CDM Monitoring Report No.12:

"Catalytic N2O destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp.”

UNFCCC 0765

Monitoring Period:
From: 01/01/2010
To: 31/03/2010

Version 1
06/04/2010

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1 Introduction

The purpose of this monitoring report is to calculate and clarify GHG emission reduction quantity achieved by this project activity for periodic verification.

This monitoring report covers the activity from **01/01/2010** to **31/03/2010** as the **12th** monitoring period.

The starting date of the project activity is the:	22/12/2005
The project was registered at UNFCCC on:	22/01/2007 with number 0765
The starting data of the crediting period is:	22/01/2007
The end date of the crediting period is:	21/01/2014

Carbon CDM Korea has implemented a project for GHG emission reduction by catalytic N_2O destruction 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.

2 Reference

Approved Baseline methodology:
AM0028 Version 1: “Catalytic N_2O destruction in the tail gas of Nitric Acid Plants”; submitted by Carbon Projektentwicklung GmbH.

Approved Monitoring methodology:
AM0028 Version 1: “Catalytic N_2O destruction in the tail gas of Nitric Acid Plants”; submitted by Carbon Projektentwicklung GmbH.

Project Design Document:
“Catalytic N_2O destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp.”
Version: 2
Date of Completion: 22/07/2006

Validation Report:
Validation of the CDM Project: “Catalytic N_2O destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp.”
REPORT NO. 775390
Date: 05/08/2006 by TÜV SÜD Industrie Service GmbH

CDM Registration:
“Catalytic N_2O destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp.”
UNFCCC Ref. Number 0765
Date of registration: 22/01/2007

3 Definition

- **y** : Monitoring period (in this report, **01/01/2010** to **31/03/2010)**
- **PDD** : Project Design Document of this project "Catalytic N2O destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp." Version 2 on July 22nd 2006.

4 General Description of Project

4.1 Project Activity

The Project Activity includes development, design, engineering, procurement, finance, construction, operation and maintenance of a system for catalytic reduction of N_2O in three Nitric Acid Plants (Hu-Chems II; Hu-Chems III; Hu-Chems IV) at Hu-Chems Fine Chemical Corp.

The EnviNOx® process used in the **Hu-Chems IV** 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.
The EnviNOx® process used in the **Hu-Chems II + III** nitric acid plants is based on the catalytic reduction of NO_x (NO and NO_2) with ammonia (NH_3) and of nitrous oxide (N_2O) with a hydrocarbon. The hydrocarbon used is propane gas of which the main constituent is propane (C_3H_8). The reactions take place over an iron zeolite catalyst bed.

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)[1]:

   $4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$ (main reaction 1) **(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) **(2)**
   $4\ NH_3 + 4\ O_2 \rightarrow 2\ N_2O + 6\ H_2O$ (side reaction 2) **(3)**

[1] 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.

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

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

$2\ NO + O_2 \rightarrow 2\ NO_2$ (main reaction 2) **(4)**

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) **(5)**
(NO is oxidised to NO_2 according to main reaction 2)

Description of catalytic reduction process:
Although the term catalytic reduction nowadays has a more general definition in terms of the transfer of electrons, the following definition is sufficient for present purposes: catalytic reduction of N_2O occurs when reactions take place between N_2O and other substances in contact with a catalyst, such that the oxygen is removed from the N_2O molecule and forms one or more compounds with other species. The substance or substances that react with N_2O to remove oxygen are termed reducing agent. A general reaction equation for the catalytic reduction of N_2O can be given as:

$n\ N_2O + x\ RA \rightarrow n\ N_2 + y_1\ P(1)O_A + y_2\ P(2)O_B + ... + z_1\ Q(1) + z_2\ Q(2) + ...$ **(6)**

where RA is a molecule of the reducing agent, $P(1)O_A$, $P(2)O_B$ are the compound formed by reaction with the oxygen of the N_2O and Q(1), Q(2) represent further products of the oxidation reaction, n, x, y_1, y_2, z_1, z_2 are the appropriate stoichiometric coefficients.

Equations reduction N_2O with propane:
$C_3H_8 + 7\ N_2O \rightarrow 3\ CO + 4\ H_2O + 7\ N_2$ **(7)**
or
$C_3H_8 + 10\ N_2O \rightarrow 3\ CO_2 + 4\ H_2O + 10\ N_2$ **(8)**

The definition does not exclude the possibility of side reactions resulting in consumption of reducing agent without any reduction of N_2O, for example with propane:
$2\ C_3H_8 + 7\ O_2 \rightarrow 6\ CO + 8\ H_2O$ **(9)**
or
$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$ **(10)**

Description of catalytic decomposition process:

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.

Overall reaction:

$$2\ N_2O \rightarrow 2\ N_2 + O_2 \quad \textbf{(11)}$$

The products of N_2O decomposition are the substances that result from decomposition reaction (N_2 and O_2)

Project Specific description:

Principles of the EnviNOx® process Hu-Chems II + III:

The EnviNOx® process used in the Hu-Chems II + III nitric acid plants is based on the catalytic reduction of NO_x (NO and NO_2) with ammonia (NH_3) and of nitrous oxide (N_2O) with a hydrocarbon. The hydrocarbon used is propane gas of which the main constituent is propane (C_3H_8). The reactions take place over an iron zeolite catalyst bed.

First the NO_x is reduced with ammonia according to such reactions as:

$$6\ NO_2 + 8\ NH_3 \rightarrow 7\ N_2 + 12\ H_2O \quad \textbf{(12)}$$
$$6\ NO + 4\ NH_3 \rightarrow 5\ N_2 + 6\ H_2O \quad \textbf{(13)}$$
$$NO + NO_2 + 2\ NH_3 \rightarrow 2\ N_2 + 3\ H_2O \quad \textbf{(14)}$$
$$4\ NO + O_2 + 4\ NH_3 \rightarrow 4\ N_2 + 6\ H_2O \quad \textbf{(15)}$$

Effectively all the NOx is removed. Some destruction of N_2O also occurs.

Secondly the nitrous oxide is reduced with hydrocarbons over the iron zeolite according to such reactions as:

$$7\ N_2O + C_3H_8 \rightarrow 7\ N_2 + 4\ H_2O + 3\ CO \quad \textbf{(16)}$$
$$10\ N_2O + C_3H_8 \rightarrow 10\ N_2 + 4\ H_2O + 3\ CO_2 \quad \textbf{(17)}$$
$$5\ O_2 + C_3H_8 \rightarrow 4\ H_2O + 3\ CO_2 \quad \textbf{(18)}$$
$$7\ O_2 + 2\ C_3H_8 \rightarrow 8\ H_2O + 6\ CO \quad \textbf{(19)}$$

Similar reactions take place between nitrous oxide and the small quantities of other hydrocarbons such as butane (C_4H_{10}) that are present in the commercial propane used. N_2O reduction by these reactions is much more effective when NO_x is absent.

A large proportion of the carbon monoxide that is formed is further oxidised to carbon dioxide over a second EnviCat®-CO / CH catalyst installed in the EnviNOx® reactor downstream of the first catalyst:

$$2\ CO + O_2 \rightarrow 2\ CO_2 \quad \textbf{(20)}$$

All the above reactions are exothermic and cause a temperature rise over the EnviNOx® reactor.

Compared with the reduction in greenhouse gas emission achieved by the destruction of N_2O the additional greenhouse gas emissions (CO_2) caused by the use of hydrocarbons in the process are insignificant but are monitored.

Principles of the EnviNOx® process Hu-Chems IV:
The EnviNOx® process used in the Hu-Chems IV 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.
In the first bed N_2O is catalytically decomposed into its elements:

$$2\,N_2O \rightarrow 2\,N_2 + O_2 \qquad \textbf{(21)}$$

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:

$$6\,NO_2 + 8\,NH_3 \rightarrow 7\,N_2 + 12\,H_2O \qquad \textbf{(22)}$$
$$6\,NO + 4\,NH_3 \rightarrow 5\,N_2 + 6\,H_2O \qquad \textbf{(23)}$$
$$NO + NO_2 + 2\,NH_3 \rightarrow 2\,N_2 + 3\,H_2O \qquad \textbf{(24)}$$
$$4\,NO + O_2 + 4\,NH_3 \rightarrow 4\,N_2 + 6\,H_2O \qquad \textbf{(25)}$$

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, CARBON CDM Korea installed three EnviNOx® systems for catalytic reduction and decomposition of NO_x and N_2O additionally to the equipment at the three nitric acid manufacturing plants. The project activity reduces the GHG emissions, which would otherwise be released to the atmosphere, if the project was not implemented. The implementation of the N_2O destruction project at Hu-Chems II and Hu-Chems III involves that propane is employed as a reducing agent for N_2O removal.

The EnviNOx® system at Hu-Chems IV was installed in December 2006 and the catalytic reduction process of N_2O started in the beginning of January 2007.
The EnviNOx® system at Hu-Chems II and Hu-Chems III was installed in February and March 2007 and the catalytic reduction process of N_2O started in the end of March 2007.

Location of the project activity:
The three EnviNOx® systems were installed at the nitric acid plants Hu-Chems II, III and IV on site of Hu-Chems Fine Chemical Corp." furthermore called "HU-CHEMS".

Location of the EnviNOx®-Systems:
Hu-Chems II: The new EnviNOx® reactor (322-R-202) is located between the existing SCR DeNOx reactor (37-R-201) and the tail gas turbine (37-C-201 T2) which is the position with the highest tail gas temperature in the nitric acid production process at Hu-Chems II.

Hu-Chems III: The new EnviNOx® reactor (323-R-302) is located between the existing SCR DeNOx reactor and the tail gas turbine of Hu-Chems III which is the position with the highest tail gas temperature in the nitric acid production process at Hu-Chems III.
Hu-Chems IV: The new EnviNOx® reactor (324-R-402) is located upstream of the tail gas turbine (324-C-401 T2) at the position with the highest tail gas temperature in the nitric acid production process at Hu-Chems IV.

4.2 Project Participants

Table 1: Project Participants

Name of Party involved	Project participants (as applicable)	Party involved considered as project participant
Republic of Korea (Host)	CARBON CDM Korea Ltd.	No
Federal Republic Germany	RWE Power AG	No

Host Country is the Republic of Korea. The Republic of Korea ratified the Kyoto Protocol in November 2002. Subsequent to the registration of the Project, Federal Republic Germany has been added as a Party involved in the Project.

Focal point:
The project participants agreed that CARBON CDM Korea Ltd. serves as focal point of communication with the Executive Board and the UNFCCC Secretariat.

Project applicant, developer and sponsor is **CARBON CDM Korea Ltd.** (furthermore called “CARBON”). CARBON CDM KOREA Ltd. is registered under the laws of the Republic of Korea. The company is a 100% daughter company of CARBON Projektentwicklung GmbH, Austria, and represents a foreign direct investment under the Foreign Investment Promotion Act (FIPA) of Korea. 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.

The RWE Group is one of Europe’s leading integrated electricity and gas companies. **RWE Power AG** is the continental power generation company within the RWE Group and Germany’s biggest power producer. RWE Power has a diverse generation portfolio including lignite, hard coal, nuclear energy, gas and renewable sources such as hydro, wind and biomass. RWE invests and participates actively in projects under the Clean Development Mechanism and Joint Implementation. The RWE team combines a track record in global commodities and emissions trading as well as risk management with broad experience and a deep understanding of specific risks inherent in CDM and JI projects.

Project Operator is **Hu-Chems Fine Chemical Corp.**. HU-CHEMS was established by separating from Nam-Hae chemical corporation in 2002. HU-CHEMS operates 14 production units which produce fine chemical products in its Yeosu, Jeonnam, industrial complex and provides excellent job conditions to its 254 employees. The company's headquarter is in Seoul.
HU-CHEMS is active in two major business areas, which are fine chemicals and biotechnology. The products are provided to major-chemicals companies in Korea as well as to world-wide major-chemical companies like Dupont and BASF on long term offtake contract basis. Nitric Acid is sold mainly to BASF, Rhodia Polyamide, Keumho Mitsui, POSCO and Hanhwa. The company is listed on the Korean Stock Exchange, KOSPI200, item code 069260, since September 17, 2002, with an aggregate value of stocks of KRW 85,377 million (end of 2005). Major shareholder is NACF with 56%. The rest of the shares are floating.
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.

