx system (removal rates of about 99% are observed whereas 96% were estimated in the ex-ante calculation).

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

Project participant and/or responsible person/ entity	☒ Project participant ☐ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Hu-Chems Fine Chemical Corp.
Street/P.O. Box	19th Floor Kukdong Bldg., 60-1, Chungmuro 3ga. Jung-gu
Building	-
City	Seoul
State/region	-
Postcode	100-705
Country	Republic of Korea
Telephone	-
Fax	+82 61 680 4620
E-mail	-
Website	www.huchems.com
Contact person	Hyun-Su Kim
Title	-
Salutation	-
Last name	Kim
Middle name	-
First name	Hyun-Su
Department	Production Management Team
Mobile	+82 10 5650 7314
Direct fax	-
Direct tel.	+82 61 680 4601
Personal e-mail	asp5592@huchems.com

Project participant and/or responsible person/ entity	☒ Project participant ☐ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Carbon CDM Korea Ltd.
Street/P.O. Box	3rd & 5th Floor Namdo Bldg., 12, Jangmoon-ro, Yongsan-gu
Building	-
City	Seoul
State/region	-
Postcode	140-809
Country	Republic of Korea
Telephone	+43 2734 322 70
Fax	+43 2734 322 70 99
E-mail	office@carbon-austria.com
Website	-

Contact person	Ferdinand Heilig
Title	-
Salutation	-
Last name	Heilig
Middle name	-
First name	Ferdinand
Department	Management
Mobile	+43 676 572 17 92
Direct fax	-
Direct tel.	+43 2734 322 70 10
Personal e-mail	heilig@carbon-austria.com

Project participant and/or responsible person/ entity	☒ Project participant ☒ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Carbon Climate Protection GmbH
Street/P.O. Box	Am Südblick 5
Building	-
City	Langenlois
State/region	-
Postcode	3550
Country	Austria
Telephone	+43 2734 322 70
Fax	+43 2734 322 70 99
E-mail	office@carbon-austria.com
Website	-
Contact person	Andreas Moser-Rammelmüller
Title	-
Salutation	-
Last name	Moser-Rammelmüller
Middle name	-
First name	Andreas
Department	CDM Project Management
Mobile	-
Direct fax	-
Direct tel.	+43 2734 322 70 60
Personal e-mail	rammelmueller@carbon-austria.com

Appendix 2. Excel book for claiming Emission Reductions

An excel book containing monitored data and calculations of baseline emissions, project emissions and emission reductions as well as additional information is attached as separate file:

HUC-6637_MP#02_UNFCCC_v1_FINAL.xlsx

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Document information

Version	*Date*	*Description*
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01	28 May 2010	EB 54, Annex 34. Initial adoption.

Decision Class: Regulatory
Document Type: Form
Business Function: Issuance
Keywords: monitoring report