Project Technology Provider is UHDE GmbH a 100% subsidiary of ThyssenKrupp. UHDE is world market leader in the field of fertilizer technology engineering and construction. Consequently, UHDE has constructed many modern fertilizer plants including nitric acid plants. Among these plants are the three Hu-Chems plants. In response to increasing concerns surrounding climate change and the destruction of the ozone layer, UHDE has developed catalyst-based processes for removing N_2O from nitric acid tail gas streams.

5 Baseline Methodology

The approved Baseline Methodology AM0028 Version 1 “Catalytic N_2O destruction in the tail gas of Nitric Acid Plants”; submitted by Carbon Projektentwicklung GmbH is applied to this project activity.

The use of the methodology is justified because the following statements are true:

- The methodology is applied to the existing production capacity installed no later than 31 December 2005.
- The three HU-CHEMS nitric acid plants have *not* installed any N_2O destruction or abatement technology prior to the start of the project activity. The project activity will not result in any shut down of an existing N_2O destruction or abatement facility at Hu-Chems II, III and IV.
- The project activity does not cause a nitric acid production increase.
- The project activity results in NO_x emission reductions that are at least as effective as the $DeNO_x$-units installed prior to the start of the project activity.
- The $DeNO_x$-units installed prior to the start of the project activity were SCR $DeNO_x$-units.
- The N_2O concentrations are measured in real time at the inlet and the outlet of the N_2O destruction facilities at Hu-Chems II, III and IV.

Project boundary

For the purpose of determining project activity emissions, the following emission sources are included:

- N_2O emissions in the tail gas downstream the project activity (Hu-Chems II, III, IV);
- CO_2 emissions associated with the use of propane as reducing agent, converted C_3H_8 (Hu-Chems II, III).

For the purpose of determining baseline emissions, the following emission sources are included:

- N_2O emissions in the tail gas upstream the project activity (Hu-Chems II, III, IV).

The following table illustrates, which emission sources are included and which are excluded from the project boundary for determination of both, baseline and project emissions.

Table 2: Overview on emission sources included or excluded from the project boundary

Baseline Emissions

Source	***Gas***		***Justification/Explanation***
Emissions of N_2O as a result of side reaction to the nitric acid production process	N_2O	Included	Main emission source, taking national N_2O emission regulations into account.

Emissions related to the production of ammonia used for NO_x reduction (Attention: Ammonia used for NO_x-reduction does not cause GHG emissions, only the production of ammonia causes GHG emissions)	CO_2 CH_4 N_2O	Excluded according to AM0028	In case of Hu-Chems II, III and IV SCR $DeNO_x$ units are already installed prior to the project start: ammonia input for SCR is considered to be of the same magnitude to project related ammonia input for NO_x reduction. Baseline emissions and project emissions are similar and therefore not considered for calculation.
N_2O emissions from SCR $DeNO_x$ unit	N_2O	Excluded according to AM0028	The presence of a SCR $DeNO_x$ unit tends to increase the N_2O emissions. Therefore the ex-post measurement of the baseline emissions at the inlet of the N_2O destruction facility represents a conservative determination of the baseline N_2O emissions.

Project Emissions

Source	***Gas***		***Justification/Explanation***
Emissions of N_2O as a result of side reaction to the nitric acid production process	N_2O	Included	Main emission source that remains in the tail gas after the N_2O destruction facility
Emissions related to the production of ammonia input used for NO_x reduction (Attention: Ammonia used for NO_x-reduction doesn't cause GHG emissions, only production causes GHG emissions)	CO_2 CH_4 N_2O	Excluded according to AM0028	In case of Hu-Chems II, III and IV SCR $DeNO_x$ units are already installed prior to the project start: ammonia input for SCR is considered of the same order as project related ammonia input for NO_x-reduction. Baseline emissions and project emissions are similar and therefore not considered for calculation. In case no SCR $DeNO_x$ unit is already installed prior to the project start: ammonia input for NO_x reduction is monitored and considered for project emissions.
In case of N_2O reduction process installed: Emissions at the project site resulting from hydrocarbons used as reducing agent	CO_2	Included	At Hu-Chems II and III a N_2O reduction process is installed and propane is used as reducing agent. Propane is used to enhance the efficiency of a N_2O catalytic reduction facility. In this case hydrocarbons are mainly converted to CO_2, while some hydrocarbons may remain intact. In order to apply a conservative approach propane is assumed to be completely converted to CO_2.
Emissions from Electricity demand	CO_2 CH_4	Excluded	GHG emissions related to the electricity consumption are insignificant (< 0.005%) and are excluded as

	N_2O		monitoring would lead to unreasonable costs.
Emissions related to the production of the hydrocarbons	CO_2 CH_4 N_2O	Excluded	GHG emissions related to the production of hydrocarbons used as reducing agent represent less than 0.001% of expected emission reductions and are not be taken into account due to unreasonable costs for monitoring.

The following figure shows the spatial extend of the project boundary.

Figure 1: Project boundary Hu-Chems II and Hu-Chems III

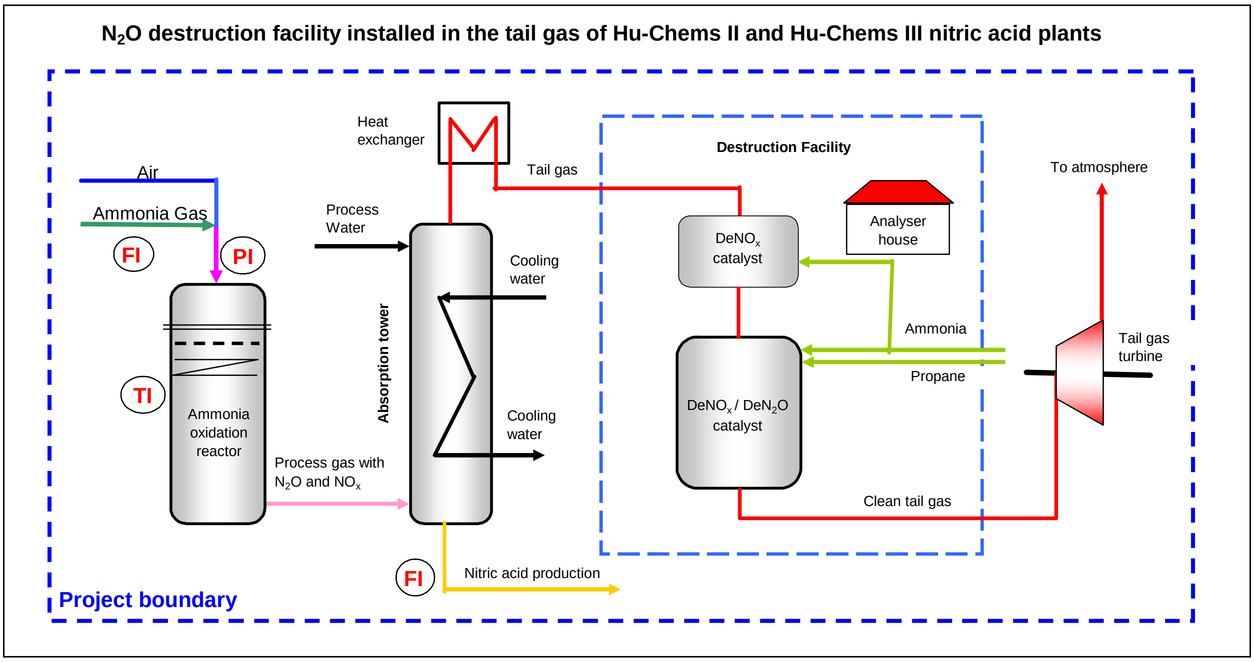
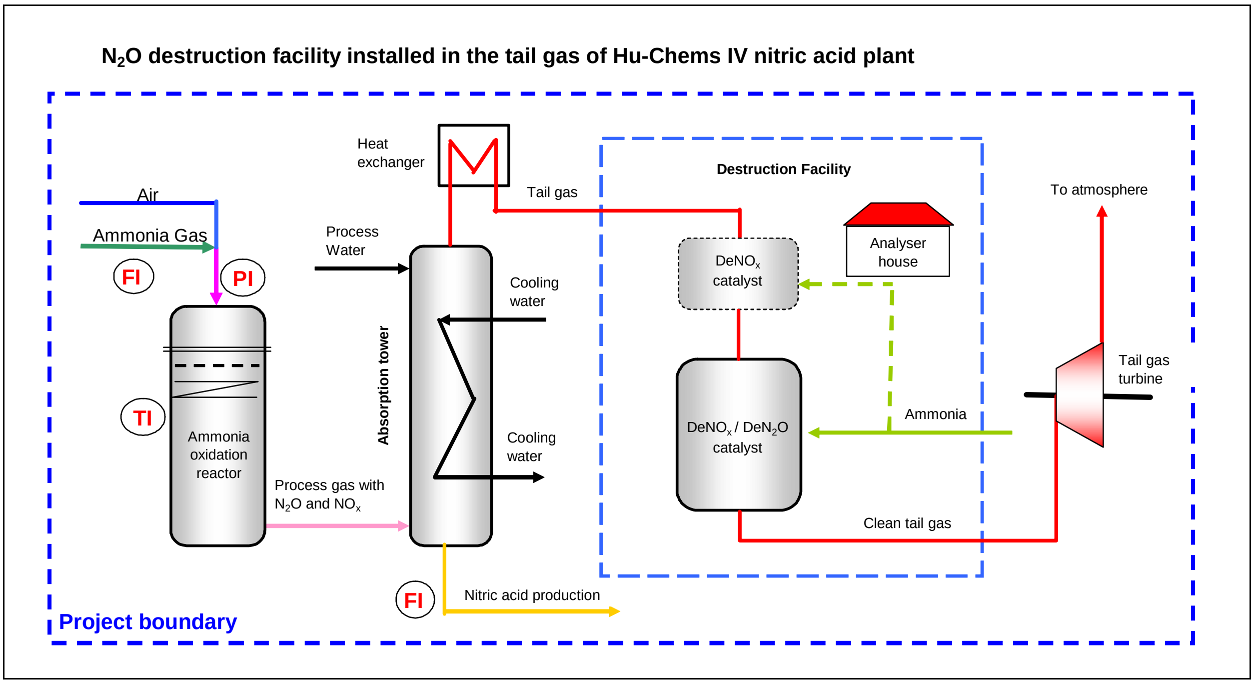


Figure 2: Project boundary Hu-Chems IV



6 Monitoring Methodology and Plan

The approved Monitoring Methodology AM0028 Version 1 “Catalytic N2O destruction in the tail gas of Nitric Acid Plants”; submitted by Carbon Projektentwicklung GmbH is applied to this project activity.

This approved Monitoring Methodology is applicable to project activities that destroy N_2O emissions either by catalytic decomposition or catalytic reduction of N_2O in the tail gas of nitric acid plants (i.e. tertiary destruction) This approved Monitoring Methodology was valid from March 3rd 2006 to October 5th 2006 (request for registration until November 30th 2006). The present project activity submitted the registration request form on November 16th 2006 and satisfies these applicability conditions.

Furthermore the use of the methodology is justified because the following statements are true:

- The methodology is applied to the existing production capacity installed no later than 31 December 2005.
- The three nitric acid plants Hu-Chems II, III and IV have not installed any N_2O destruction or abatement technology prior to the starting data of the project activity.
- The project activity did not cause a nitric acid production increase.
- The project activity results in NO_x emission reductions that are at least as effective as the existing $DeNO_x$-unit.
- The $DeNO_x$-units installed at Hu-Chems II, III and IV nitric acid plants were SCR $DeNO_x$-units.
- The N_2O concentrations are measured in real time at the inlet and the outlet of the N_2O destruction facilities at Hu-Chems II, III and IV.
- Relevant historical data and manufacturer information were available.
- The monitoring methodology is used in conjunction with the “Baseline Methodology for Catalytic N_2O destruction in the tail gas of Nitric Acid Plants”.

The data being collected in order to monitor GHG emissions from the project activity are described below and detailed in Annex 1 of the Monitoring Report.

Table 3: Description of Monitoring Data

Overall:

ID number	Data Variable	Source of data	Data unit	Recording Frequency
P1	PE_y Project emissions	Monitoring system	tCO_2e	Annual
P2	PE_ND,y Project emissions from N_2O not destroyed	Monitoring system	tCO_2e	Annual
P3	PE_DF,y Project emissions from destruction facility	Monitoring system	tCO_2e	Annual

Hu-Chems II:

ID number	Data Variable	Source of data	Data unit	Recording Frequency
P4	PE_y,II Project emissions	Monitoring system	tCO2e	Annual
P5	PE_ND,y,II Project emissions from N2O not destroyed	Monitoring system	tCO2e	Annual
P6	PE_DF,y,II Project emissions from destruction facility	Monitoring system	tCO2e	Annual

P7	PE_N2O,y,II N_2O not destroyed by facility	Monitoring system	tN_2O	Daily
P8	F_TG,I,II Volume flow tail gas at N_2O destruction facility	Flow meter	m^3/h	Daily
P9	CO_N2O,i ,II N_2O concentration at destruction facility outlet	Monitoring system, measuring device	tN_2O/Nm^3	Daily
P10	M_i,II Measuring Interval	Measuring device, data management system	H	Daily
P11	PE_HC,y,II Emissions from hydrocarbon use in destruction facility	Monitoring system	tCO_2e	Annual
P12	HCE_C,y,II Converted hydrocarbon emissions	Monitoring system	tCO_2e	Annual
P13	Q_HC,y,II Hydrocarbon input (reducing agent)	Measuring device	m^3	Daily
P14	ρ_HC,II Hydrocarbon density	Certificate hydrocarbon supplier or default value	t/m^3	Yearly
P15	EF_HC,II Hydrocarbon CO_2 emission factor	IPCC	tCO_2/t	Once
P16	OXID_HC,II Hydrocarbon oxidation factor	According to AM0028 OXID_HC,II is 100% (conservative approach)	%	Daily

P17	Type_HC,II Type of hydrocarbon	Hydrocarbon supplier	-	Once

Hu-Chems III:

ID number	Data Variable	Source of data	Data unit	Recording Frequency
P18	PE_y,III Project emissions	Monitoring system	tCO_2e	Annual
P19	PE_ND,y,III Project emissions from N_2O not destroyed	Monitoring system	tCO_2e	Annual
P20	PE_DF,y,III Project emissions from destruction facility	Monitoring system	tCO_2e	Annual
P21	PE_N2O,y,III N_2O not destroyed by facility	Monitoring system	tN_2O	Daily
P22	F_TG,I,III Volume flow tail gas at N_2O destruction facility	Flow meter	m^3/h	Daily
P23	CO_N2O,i ,III N_2O concentration at destruction facility outlet	Monitoring system, measuring device	tN_2O/Nm^3	Daily
P24	M_i,III Measuring Interval	Measuring device, data management system	H	Daily

P25	PE_HC,y,III Emissions from hydrocarbon use in destruction facility	Monitoring system	tCO_2e	Annual
P26	HCE_C,y,III Converted hydrocarbon emissions	Monitoring system	tCO_2e	Annual
P27	Q_HC,y,III Hydrocarbon input (reducing agent)	Measuring device	m^3	Daily
P28	ρ_HC,III Hydrocarbon density	Certificate hydrocarbon supplier or default value	t/m^3	Yearly
P29	EF_HC,III Hydrocarbon CO_2 emission factor	IPCC	tCO_2/t	Once
P30	OXID_HC,III Hydrocarbon oxidation factor	According to AM0028 OXID_HC,III is 100% (conservative approach)	%	Daily
P31	Type_HC,III Type of hydrocarbon	Hydrocarbon supplier	-	Once

Hu-Chems IV:

ID number	Data Variable	Source of data	Data unit	Recording Frequency
P32	PE_y,IV Project emissions	Monitoring system	tCO_2e	Annual

P33	PE_ND,y,IV Project emissions from N_2O not destroyed	Monitoring system	tCO_2e	Annual
P34	PE_DF,y,IV Project emissions from destruction facility	Monitoring system	tCO_2e	Annual
P35	PE_N2O,y,IV N_2O not destroyed by facility	Monitoring system	tN_2O	Daily
P36	F_TG,I,IV Volume flow tail gas at N_2O destruction facility	Flow meter	m³/h	Daily
P37	CO_N2O,i ,IV N_2O concentration at destruction facility outlet	Monitoring system, measuring device	tN_2O/ Nm³	Daily
P38	M_i,IV Measuring Interval	Measuring device, data management system	H	Daily

The data being collected in order to monitor baseline emissions are described below and detailed in Annex 1 of the Monitoring Report.

Hu-Chems II:

ID number	Data Variable	Source of data	Data unit	Recording Frequency
B1	P_HNO3,y,II Plant output of HNO_3	Production reports	$tHNO_3$	Daily

B2	QI_N2O,y,II Quantity of N_2O at inlet of destruction facility		tN_2O	Daily
B3	CI_N2O,I,II N_2O concentration at N_2O destruction facility inlet	Monitoring system, measuring device	tN_2O/Nm^3	Daily
B4	QR_N2O,y Regulation I: annual quantity N_2O limited	National legislation	tN_2O	Date of regulation
B5	RSE_N2O,y Regulation II: N_2O emissions per unit of nitric acid	National legislation	$tN_2O/t\ HNO_3$	Date of regulation
B6	CR_N2O Regulation III: N_2O concentration in tail gas limited	National legislation	tN_2O/m^3	Date of regulation
B7	P_HNO3,hist,II Design capacity	Manufacturer's specifications	T	Once
B8	T_g,hist,II Historical opera-ting temperature range of the ammonia oxidation reactor	Production reports / manufacturer's Specification	^oC	Once
B9	P_g,hist,II Historical operating pressure range of the ammonia oxidation reactor	Production reports / manufacturer's specifications	Pa	Once
B10	T_g,II Actual operating temperature ammonia oxidation reactor	Measuring device	^oC	Continuous
B11	P_g,II Actual operating pressure ammonia oxidation reactor	Measuring device	Pa	Continuous

B12	Reg_NOx National regulation on NO_x emissions	National regulations, Ministry of Environment	tNO_x/m^3	Date of regulation
B13	G_sup,II Supplier of the ammonia oxidation catalyst	Supplier's information	-	
B14	G_com,II Composition of the ammonia oxidation catalyst	Annual reports, supplier's information	%	Date of changing gauze composition
B15	G_sup,hist,II Historical supplier of ammonia oxidation catalyst	Annual reports, supplier's information	-	Once
B16	G_com,hist,II Historical composition of the ammonia oxidation catalyst	Supplier's information	%	Date of start of use of catalyst
B17	SE_N2O,II N_2O emission rate per ton of nitric acid	Monitoring reports	tN_2O/t HNO_3	Yearly
B18	A_OR,hist,II Max. historical ammonia flow rate to the ammonia oxidation reactor	Production reports / manufacturer's specifications / literature	tNH_3/day	Once
B19	A_OR,d,II Actual ammonia flow rate to the ammonia oxidation reactor	Measuring device	tNH_3/day	Continuous

Hu-Chems III:

ID number	Data Variable	Source of data	Data unit	Recording Frequency
B20	P_HNO3,y,III Plant output of HNO_3	Production reports	$tHNO_3$	Daily
B21	QI_N2O,y,III Quantity of N_2O at inlet of destruction facility		tN_2O	Daily
B22	CI_N2O,I,III N_2O concentration at N_2O destruction facility inlet	Monitoring system, measuring device	tN_2O/Nm^3	Daily
B23	T_g,hist,III Historical opera-ting temperature range of the ammonia oxidation reactor	Production reports / manufacturer's Specification	^oC	Once
B24	P_g,hist,III Historical operating pressure range of the ammonia oxidation reactor	Production reports / manufacturer's specifications	Pa	Once
B25	T_g,III Actual operating temperature ammonia oxidation reactor	Measuring device	^oC	Continuous
B26	P_g,III Actual operating pressure ammonia oxidation reactor	Measuring device	Pa	Continuous
B27	G_sup,III Supplier of the ammonia oxidation catalyst	Supplier's information	-	
B28	G_com,III Composition of the ammonia oxidation catalyst	Annual reports, supplier's information	%	Date of changing gauze composition

B29	G_sup,hist,III Historical supplier of ammonia oxidation catalyst	Annual reports, supplier's information	-	Once
B30	G_com,hist,III Historical composition of the ammonia oxidation catalyst	Supplier's information	%	Date of start of use of catalyst
B31	SE_N2O,III N_2O emission rate per ton of nitric acid	Monitoring reports	$tN_2O/t\ HNO_3$	Yearly
B32	A_OR,hist,III Max. historical ammonia flow rate to the ammonia oxidation reactor	Production reports / manufacturer's specifications / literature	tNH_3/day	Once
B33	A_OR,d,III Actual ammonia flow rate to the ammonia oxidation reactor	Measuring device	tNH_3/day	Continuous

<u>Hu-Chems IV:</u>

ID number	Data Variable	Source of data	Data unit	Recording Frequency
B34	P_HNO3,y,IV Plant output of HNO_3	Production reports	$tHNO_3$	Daily
B35	QI_N2O,y,IV Quantity of N_2O at inlet of destruction facility		tN_2O	Daily
B36	CI_N2O,I,IV N_2O concentration at N_2O destruction facility inlet	Monitoring system, measuring device	tN_2O/Nm^3	Daily

B37	P_HNO3,hist,IV Design capacity	Manufacturer's specifications	T	Once
B38	T_g,hist,IV Historical opera-ting temperature range of the ammonia oxidation reactor	Production reports / manufacturer's Specification	^{o}C	Once
B39	P_g,hist,IV Historical operating pressure range of the ammonia oxidation reactor	Production reports / manufacturer's specifications	Pa	Once
B40	T_g,IV Actual operating temperature ammonia oxidation reactor	Measuring device	^{o}C	Continuous
B41	P_g,IV Actual operating pressure ammonia oxidation reactor	Measuring device	Pa	Continuous
B42	G_sup,IV Supplier of the ammonia oxidation catalyst	Supplier's information	-	
B43	G_com,IV Composition of the ammonia oxidation catalyst	Annual reports, supplier's information	%	Date of changing gauze composition
B44	G_sup,hist,IV Historical supplier of ammonia oxidation catalyst	Annual reports, supplier's information	-	Once
B45	G_com,hist,IV Historical composition of the ammonia oxidation catalyst	Supplier's information	%	Date of start of use of catalyst
B46	SE_N2O,IV N_2O emission rate per ton of nitric acid	Monitoring reports	tN_2O/t HNO_3	Yearly

B47	A_OR,hist,IV Max. historical ammonia flow rate to the ammonia oxidation reactor	Production reports / manufacturer's specifications / literature	tNH_3/day	Once
B48	A_OR,d,IV Actual ammonia flow rate to the ammonia oxidation reactor	Measuring device	tNH_3/day	Continuous

7 Quality Control (QC) and Quality Assurance (QA)

7.1 Quality Management System

Project Operator is Hu-Chems Fine Chemical Corp. (HU-CHEMS). HU-CHEMS operates 14 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 CDM Korea is responsible for reporting of data under the CDM Project.

7.2 Quality Control and Quality Assurance procedures

The quality assurance and quality control procedures, in terms of equipment operations and maintenance, have been defined based on applicable international standards, as well as standards provided by technology provider. HU-CHEMS is certified under ISO 9001 and 14001 and applies appropriate QA & QC procedures.

The QC and QA procedures are set and implemented in order to:
1. secure a good consistency through planning to implementation of the CDM project and,
2. stipulate the responsibilities for operation and monitoring and,
3. avoid any misunderstanding between people and organizations involved.

7.2.1 Periodical observation of the automated monitoring system and Back-Up Plans for measuring systems

<u>EnviNOx® – Automatic DCS system:</u>
The EnviNOx® systems are 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 CDM Korea. 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 analysers 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 overall 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, Carbon CDM Korea 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. The contract was coming into force after the start-up period of the project activity. Health check reports and inspection visit reports are available and submitted to the DOE for verification.

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

In order to enable the highest level of availability and accuracy of instruments, Carbon CDM Korea 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 – 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.

Back Up – Certified test gases
Pressure levels of test gases used for the regular, automatic calibration of the inlet and outlet analysers 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 available and submitted 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 by Carbon CDM Korea was to ensure immediate response to such special events in the system.

The following table summarizes the periodical observations of the AMS.

Table 4: 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
Emerson Process Management Korea (EPMK)	Health check of AMS System	Monthly	Health Check Report
EPMK	Health Check of Instruments	Monthly	Health Check Report
EPMK	Inspection check of AMS System	Quarterly	Inspection Check Report

EPMK	Inspection check of Instruments	Quarterly	Inspection Report
UHDE	Supervision	Continuously	Plausibility Check

All resulting documents are analysed and evaluated by Carbon CDM Korea under supervision of Carbon Austria. In case of any upcoming problem or failure of the EnviNOx® system and/or the automated monitoring system Carbon CDM Korea 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.

7.2.2 Systematic measures for QA for monitoring data during AMS down times

In order to ensure data quality, back up plans (refer to 7.2.1) are in place. In case of (scheduled or unscheduled) AMS down times, demonstration of normal plant operation and estimation of emission reductions are conducted according to the PDD. The procedure how to determine the Emissions Reductions during AMS down times and to ensure suitability and conservativeness is a six-step approach. Related data and documents are provided to the DOE for verification, if applicable in the covered monitoring period:

(1) Demonstration, that Nitric Acid plant is under normal operation
Suitable operating parameters are provided, in order to demonstrate that the nitric acid plant is operating under normal conditions.

(2) Demonstration, that EnviNO$_X$® system is under normal operation
Suitable operating parameters are provided, in order to demonstrate that the EnviNO$_X$® system is operating under normal conditions.

(3) Correlation method
The systematic estimation of a missing parameter is based on correlation methods applying parameters historically correlating with the missing parameter (e.g. minimum historical efficiency of the EnviNO$_X$® system; the flow of N_2O reducing agent to the reactor; the tail gas volume flow, N_2O concentration etc.).

(4) Conservativeness check
Conservativeness is ensured by considering limiting values when determining the missing parameter. Such are minimum (or maximum) thresholds (depending on baseline or project emission determination) obtained from hours prior and after the AMS downtime.

(5) Recalculation
Determination of emission reductions for hours during AMS downtimes is based on the result of step (3) and step (4).

(6) Operation check
Operating parameters of the nitric acid plant and the EnviNOx® system are compared with values prior and after the AMS was out of operation or deactivated for maintenance reasons to ensure that those values are within a plausible range.

This multi-step approach guarantees a conservative estimation of Emissions Reductions during AMS downtimes.

7.3 Calibration and maintenance

The maintenance methods and procedures 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.

Records of conducted maintenance activities by Hu-Chems are available and submitted to the DOE for verification.

As pointed out in section 7.2, Carbon CDM Korea has contracted Emerson Process Management Korea to execute monthly on-site **Health Checks** and quarterly on-site **Inspection Visits**. System components, measurement devices and the automated monitoring system required for the monitoring of the CDM project are covered by these contracts. Service reports of conducted health checks, inspection visits and further maintenance activities and checks, respectively are available and submitted to the DOE for verification.

The sampling system is inspected regularly by Emerson Process Management Korea. Additionally, the most recent sample line check by applying test at the beginning of the sample line has been performed for all analysers of all three plants on the 29th June 2009 and showed positive results. Reports of these checks are made available to the DOE.

All measuring and analytical instruments are being calibrated as defined in the Approved Methodology AM0028. Calibration procedures have been incorporated in Hu-Chems Quality Management System and Procedures. All relevant instruments have been calibrated accordingly.

Carbon CDM Korea has mandated Emerson Process Management Korea to execute additional calibration & health check services to ensure accuracy of all monitoring instruments related to the CDM Project. These additional services consist of calibration verification, diagnostic tests, zero and span status checks as well as check of the electrical connections and component status.

Service reports of conducted additional calibration & health check services and calibration certificates of new installed instruments are made available to the DOE.

Table 5: Instrument overview – Hu-Chems II

Hu-Chems Plant II - EnviNOx® Monitoring Instruments		
Instrument	**TAG Number**	**Latest service applied**
EnviNOx® Inlet Analyser (NDIR)	322-AI-2-0125	31/03/2010 – Monthly Health Check Service (Emerson)
EnviNOx® Outlet Analyser (NDIR)	322-AI-2-0127	31/03/2010 – Monthly Health Check Service (Emerson)
Tail Gas Flow (Differential Pressure Transmitter)	322-FT-2-5130B	19/03/2009 – Installation of new instrument
Tail Gas Flow (Differential Pressure Transmitter)	322-FT-2-5184B	19/03/2009 – Installation of new instrument
Tail Gas Pressure (Pressure Transmitter)	322-PT-2-3133	19/03/2009 – Installation of new instrument
Tail Gas Pressure (Pressure Transmitter)	322-PT-2-3134	19/03/2009 – Installation of new instrument

Tail Gas Temperature (Temperature Transmitter)	322-TT-2-1136	19/03/2009 – Installation of new instrument
Tail Gas Temperature (Temperature Transmitter)	322-TT-2-1137	19/03/2009 – Installation of new instrument
Propane Flow (Flowmeter)	322-FT-2-5121	18/03/2009 – Installation of new instrument
Propane Temperature (Temperature Transmitter)	322-TT-2-1119	10/03/2009 – Calibration Service (Emerson)
Propane Pressure (Pressure Transmitter)	322-PT-2-3118	30/12/2008 – Calibration Service (Emerson)
Hu-Chems Plant II - Nitric Acid Plant Monitoring Instruments		
Instrument	**TAG Number**	**Latest service applied**
Ammonia Flow (Flowmeter)	322-FT-2-503	09/09/2009 – Installation of new instrument
Ammonia Temperature (Temperature Transmitter)	322-TT-2-103	09/09/2009 – Installation of new instrument
Ammonia Pressure (Pressure Transmitter)	322-PT-2-303	09/09/2009 – Installation of new instrument
Pressure in AOR (Pressure Transmitter)	322-PT-2-304	12/05/2009 – Calibration Service (Emerson)
Temperature in AOR (Temperature Transmitter)	322-TT-2-115	07/01/2010 – Installation of new thermoelement
Temperature in AOR (Temperature Transmitter)	322-TT-2-116	07/01/2010 – Installation of new thermoelement
Nitric Acid Flow (Flowmeter)	322-FT-2-512	09/09/2009 – Installation of new instrument

Table 6: Instrument overview – Hu-Chems III

Hu-Chems Plant III - EnviNOx® Monitoring Instruments		
Instrument	**TAG Number**	**Latest service applied**
EnviNOx® Inlet Analyser (NDIR)	323-AI-3-0125	31/03/2010 – Monthly Health Check Service (Emerson)
EnviNOx® Outlet Analyser (NDIR)	323-AI-3-0127	31/03/2010 – Monthly Health Check Service (Emerson)
Tail Gas Flow (Differential Pressure Transmitter)	323-FT-3-5130B	29/12/2008 – Calibration Service (Emerson)
Tail Gas Flow (Differential Pressure Transmitter)	323-FT-3-3184B	29/12/2008 – Calibration Service (Emerson)
Tail Gas Pressure (Pressure Transmitter)	323-PT-3-3133	29/12/2008 – Calibration Service (Emerson)
Tail Gas Pressure (Pressure Transmitter)	323-PT-3-3134	29/12/2008 – Calibration Service (Emerson)
Tail Gas Temperature (Temperature Transmitter)	323-TT-3-1136	09/03/2009 – Calibration Service (Emerson)
Tail Gas Temperature (Temperature Transmitter)	323-TT-3-1137	09/03/2009 – Calibration Service (Emerson)
Propane Flow (Flowmeter)	323-FT-3-5121	07/05/2009 – Installation of new instrument
Propane Temperature (Temperature Transmitter)	323-TT-3-1119	09/03/2009 – Calibration Service (Emerson)
Propane Pressure (Pressure Transmitter)	323-PT-3-3118	29/12/2008 – Calibration Service (Emerson)
Hu-Chems Plant III - Nitric Acid Plant Monitoring Instruments		
Instrument	**TAG Number**	**Latest service applied**
Ammonia Flow (Flowmeter)	323-FT-3-503	13/08/2009 – Installation of new instrument
Ammonia Temperature (Temperature Transmitter)	323-TT-3-103	13/08/2009 – Installation of new instrument
Ammonia Pressure (Pressure Transmitter)	323-PT-3-303	13/08/2009 – Installation of new instrument
Pressure in AOR (Pressure Transmitter)	323-PT-3-304	09/05/2009 – Calibration Service (Emerson)
Temperature in AOR (Temperature Transmitter)	323-TT-3-115	10/02/2010 – Installation of new thermoelement
Temperature in AOR (Temperature Transmitter)	323-TT-3-116	10/02/2010 – Installation of new thermoelement
Nitric Acid Flow (Flowmeter)	323-FT-3-512	10/02/2010 – Installation of new instrument

Table 7: Instrument overview – Hu-Chems IV

Hu-Chems Plant IV - EnviNOx® Monitoring Instruments		
Instrument	**TAG Number**	**Latest service applied**
EnviNOx® Inlet Analyser (NDIR)	324-AI-4-0108	31/03/2010 – Monthly Health Check Service (Emerson)
EnviNOx® Outlet Analyser (NDIR)	324-AI-4-0107	31/03/2010 – Monthly Health Check Service (Emerson)
Tail Gas Flow (Differential Pressure Transmitter)	324-FT-4-4115B	29/01/2009 – Calibration Service (Emerson)
Tail Gas Flow (Differential Pressure Transmitter)	324-FT-4-4116B	29/01/2009 – Calibration Service (Emerson)
Tail Gas Pressure (Pressure Transmitter)	324-PT-4-3113	29/01/2009 – Calibration Service (Emerson)
Tail Gas Pressure (Pressure Transmitter)	324-PT-4-3114	29/01/2009 – Calibration Service (Emerson)
Tail Gas Temperature (Temperature Transmitter)	324-TT-4-1111	29/01/2009 – Calibration Service (Emerson)
Tail Gas Temperature (Temperature Transmitter)	324-TT-4-1112	29/01/2009 – Calibration Service (Emerson)
Hu-Chems Plant IV - Nitric Acid Plant Monitoring Instruments		
Instrument	**TAG Number**	**Latest service applied**
Ammonia Flow (Flowmeter)	324-FT-4-5020	21/10/2009 – Installation of new instrument
Pressure in AOR (Pressure Transmitter)	324-PT-4-305A	29/01/2009 – Calibration Service (Emerson)
Pressure in AOR (Pressure Transmitter)	324-PT-4-305B	29/01/2009 – Calibration Service (Emerson)
Temperature in AOR (Temperature Transmitter)	324-TT-4-106A	21/10/2009 – Installation of new thermoelement
Temperature in AOR (Temperature Transmitter)	324-TT-4-106C	21/10/2009 – Installation of new thermoelement
Nitric Acid Flow (Flowmeter)	324-FT-4-609	21/10/2009 – Installation of new instrument

7.4 Plausibility Check

Continuous Monitoring of N_2O concentrations (i.e. CI_N2O,i and CO_N2O,i for all three plants) is done according to the Monitoring Plan in the PDD. Plausibility is regularly checked by laboratory measurement of N_2O concentrations, using Gas Chromatography. Results of laboratory measurements are made available to the DOE for verification.

7.5 Environmental Impacts

According to Article 4 of the Korean Environmental Impact Assessment Law and the item 3 of the Article 2 of its Enforcement Ordinance, no EIA was required for the project activity.
NO_x emissions are measured at the outlet of the EnviNOx® systems.

The continuous measurement of the NO_x concentration reports the following concentrations:

- Hu-Chems II: 4.7 ppm
- Hu-Chems III: 2.4 ppm
- Hu-Chems IV: 23.4 ppm

7.6 Social Fund

As described in the PDD a social fund was established by the project developer and the project operator. This fund will contribute to the social benefit of the people living in the area of the project activity by financing projects and social activities. The contribution to the Social Fund in 2009 was about 583,000,000 Korean WON, equivalent to about 320,000 Euro. Projects and Organizations supported by the CDM Social Fund are the Yeodo Academy, the Endowment of In-Company welfare fund and the Sang am village fund. The Yeodo Academy intends to improve the basic elementary and secondary education and the objective of the Welfare Fund is to contribute to working employees' life stabilization and welfare improvement.

- Social Fund 2007: 250,931,278 WON (~ 150,000 Euro)
- Social Fund 2008: 854,902,652 WON (~ 530,000 Euro)
- Social Fund 2009: 582,706,027 WON (~ 320,000 Euro)

8 GHG Calculation

In terms of the Approved Methodology (AM0028 / Version 1), the emission reduction (ER_y) by the project activity during a given period *y* is the difference between the baseline emissions (BE_y), project emissions (PE_y) and leakage emissions (LE_y), as follows:

ER_y = BE_y – PE_y – LE_y **(26)**

where:

ER_y	Emissions reductions of the project activity during the year *y* (tCO_2e)
BE_y	Baseline emissions during the year y (tCO_2e)
PE_y	Project emissions during the year y (tCO_2e)
LE_y	Leakage emissions in year y (tCO_2e)

Project Emissions:

The emissions due to the project activity are composed of (a) the emissions of not destroyed N_2O and (b) emissions from auxiliary hydrocarbons input resulting from the operation of the EnviNOx® systems at Hu-Chems II and III.

N_2O emissions not destroyed by the project activity are calculated based on the continuous measurement of the N_2O concentration in the tail gas of the EnviNOx® systems and the volume flow rates of the tail gas streams. The emissions related to the operation of the N_2O destruction facility are given by on-site emissions due to the hydrocarbons used as input to the EnviNOx® systems (Hydrocarbons are used in plant Hu-Chems II and Hu-Chems III only. No hydrocarbons are used in plant Hu-Chems IV).

PE_y = PE_y,II + PE_y,III + PE_y,IV **(27)**

e.g.

PE_y,II = PE_ND,y,II + PE_DF,y,II **(28)**

where:

PE_y	Project emissions in year y (tCO_2e)
PE_y,II	Project emissions Hu-Chems II in year y (tCO_2e)
PE_y,III	Project emissions Hu-Chems III in year y (tCO_2e)
PE_y,IV	Project emissions Hu-Chems IV in year y (tCO_2e)
PE_ND,y	Project emissions from N_2O not destroyed in year y(tCO_2e)
PE_DF,y	Project emissions related to the operation of the destruction facility in year y (tCO_2e)
PE_ND,y,II	Project emissions from N_2O not destroyed in year y Hu-Chems II (tCO_2e)
PE_ND,y,III	Project emissions from N_2O not destroyed in year y Hu-Chems III (tCO_2e)
PE_ND,y,IV	Project emissions from N_2O not destroyed in year y Hu-Chems IV (tCO_2e)
PE_DF,y,II	Project emissions from the operation of the destruction facility in year y Hu-Chems II (tCO_2e)
PE_DF,y,III	Project emissions from the operation of the destruction facility in year y Hu-Chems III (tCO_2e)
PE_DF,y,IV	Project emissions from the operation of the destruction facility in year y Hu-Chems IV (tCO_2e)

PE_y,II = PE_ND,y,II + PE_DF,y,II = [2,519 tCO2e + 227 tCO2e]

= PE_N2O,y,II x GWP_N2O + PE_HC,y,II =

= $\sum_i^n F\_TG,i,II$ x CO_N2O,i,II x M_i,II x GWP_N2O + HCE_C,y,II =

= $\sum_i^n F\_TG,i,II$ x CO_N2O,i,II x M_i,II x GWP_N2O +

ρ_HC,II x Q_HC,y,II x EF_HC,II x OXID_HC,II/100 =

= 2,746 tCO2e

PE_y,III = PE_ND,y,III + PE_DF,y,III = [2,009 tCO2e + 258 tCO2e]

= PE_N2O,y,III x GWP_N2O + PE_HC,y,III =

= $\sum_i^n F\_TG,i,III$ x CO_N2O,i,III x M_i,III x GWP_N2O + HCE_C,y,III =

= $\sum_i^n F\_TG,i,III$ x CO_N2O,i,III x M_i,III x GWP_N2O +

ρ_HC,III x Q_HC,y,III x EF_HC,III x OXID_HC,III/100 =

= 2,267 tCO_2e

PE_y,IV = PE_ND,y,IV + PE_DF,y,IV = [3,449 tCO2e + 0 tCO2e]

= PE_N2O,y,IV x GWP_N2O =

= $\sum_i^n F\_TG,i,IV$ x CO_N2O,i,IV x M_i,IV x GWP_N2O =

= **3,449 tCO_2e**

PE_y = PE_y,II + PE_y,III + PE_y,IV = [2,746 tCO2e + 2,267 tCO2e + 3,449 tCO2e]

= 8,462 tCO_2e

Project emissions are limited to the design capacity of the nitric acid plant. According to AM0028 the design capacity is measured in tons of nitric acid per year. The actual nitric acid production in the covered monitoring period does not exceed the design capacity.

Baseline Emissions:

It has been checked that there are no Korean regulations in place that would limit the quantity of N_2O that can be taken into account for the calculation of baseline emissions. Baseline emissions of the project activity are determined based on the quantity of N_2O emitted in the baseline scenario, taking national regulations, production levels and operating conditions into consideration. The quantity of N_2O is determined based on the measurements of the N_2O at the inlet of the EnviNOx®-Systems.

BE_y = BE_y,II + BE_y,III + BE_y,IV = BE_N2O,y x GWP_N2O **(29)**

e.g.
BE_y,II = BE_N2O,II x GWP_N2O **(30)**

where:

BE_y	Baseline emissions in year y (tCO_2e)
BE_y,II	Baseline emissions Hu-Chems II in year y (tCO_2e)
BE_y,III	Baseline emissions Hu-Chems III in year y (tCO_2e)
BE_y,IV	Baseline emissions Hu-Chems IV in year y (tCO_2e)
BE_N2O,y	Baseline emissions of N_2O in year y (tN_2O)
GWP_N2O	Global warming potential of N_2O = 310
BE_N2O,II	Baseline emissions of N_2O in year y at Hu-Chems II (tN_2O)
BE_N2O,III	Baseline emissions of N_2O in year y at Hu-Chems III (tN_2O)
BE_N2O,IV	Baseline emissions of N_2O in year y at Hu-Chems IV (tN_2O)

BE_y,II = BE_N2O,y,II x GWP_N2O = [316.69 tN2O x 310 tCO2e / tN2O]

= $\sum_i^n F\_TG,i,II$ x CI_N2O,i,II x M_i,II x GWP_N2O =

= **98,175 tCO_2e**

BE_y,III = BE_N2O,y,III x GWP_N2O = [333.23 tN2O x 310 tCO2e / tN2O]

= $\sum_i^n F\_TG,i,III$ x CI_N2O,i,III x M_i,III x GWP_N2O =

= **103,301 tCO2e**

BE_y,IV = BE_N2O,y,IV x GWP_N2O = [640.71 tN2O x 310 tCO2e / tN2O]

= $\sum_i^n F\_TG,i,IV$ x CI_N2O,i,IV x M_i,IV x GWP_N2O =

= **198,621 tCO2e**

BE_y = BE_y,II + BE_y,III + BE_y,IV = [98,175 tCO2e + 103,301 tCO2e + 198,621 tCO2e]

= **400,097 tCO2e**

Baseline emissions are limited to the design capacities of the nitric acid plants. According to AM0028 the design capacity is measured in tons of nitric acid per year. The actual nitric acid production in the covered monitoring period does not exceed the design capacity.

Leakage Emissions:

As described the project activity does not result in any relevant leakage emission, therefore:

LE_y = 0 **(31)**

Emission Reduction:

The total emission reduction achieved by this project activity during the monitoring period is therefore:

ER_y = BE_y – PE_y – LE_y **(32)**

= 400,097 tCO2e – 8,462 tCO2e – 0 =

= **391,635 tCO2e**

The above emission reductions cover the monitoring period from **01/01/2010** to **31/03/2010**.

Calculation of Project and Baseline Emission parameters (valid for all three EniNOx® systems)

Applied Steps

1. The "DeltaV" automatic measuring system (AMS) used for plant operation & CDM Monitoring was designed by the company Emerson, the overall supplier of components related to the monitoring system.
2. The DeltaV System automatically takes average concentrations from the continuously measuring analysers every 10 seconds.
3. Based on these concentrations and corresponding flows, relevant Project and Baseline Emission Parameters are calculated by the DeltaV System every 10 seconds.
4. The DeltaV Continuous Historian captures and stores the time-series parameter values from the run-time DeltaV system.

5. The DeltaV System generates daily DeltaV Reports, where averages (concentrations) and totals (Flows, Project/Baseline emission parameters) of the collected values over one day are contained, as required by the PDD.
6. Finally, based on these daily DeltaV Reports, calculation of Emission Reductions is conducted. A comprehensive overview overview on monitoring data and calculation of Emission Redutions is made available to the DOE for verification.

Due to the calculation at a very early stage (10 seconds basis), a highly representative and accurate calculation is achieved, since calculations which are based on concentrations and volume flows are not adulterated due to big calculation intervals.
This approach and all implemented formulas in the Delta V system fully comply with the approved Monitoring Methodology AM0028 Version 1 “Catalytic N_2O destruction in the tail gas of Nitric Acid Plants” and the respective, registered PDD.

Plausibility Check
In order to assess the automatic calculation of Project and Baseline Emission Parameters in the DeltaV system, a plausibility check was performed. For that purpose, the calculation of Project and Baseline Emission Parameters has been conducted manually, based on daily average and total values and using the same formulas implemented in the DeltaV system. The result clearly shows plausible data with only slight variations (Hu-Chems II: 0.001%; Hu-Chems III 0.001%; Hu-Chems IV: 0.003%) in the Emission Reduction calculation. Anyway, calculations with average concentrations on a daily basis compared to calculations on a 10 second basis do not represent the most accurate way to calculate Emission Reductions.

Conclusion
Applied ER calculations on a 10 seconds basis guarantee a highly representative and accurate (almost real time) approach. The applied approach is in full compliance with methodology AM0028 Version 1 and respective, registered PDD. Plausibility Check is to prove correct and transparent application of formulas and clearly shows plausible data.

Comparison of actual emission reductions with ex-ante emission reduction estimation in PDD:

Table 8: Comparison of emission reductions with PDD values – Hu-Chems II

Comparison of ER with PDD values: Hu-Chems II	
Source	**Value**
Emission reduction estimation according to PDD (one year)	329,397 tCO2e
Corresponding PDD estimation (over 90 days)	81,221 tCO2e
Actual calculation of emission reduction in monitoring period (over 90 days)	95,429 tCO2e

The excess of the actual emission reduction during the monitoring period compared to the corresponding ex-ante estimation according to the PDD in nitric acid plant II is caused by following reasons:

- For the PDD calculation, a destruction rate of [94.00%] was used, the actual destruction rate reaches an average level of about [97.43%];
- Due to the absence of actual values, an inlet concentration of [3.5E-06 tN_2O / Nm^3] for baseline emission estimation in the PDD was used. Actual concentrations measured reach an average level of [3.9E-06 tN_2O / Nm^3] and therefore lead to higher baseline emissions;

It should be noted that the ex-ante estimation of emissions reductions in the PDD was generally based on conservative assumptions.

Table 9: Comparison of emission reductions with PDD values – Hu-Chems III

Comparison of ER with PDD values: Hu-Chems III	
Source	**Value**
Emission reduction estimation according to PDD (one year)	329,397 tCO2e
Corresponding PDD estimation (over 90 days)	81,221 tCO2e
Actual calculation of emission reduction in monitoring period (over 90 days)	101,034 tCO2e

The excess of the actual emission reduction during the monitoring period compared to the corresponding ex-ante estimation according to the PDD in nitric acid plant II is caused by following reasons:

- For the PDD calculation, a destruction rate of [94.00%] was used, the actual destruction rate reaches an average level of about [98.06%];
- Due to the absence of actual values, an inlet concentration of [3.5E-06 tN_2O / Nm^3] for baseline emission estimation in the PDD was used. Actual concentrations measured reach an average level of [3.8E-06 tN_2O / Nm^3] and therefore lead to higher baseline emissions;
- Due to the absence of tail gas flow measurement, the tail gas flow used for emission reduction determination in the PDD was estimated with [41,000 Nm^3 / h]. Actual flows measured reach an average level of [41,777 Nm^3 / h] and therefore contribute to a higher emission reduction than estimated.

It should be noted that the ex-ante estimation ER of emissions reductions in the PDD was generally based on conservative assumptions.

Table 10: Comparison of emission reductions with PDD values – Hu-Chems IV

Comparison of ER with PDD values: Hu-Chems IV	
Source	**Value**
Emission reduction estimation according to PDD (one year)	621,634 tCO2e
Corresponding PDD estimation (over 90 days)	153,280 tCO2e
Actual calculation of emission reduction in monitoring period (over 90 days)	195,172 tCO2e

The excess of the actual emission reduction during the monitoring period compared to the corresponding ex-ante estimation according to the PDD in nitric acid plant IV is caused by following reasons:

- For the PDD calculation, a destruction rate of [94.00%] was used, the actual destruction rate reaches an average level of about [98.26%];
- Due to the absence of actual values, an inlet concentration of [1.7E-06 tN_2O / Nm^3] for baseline emission estimation in the PDD was used. Actual concentrations measured reach an average level of [1.9E-06 tN_2O / Nm^3] and therefore lead to higher baseline emissions;
- Due to the absence of tail gas flow measurement, the tail gas flow used for emission reduction determination in the PDD was estimated with [149,675 Nm^3 / h]. Actual flows measured reach an average level of [156,700 Nm^3 / h] and therefore contribute to a higher emission reduction than estimated.

It should be noted that the ex-ante estimation of emissions reductions in the PDD was generally based on conservative assumptions.

9 Check against baseline requirements

In order to avoid that the operation of the nitric acid production plant is manipulated in a way to increase the N_2O generation, thereby increasing the CERs, actual operating conditions have been checked against the baseline requirements.

Operating temperature:
In each nitric acid plant, the temperature in the ammonia oxidation reactor (AOR) is monitored by three thermocouples, whereas in each case two thermocouples are used for the CDM project. The operating temperatures in the AOR are automatically collected and transferred to the Delta-V distributed control system (Delta-V system) serving the CDM project. Based on these two thermocouples, the Delta-V system automatically calculates and reports the daily average temperature. Subsequently, the Delta-V system generates daily reports including the daily average AOR temperature.

The data from the daily reports generated by the Delta-V system are transferred to excel sheets (one for each nitric acid plant) in order to present all parameters as required by AM0028 in an overall format. These files also include the daily average values of the ammonia oxidation temperatures and an automatic check of each daily average value in order to see if the operation has been within the permitted operating ranges.

The actual average daily operating temperatures in the three ammonia oxidation reactors are within the permitted ranges for all days covered by this monitoring report.

Operating pressure:
The operating pressure representing the pressure in the ammonia oxidation reactors (AOR) are measured in the primary air supply lines of the three nitric acid plants. The operating pressures are automatically collected and transferred to the Delta-V distributed control system (Delta-V system), serving the CDM project.. Subsequently, the Delta-V system generates daily reports including the daily average AOR pressure.

The data from the daily reports generated by the Delta-V system are transferred to excel sheets (one for each nitric acid plant) in order to present all parameters as required by AM0028 in an overall format. These files also include the daily average values of the ammonia oxidation pressures and an automatic check of each daily average value in order to see if the operation has been within the permitted operating ranges.

The actual average daily operating pressures in the three ammonia oxidation reactors are within the permitted ranges for all days covered by this monitoring period.

Ammonia flow rate to the ammonia oxidation reactor:

The ammonia inlet flows to the ammonia oxidation reactors (AOR) are monitored by flow meters and automatically collected and transferred to the Delta-V distributed control system (Delta-V system) serving the CDM project. The Delta-V system generates daily reports including daily ammonia input to the AOR.

The data from the daily reports generated by the Delta-V system are transferred to excel sheets (one for each nitric acid plant) in order to present all parameters as required by AM0028 in an overall format. These files also include the total daily ammonia inlet flows and an automatic check of each daily value in order to see if the operation has been within the permitted operating ranges.

The daily ammonia input to the three ammonia oxidation reactors are within the permitted ranges for all days covered by this monitoring report.

HNO3 production:

The nitric acid produced (recorded as 100% nitric acid) is determined from the volume flow measured with flow meters. The hourly volume flow rate is available from the Hu-Chems Fine Chemical distributed control system (DCS).

The concentration and density of the acid is determined by laboratory analysis three times daily. The daily average of the nitric acid concentration and density are calculated and used for the specific day.

The nitric acid production in tons 100% concentration is manually calculated from the volume flow, density and concentration of the acid and manually transferred to the DCS and serving the CDM project. The DCS generates daily reports including the daily nitric acid production.

The data from the daily reports generated by the DCS are transferred to excel sheets (one for each nitric acid plant) in order to present all parameters as required by AM0028 in an overall format. These files also include the daily 100% nitric acid production.

The plausibility of HNO_3 production data is regularly checked for all three nitric acid plant. During the actual monitoring period, the conversion rates of ammonia nitrogen to nitric acid are within plausible ranges in all three nitric acid plants.

The nitric acid production in all three nitric acid plants is within the permitted range.

Table 11: Summary of Nitric Acid Production

Nitric Acid plant	Hu-Chems II	Hu-Chems III	Hu-Chems IV
Data unit	$tHNO_3$	$tHNO_3$	$tHNO_3$
Nitric Acid produced from 22nd of January 2009* until 21st January 2010	**84,434**	**92,985**	**424,070**
Nitric Acid produced from 22nd of January 2010* until 31st March 2010**	**20,150**	**20,380**	**85,508**
Limit of annual Nitric Acid Production according to PDD	**116,800**	**116,800**	**467,200**

*The starting date of the crediting period was the 22nd of January 2007.
**The end date of the covered monitoring period is the 31st of March 2010

<u>Composition of the ammonia oxidation catalyst:</u>
The composition of the ammonia oxidation catalyst is the same kind of catalyst composition already in operation prior to the start of the project activity. Evidence on compliance of supplier and composition with historical data is made available to the DOE during verification.

Table 12: Summary on installed catalyst gauzes

Nitric Acid plant	Hu-Chems II	Hu-Chems III	Hu-Chems IV
Installation date	29/09/2009 07/01/2010	12/11/2009 10/02/2010	21/10/2009
Supplier of currently installed gauzes	Johnson Matthey	Johnson Matthey	Johnson Matthey
Composition of currently installed gauzes	90%Pt, 5%Rh, 5%Pd	90%Pt, 5%Rh, 5%Pd	95%Pt, 5%Rh
Historical supplier of gauzes	Johnson Matthey and/or Umicore	Johnson Matthey and/or Umicore	Johnson Mattthey and/or Umicore
Historical composition of gauzes	90%Pt, 5%Rh, 5%Pd	90%Pt, 5%Rh, 5%Pd	95%Pt, 5%Rh and/or 92%Pt, 8%Rh

10 Downtimes & observations during the monitoring period

10.1 Downtimes of Nitric Acid Plants

During the below mentioned periods, the Nitric Acid Plants were out of operation due to the given reasons.

Table 13 - Downtimes of the nitric acid plants

Nitric Acid Plant downtimes					
Plant	Downtime - Start		Downtime - End		Downtime Reason
Plant 2	Date	Time	Date	Time	Description
2	07.01.2010	02:00	08.01.2010	09:00	Exchange of Ammonia Oxidation Catalyst
2	28.01.2010	02:00	28.01.2010	09:00	Emergency Shut-Down: Compressor Malfunction
2	16.03.2010	09:00	17.03.2010	06:00	Emergency Shut-Down: Malfunction of instrument air compressor
Plant 3	Date	Time	Date	Time	Description
3	10.02.2010	04:00	11.02.2010	04:00	Exchange of Ammonia Oxidation Catalyst
3	16.03.2010	09:00	16.03.2010	20:00	Emergency Shut-Down: Malfunction of instrument air compressor
Plant 4	Date	Time	Date	Time	Description
4	16.03.2010	09:00	16.03.2010	14:00	Emergency Shut-Down: Malfunction of instrument air compressor

10.2 Downtimes of EnviNOx® Systems

During the below mentioned periods, the EnviNOx® Systems were out of operation due to the given reasons. No Emission Reduction is claimed during these downtimes.

Table 14 - Downtimes of the EnviNOx® Systems

EnviNOx® System downtimes					
Plant	Downtime - Start		Downtime - End		Downtime Reason
Plant 2	Date	Time	Date	Time	Description
2	06.01.2010	20:00	08.01.2010	12:00	Shutdown of NA Plant (Exchange of Ammonia Oxidation Catalyst)
2	28.01.2010	02:00	28.01.2010	14:00	Shutdown of NA Plant (Compressor Malfunction)
2	16.03.2010	09:00	17.03.2010	09:00	Shutdown of NA Plant (Malfunction of instrument air compressor)
2	20.03.2010	13:00	20.03.2010	19:00	Shutdown of EnviNOx System (valve malfunction(FV-0108))
Plant 3	Date	Time	Date	Time	Description
3	09.02.2010	19:00	11.02.2010	06:00	Shutdown of NA Plant (Exchange of Ammonia Oxidation Catalyst)
3	16.03.2010	09:00	17.03.2010	01:00	Shutdown of NA Plant (Malfunction of instrument air compressor)
Plant 4	Date	Time	Date	Time	Description
4	16.03.2010	09:00	16.03.2010	14:00	Shutdown of NA Plant (Malfunction of instrument air compressor)

10.3 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.

EnviNOx® System at Nitric Acid Plants #2, #3 and #4:
Between the 12th January 2010 and 18th January 2010, engineers from Emerson Germany and Emerson Korea have jointly performed a programmed, extended general maintenance service of the inlet analyzers and the outlets analyzer of all three EnviNOx® Systems. This service was already longer-term scheduled in order to apply best available quality standards as recommended by the supplier of the AMS and was not conducted upon any AMS malfunction. In the course of the maintenance works, the inlet analyzers and the outlet analyzers have occasionally been deactivated:

During the downtimes of the analyzers, the nitric acid plants as well as the EnviNOx® systems were in normal operation and Emissions Reductions have been conservatively determined as described in section 7.2.2 of this Monitoring Report, fully in line with the applied methodology and the registered PDD.

Annex 1

Data and parameter monitored Hu-Chems:

Data / Parameter:	**PE_y**
Data unit:	tCO_2e
Description:	Project emissions
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculation
Value monitoring period:	**8,462 tCO_2e**

Data / Parameter:	**PE_ND,y**
Data unit:	tCO_2e
Description:	Project emissions from N_2O not destroyed
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculation
Value monitoring period:	**7,977 tCO_2e**

Data / Parameter:	**PE_DF,y**
Data unit:	tCO_2e
Description:	Project emissions from destruction facility
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculation
Value monitoring period:	**485 tCO_2e**

Data / Parameter:	**BE_y**
Data unit:	tCO_2e
Description:	Baseline emissions
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculation
Value monitoring period:	**400,097 tCO_2e**

Data / Parameter:	**REG_NOx**
Data unit:	$tNOx/m^3$
Description:	National regulation on NO_x emissions
Source of data to be used:	Regional authorities
Description of measurement methods and procedures to be applied:	Official notification local authorities
Value monitoring period:	**200 ppmv**

Data and parameter monitored Hu-Chems II:

Data / Parameter:	**PE_y,II**
Data unit:	tCO_2e
Description:	Project emissions Hu-Chems II
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**2,746 tCO_2e**

Data / Parameter:	**PE_ND,II**
Data unit:	tCO_2e
Description:	Project emissions from N_2O not destroyed Hu-Chems II
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**2,519 tCO_2e**

Data / Parameter:	**PE_DF,II**
Data unit:	tCO_2e
Description:	Project emissions from destruction facility Hu-Chems II
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**227 tCO_2e**

Data / Parameter:	**PE_N_2O,II**
Data unit:	tN_2O

Description:	N_2O not destroyed by facility Hu-Chems II
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**8.12 tN_2O**

Data / Parameter:	**F_TG,II**
Data unit:	Nm^3/h
Description:	Volume flow tail gas at N_2O destruction facility interval i Hu-Chems II
Source of data to be used:	Venturi tube, designed and manufactured in accordance with ISO 5167-4:2003 Standard Normal Conditions: 1,013.25 hPa, 273.15K)
Description of measurement methods and procedures to be applied:	Flow metering system automatically record volume flow adjusted to standard temperature and pressure.
Value monitoring period:	**81,042,096 Nm^3** **(39,000 Nm^3/h)**

Data / Parameter:	**CO_N2O,II**
Data unit:	tN_2O/ Nm^3
Description:	N_2O concentration at destruction facility outlet Hu-Chems II
Source of data to be used:	Non-dispersive infrared photometry for N_2O
Description of measurement methods and procedures to be applied:	In the effluent of the EnviNOx®- system, the concentrations of nitrous oxide (N_2O) is analysed continuously. Analysis is done by using non-dispersive infrared photometry for N_2O.
Value monitoring period:	**1.00E-07 tN_2O/Nm^3**

Data / Parameter:	**M_i,II**
Data unit:	h
Description:	Measuring Interval

Source of data to be used:	Delta V System, Monitoring System
Description of measurement methods and procedures to be applied:	The DeltaV System automatically takes average readings from the continuously measuring analysers every 10 seconds. Based on raw data, the Monitoring System calculates Project and Baseline Emission Parameters every 10 seconds. The DeltaV System generates daily DeltaV Reports, where averages (concentrations) and totals (Flows, Project/Baseline emission parameters) of the collected values over one day are contained, as required by the PDD.
Value monitoring period:	**10 seconds**

Data / Parameter:	**PE_HC,II**
Data unit:	tCO_2e
Description:	Emissions from hydrocarbon use in destruction facility Hu-Chems II
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**227 tCO_2e**

Data / Parameter:	**HCE_C, II**
Data unit:	tCO_2e
Description:	Converted hydrocarbon emissions Hu-Chems II
Source of data to be used:	Monitoring System
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**227 tCO_2e**

Data / Parameter:	**Q_HC,II**
Data unit:	Nm^3
Description:	Hydrocarbon input (propane as reducing agent) Hu-Chems II
Source of data to be	Flow meter

used:	
Description of measurement methods and procedures to be applied:	The propane used as reducing agent is measured by standard flow meters. Flow is converted to standard conditions based on temperature and pressure measurement.
Value monitoring period:	**37,788 Nm³**

Data / Parameter:	**ρ_HC, II**
Data unit:	t/m³
Description:	Hydrocarbon density Hu-Chems II
Source of data to be used:	Hydrocarbon supplier or default value
Description of measurement methods and procedures to be applied:	For hydrocarbon density, a default value of 2.00E-03 t/Nm³ is applied. According to supplier certificates, actual density of the delivered hydrocarbon is below the applied density. Thus, applied density is conservative.
Value monitoring period:	**2.00E-03 t/Nm³** Standard Normal Conditions: 1,013.25 hPa, 273.15K

Data / Parameter:	**EF_HC,II**
Data unit:	tCO_2e/t
Description:	Hydrocarbon CO_2 emission factor Hu-Chems II
Source of data to be used:	IPCC (Value is determined in PDD)
Description of measurement methods and procedures to be applied:	According to the PDD, the hydrocarbon emission factor is given with 3.0 tCO_2e/t.
Value monitoring period:	**3.0 tCO_2e/t**

Data / Parameter:	**OXID_HC,II**
Data unit:	%
Description:	Hydrocarbon oxidation factor Hu-Chems II

Source of data to be used:	PDD
Description of measurement methods and procedures to be applied:	According to AM0028 OXID_HC,II is 100% (conservative approach)
Value monitoring period:	**100%**

Data / Parameter:	**Type_HC,II**
Data unit:	-
Description:	Type of hydrocarbon
Source of data to be used:	Hydrocarbon supplier
Description of measurement methods and procedures to be applied:	As per certificate of supplier. No methane is present in the hydrocarbon.
Value monitoring period:	**Propane**

Data / Parameter:	**P_HNO3,II**
Data unit:	$tHNO_3$
Description:	Plant output of HNO_3 Hu-Chems II
Source of data to be used:	Production reports
Description of measurement methods and procedures to be applied:	The actual nitric acid production is measured according to the installed instruments. The instrument signals are recorded in control rooms and used to determine whether the nitric acid production is within the historical designed capacity.
Value monitoring period:	**26,088 $tHNO_3$**

Data / Parameter:	**QI_N2O,II**
Data unit:	tN2O
Description:	Quantity of N2O at inlet of destruction facility Hu-Chems II
Source of data to be	Monitoring system

used:	
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**316.69 tN_2O**

Data / Parameter:	**CI_N2O,II**
Data unit:	tN_2O/ Nm^3
Description:	N_2O concentration at destruction facility inlet Hu-Chems II
Source of data to be used:	Non-dispersive infrared photometry for N_2O
Description of measurement methods and procedures to be applied:	In the feed of the EnviNOx®- system, the concentrations of nitrous oxide (N_2O), is analysed continuously. Analysis is done by using non-dispersive infrared photometry in a combined analyser device.
Value monitoring period:	**3.91E-06 tN_2O/Nm^3**

Data / Parameter:	**QR_N2O,y** **RSE_N2O,y** **CR_N2O**
Data unit:	tN_2O $tN_2O/t\ HNO_3$ tN_2O/m^3
Description:	National regulation on N_2O emissions
Source of data used:	Regional authorities
Description of measurement methods and procedures to be applied:	Actual no regulations on N_2O emissions are in place.
Value monitoring period:	Not applicable

Data / Parameter:	**P_HNO3,hist,II**
Data unit:	$tHNO_3$

Description:	Design capacity
Source of data used:	PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**116,800 $tHNO_3$**

Data / Parameter:	**T_g,hist,II**
Data unit:	°C
Description:	Historical operating temperature of the ammonia oxidation reactor Hu-Chems II
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**880 – 910 °C**

Data / Parameter:	**P_g,hist,II**
Data unit:	barg
Description:	Historical operating pressure of the ammonia oxidation reactor Hu-Chems II
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**5.0 – 9.8 barg**

Data / Parameter:	**T_g,II**
Data unit:	°C
Description:	Actual operating temperature ammonia oxidation reactor Hu-Chems II
Source of data to be used:	Thermocouple
Description of measurement methods	The actual temperature at the ammonia oxidation catalyst is measured with the installed measuring devices.

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and procedures to be applied:	Actual daily temperatures are reported in the Delta V Daily reports.
Value monitoring period:	**899.7 °C**

Data / Parameter:	**P_g,II**
Data unit:	Barg
Description:	Actual operating pressure ammonia oxidation reactor Hu-Chems II
Source of data to be used:	Pressure transmitter
Description of measurement methods and procedures to be applied:	The actual pressure at the ammonia oxidation catalyst is measured with the installed measuring devices.
Value monitoring period:	**8.61 barg**

Data / Parameter:	**G_sup,II**
Data unit:	-
Description:	Supplier of the ammonia oxidation catalyst Hu-Chems II
Source of data to be used:	Ammonia oxidation catalyst supplier
Description of measurement methods and procedures to be applied:	Commercial Invoice
Value monitoring period:	**Johnson Matthey**

Data / Parameter:	**G_com,II**
Data unit:	%
Description:	Composition of the ammonia oxidation catalyst Hu-Chems II
Source of data to be used:	Ammonia oxidation catalyst supplier
Description of measurement methods and procedures to be applied:	Supplier's information
Value monitoring period:	**90% Pt** **5% Rh**

	5% Pd

Data / Parameter:	**G_sup,hist,II**
Data unit:	-
Description:	Historical supplier of the ammonia oxidation catalyst Hu-Chems II
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**Johnson Matthey** **and/or** **Umicore**

Data / Parameter:	**G_com,hist,II**
Data unit:	%
Description:	Historical composition of the ammonia oxidation catalyst Hu-Chems II
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**90% Pt** **5% Rh** **5% Pd**

Data / Parameter:	**SE_N2O,II**
Data unit:	$tN_2O/tHNO_3$
Description:	N_2O emission rate per ton of nitric acid Hu-Chems II
Source of data to be used:	Production reports
Description of measurement methods and procedures to be applied:	The quantity of N_2O at the inlet of the destruction facility is calculated based on the concentration at the inlet and the volume flow. The actual nitric acid production is measured according to the installed instruments.
Value monitoring period:	**0.012 $tN_2O/tHNO_3$**

Data / Parameter:	**A_OR,hist,II**

Data unit:	tNH_3/d
Description:	Max. historical ammonia flow rate to the ammonia oxidation reactor Hu-Chems II
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**91.82 tNH_3/d**

Data / Parameter:	**A_OR,d,II**
Data unit:	tNH_3/d
Description:	Actual ammonia flow rate to the ammonia oxidation reactor Hu-Chems II
Source of data to be used:	Flow meter
Description of measurement methods and procedures to be applied:	The actual ammonia flow to the ammonia oxidation reactor is measured with the already installed measuring devices. Actual daily ammonia flow is reported in the Delta V Daily reports.
Value monitoring period:	**82.31 tNH_3/d**

Data and parameter monitored Hu-Chems III:

Data / Parameter:	PE_y,III
Data unit:	tCO_2e
Description:	Project Emissions Hu-Chems III
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**2,267 tCO_2e**

Data / Parameter:	PE_ND,III
Data unit:	tCO_2e
Description:	Project emissions from N_2O not destroyed Hu-Chems III
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**2,009 tCO_2e**

Data / Parameter:	PE_DF,III
Data unit:	tCO_2e
Description:	Project emissions from destruction facility Hu-Chems III
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**258 tCO_2e**

Data / Parameter:	**PE_N2O,III**
Data unit:	tN_2O
Description:	N_2O not destroyed by facility Hu-Chems III
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**6.48 tN_2O**

Data / Parameter:	**F_TG,III**
Data unit:	Nm^3/h
Description:	Volume flow tail gas at N_2O destruction facility interval i Hu-Chems III
Source of data to be used:	Venturi tube, designed and manufactured in accordance with ISO 5167-4:2003 Standard Normal Conditions: 1,013.25 hPa, 273.15K)
Description of measurement methods and procedures to be applied:	Flow metering system automatically record volume flow adjusted to standard temperature and pressure.
Value monitoring period:	**88,107,239 Nm^3** **(41,777 Nm^3/h)**

Data / Parameter:	**CO_N2O,III**
Data unit:	tN_2O/ Nm^3
Description:	N_2O concentration at destruction facility outlet Hu-Chems III
Source of data to be used:	Non-dispersive infrared photometry for N_2O
Description of measurement methods and procedures to be applied:	In the effluent of the EnviNOx®- system, the concentrations of nitrous oxide (N_2O) is analysed continuously. Analysis is done by using non-dispersive infrared photometry for N_2O.
Value monitoring period:	**7.35E-08 tN_2O/Nm^3**

Data / Parameter:	**M_i,III**
Data unit:	h

Description:	Measuring Interval
Source of data to be used:	Delta V System, Monitoring System
Description of measurement methods and procedures to be applied:	The DeltaV System automatically takes average readings from the continuously measuring analysers every 10 seconds. Based on raw data, the Monitoring System calculates Project and Baseline Emission Parameters every 10 seconds. The DeltaV System generates daily DeltaV Reports, where averages (concentrations) and totals (Flows, Project/Baseline emission parameters) of the collected values over one day are contained, as required by the PDD.
Value monitoring period:	**10 seconds**

Data / Parameter:	**PE_HC,III**
Data unit:	tCO_2e
Description:	Emissions from hydrocarbon use in destruction facility Hu-Chems III
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**258 tCO_2e**

Data / Parameter:	**HCE_C, III**
Data unit:	tCO_2e
Description:	Converted hydrocarbon emissions Hu-Chems III
Source of data to be used:	Monitoring System
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**258 tCO2e**

Data / Parameter:	**Q_HC,III**
Data unit:	Nm^3
Description:	Hydrocarbon input (propane as reducing agent) Hu-Chems III

Source of data to be used:	Flow meter
Description of measurement methods and procedures to be applied:	The propane used as reducing agent is measured by standard flow meters. Flow is converted to standard conditions based on temperature and pressure measurement.
Value monitoring period:	**42,969 Nm^3**

Data / Parameter:	**ρ_HC, III**
Data unit:	t/m^3
Description:	Hydrocarbon density Hu-Chems III
Source of data to be used:	Hydrocarbon supplier or default value
Description of measurement methods and procedures to be applied:	For hydrocarbon density, a default value of 2.00E-03 t/Nm^3 is applied. According to supplier certificates, actual density of the delivered hydrocarbon is below the applied density. Thus, applied density is conservative.
Value monitoring period:	**2.00E-03 t/Nm^3** Standard Normal Conditions: 1,013.25 hPa, 273.15K

Data / Parameter:	**EF_HC,III**
Data unit:	tCO_2e/t
Description:	Hydrocarbon CO_2 emission factor Hu-Chems III
Source of data to be used:	IPCC (Value is determined in PDD)
Description of measurement methods and procedures to be applied:	According to the PDD, the hydrocarbon emission factor is given with 3.0 tCO_2e/t.
Value monitoring period:	**3.0 tCO2e/t**

Data / Parameter:	**OXID_HC,III**

Data unit:	%
Description:	Hydrocarbon oxidation factor Hu-Chems III
Source of data to be used:	
Description of measurement methods and procedures to be applied:	According to AM0028 OXID_HC,III is 100% (conservative approach)
Value monitoring period:	**100%**

Data / Parameter:	**Type_HC,III**
Data unit:	-
Description:	Type of hydrocarbon
Source of data to be used:	Hydrocarbon supplier
Description of measurement methods and procedures to be applied:	As per certificate of supplier.
Value monitoring period:	**Propane**

Data / Parameter:	**P_HNO3,III**
Data unit:	$tHNO_3$
Description:	Plant output of HNO_3 Hu-Chems III
Source of data to be used:	Production reports
Description of measurement methods and procedures to be applied:	The actual nitric acid production is determined based on flow measurement according to the installed instruments and on laboratory concentration and density determination according to a respective procedure. The instrument signals are recorded in control rooms and used to determine whether the nitric acid production is within the historical designed capacity.
Value monitoring period:	**26,732 $tHNO_3$**

Data / Parameter:	**QI_N2O,III**

Data unit:	tN_2O
Description:	Quantity of N_2O at inlet of destruction facility Hu-Chems III
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**333.23 tN_2O**

Data / Parameter:	**CI_N2O,III**
Data unit:	tN_2O/ Nm³
Description:	N_2O concentration at destruction facility inlet Hu-Chems III
Source of data to be used:	Non-dispersive infrared photometry for N_2O
Description of measurement methods and procedures to be applied:	In the feed of the EnviNOx®- system, the concentrations of nitrous oxide (N_2O), is analysed continuously. Analysis is done by using non-dispersive infrared photometry in a combined analyser device.
Value monitoring period:	**3.78E-06 tN_2O/Nm³**

Data / Parameter:	**T_g,hist,III**
Data unit:	°C
Description:	Historical operating temperature range of the ammonia oxidation reactor Hu-Chems III
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**880 – 910 °C**

Data / Parameter:	**P_g,hist,III**
Data unit:	barg
Description:	Historical operating pressure range of the ammonia oxidation reactor Hu-

	Chems III
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**5.0 – 9.8 barg**

Data / Parameter:	**T_g, III**
Data unit:	°C
Description:	Actual operating temperature ammonia oxidation reactor Hu-Chems III
Source of data to be used:	Thermocouple
Description of measurement methods and procedures to be applied:	The actual temperature at the ammonia oxidation catalyst is measured with the installed measuring devices. Actual daily temperatures are reported in the Delta V Daily reports.
Value monitoring period:	**899.1 °C**

Data / Parameter:	**P_g, III**
Data unit:	Barg
Description:	Actual operating pressure ammonia oxidation reactor Hu-Chems III
Source of data to be used:	Pressure transmitter
Description of measurement methods and procedures to be applied:	The actual pressure at the ammonia oxidation catalyst is measured with the installed measuring devices.
Value monitoring period:	**9.15 barg**

Data / Parameter:	**G_sup, III**
Data unit:	-
Description:	Supplier of the ammonia oxidation catalyst Hu-Chems III
Source of data to be used:	Ammonia oxidation catalyst supplier
Description of	Commercial Invoice

measurement methods and procedures to be applied:	
Value monitoring period:	**Johnson Matthey**

Data / Parameter:	**G_com,III**
Data unit:	%
Description:	Composition of the ammonia oxidation catalyst Hu-Chems III
Source of data to be used:	Ammonia oxidation catalyst supplier
Description of measurement methods and procedures to be applied:	Certificate catalyst supplier
Value monitoring period:	**90% Pt** **5% Rh** **5% Pd**

Data / Parameter:	**G_sup,hist,III**
Data unit:	-
Description:	Historical supplier of ammonia oxidation catalyst Hu-Chems III
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**Johnson Matthey** **and/or** **Umicore**

Data / Parameter:	**G_com,hist,III**
Data unit:	%
Description:	Historical composition of the ammonia oxidation catalyst Hu-Chems III
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring	**90% Pt**

period:	**5% Rh** **5% Pd**

Data / Parameter:	**SE_N2O,III**
Data unit:	$tN_2O/tHNO_3$
Description:	N_2O emission rate per ton of nitric acid Hu-Chems III
Source of data to be used:	Production reports
Description of measurement methods and procedures to be applied:	The quantity of N_2O at the inlet of the destruction facility is calculated based on the concentration at the inlet and the volume flow. The actual nitric acid production is measured according to the installed instruments.
Value monitoring period:	**0.012 tN2O/tHNO$_3$**

Data / Parameter:	**A_OR,hist,III**
Data unit:	tNH_3/d
Description:	Max. historical ammonia flow rate to the ammonia oxidation reactor Hu-Chems III
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**92.57 tNH_3/d**

Data / Parameter:	**A_OR,d,III**
Data unit:	tNH_3/d
Description:	Actual ammonia flow rate to the ammonia oxidation reactor Hu-Chems III
Source of data to be used:	Flow meter
Description of measurement methods and procedures to be applied:	The actual ammonia flow to the ammonia oxidation reactor is measured with the already installed measuring devices. Actual daily ammonia flow is reported in the Delta V Daily reports.
Value monitoring period:	**85.52 tNH_3/d**

Data and parameter monitored Hu-Chems IV:

Data / Parameter:	**PE_y,IV**
Data unit:	tCO_2e
Description:	Project emissions Hu-Chems IV
Source of data to be used:	Monitoring System
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**3,449 tCO_2e**

Data / Parameter:	**PE_ND,IV**
Data unit:	tCO_2e
Description:	Project emissions from N2O not destroyed Hu-Chems IV
Source of data to be used:	Monitoring System
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**3,449 tCO_2e**

Data / Parameter:	**PE_DF,IV**
Data unit:	tCO_2e
Description:	Project emissions from destruction facility Hu-Chems IV
Source of data to be used:	
Description of measurement methods and procedures to be applied:	Not applicable
Value monitoring period:	**Not applicable**

Data / Parameter:	**PE_N2O,IV**
Data unit:	tN_2O
Description:	N_2O not destroyed by facility Hu-Chems IV

Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**11.12 tN_2O**

Data / Parameter:	F_TG,IV
Data unit:	Nm³/h
Description:	Volume flow tail gas at N_2O destruction facility interval i Hu-Chems IV
Source of data to be used:	Venturi tube, designed and manufactured in accordance with ISO 5167-4:2003 Standard Normal Conditions: 1,013.25 hPa, 273.15K)
Description of measurement methods and procedures to be applied:	Flow metering system automatically record volume flow adjusted to standard temperature and pressure.
Value monitoring period:	**337,688,892 Nm³** **(156,700 Nm³/h)**

Data / Parameter:	CO_N2O,IV
Data unit:	tN_2O/ Nm³
Description:	N_2O concentration at destruction facility outlet Hu-Chems IV
Source of data to be used:	Non-dispersive infrared photometry for N_2O
Description of measurement methods and procedures to be applied:	In the effluent of the EnviNOx®- system, the concentrations of nitrous oxide (N_2O) is analysed continuously. Analysis is done by using non-dispersive infrared photometry for N_2O.
Value monitoring period:	**3.29E-08 tN_2O/Nm³**

Data / Parameter:	M_i,IV
Data unit:	h
Description:	Measuring Interval
Source of data to be	Delta V System, Monitoring System

used:	
Description of measurement methods and procedures to be applied:	The DeltaV System automatically takes average readings from the continuously measuring analysers every 10 seconds. Based on raw data, the Monitoring System calculates Project and Baseline Emission Parameters every 10 seconds. The DeltaV System generates daily DeltaV Reports, where averages (concentrations) and totals (Flows, Project/Baseline emission parameters) of the collected values over one day are contained, as required by the PDD.
Value monitoring period:	**10 seconds**

Data / Parameter:	**P_HNO3,IV**
Data unit:	$tHNO_3$
Description:	Plant output of HNO_3 Hu-Chems IV
Source of data to be used:	Production reports
Description of measurement methods and procedures to be applied:	The actual nitric acid production is measured according to the installed instruments. The instrument signals are recorded in control rooms and used to determine whether the nitric acid production is within the historical designed capacity.
Value monitoring period:	**111,787 $tHNO_3$**

Data / Parameter:	**QI_N2O,IV**
Data unit:	tN_2O
Description:	Quantity of N_2O at inlet of destruction facility Hu-Chems IV
Source of data to be used:	Monitoring system
Description of measurement methods and procedures to be applied:	Calculated
Value monitoring period:	**640.71 tN_2O**

Data / Parameter:	**CI_N2O,IV**
Data unit:	tN_2O/ Nm^3
Description:	N_2O concentration at destruction facility inlet Hu-Chems IV

Source of data to be used:	Non-dispersive infrared photometry for N_2O
Description of measurement methods and procedures to be applied:	In the feed of the EnviNOx®- system, the concentrations of nitrous oxide (N_2O), is analysed continuously. Analysis is done by using non-dispersive infrared photometry in a combined analyser device.
Value monitoring period:	**1.90E-06 tN_2O/Nm^3**

Data / Parameter:	**P_HNO3,hist,IV**
Data unit:	$tHNO_3$
Description:	Design capacity Hu-Chems IV
Source of data used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**467,200 tHNO3**

Data / Parameter:	**T_g,hist,IV**
Data unit:	°C
Description:	Historical operating temperature of ammonia oxidation reactor Hu-Chems IV
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**860 – 910 °C**

Data / Parameter:	**P_g,hist,IV**
Data unit:	barg
Description:	Historical operating pressure of the ammonia oxidation reactor Hu-Chems IV
Source of data to be used:	According to PDD
Description of measurement methods	

and procedures to be applied:	
Value monitoring period:	**2.2 – 4.4 barg**

Data / Parameter:	**T_g, IV**
Data unit:	°C
Description:	Actual operating temperature ammonia oxidation reactor Hu-Chems IV
Source of data to be used:	Thermocouple
Description of measurement methods and procedures to be applied:	The actual temperature at the ammonia oxidation catalyst is measured with the installed measuring devices. Actual daily temperatures are reported in the Delta V Daily reports.
Value monitoring period:	**885.6 °C**

Data / Parameter:	**P_g, IV**
Data unit:	Barg
Description:	Actual operating pressure ammonia oxidation reactor Hu-Chems IV
Source of data to be used:	Pressure transmitter
Description of measurement methods and procedures to be applied:	The actual pressure at the ammonia oxidation catalyst is measured with the installed measuring devices.
Value monitoring period:	**3.59 barg**

Data / Parameter:	**G_sup, IV**
Data unit:	-
Description:	Supplier of the ammonia oxidation catalyst Hu-Chems IV
Source of data to be used:	Ammonia oxidation catalyst supplier
Description of measurement methods and procedures to be applied:	Commercial Invoice
Value monitoring period:	**Johnson Matthey**

Data / Parameter:	**G_com,IV**
Data unit:	%
Description:	Composition of the ammonia oxidation catalyst Hu-Chems IV
Source of data to be used:	Ammonia oxidation catalyst supplier
Description of measurement methods and procedures to be applied:	Certificate catalyst supplier
Value monitoring period:	**95% Pt** **5% Rh**

Data / Parameter:	**G_sup,hist,IV**
Data unit:	-
Description:	Historical supplier of the ammonia oxidation catalyst Hu-Chems IV
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**Johnson Matthey** **and/or** **Umicore**

Data / Parameter:	**G_com,hist,IV**
Data unit:	%
Description:	Historical composition of the ammonia oxidation catalyst Hu-Chems IV
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**95% Pt** **5% Rh** **and/or** **92% Pt**

	8% Rh

Data / Parameter:	SE_N2O,IV
Data unit:	$tN_2O/tHNO_3$
Description:	N_2O emission rate per ton of nitric acid Hu-Chems IV
Source of data to be used:	Production reports
Description of measurement methods and procedures to be applied:	The quantity of N_2O at the inlet of the destruction facility is calculated based on the concentration at the inlet and the volume flow. The actual nitric acid production is measured according to the installed instruments.
Value monitoring period:	**0.006 $tN_2O/tHNO_3$**

Data / Parameter:	A_OR,hist,IV
Data unit:	tNH_3/d
Description:	Max. historical ammonia flow rate to the ammonia oxidation reactor
Source of data to be used:	According to PDD
Description of measurement methods and procedures to be applied:	
Value monitoring period:	**355.50 tNH_3/d**

Data / Parameter:	A_OR,d,IV
Data unit:	tNH_3/d
Description:	Actual ammonia flow rate to the ammonia oxidation reactor Hu-Chems IV
Source of data to be used:	Flow meter
Description of measurement methods and procedures to be applied:	The actual ammonia flow to the ammonia oxidation reactor is measured with the already installed measuring devices. Actual daily ammonia flow is reported in the Delta V Daily reports.
Value monitoring period:	**348.05 tNH_3/d**

Annex 2

Table 15: Overview on monitoring parameters Hu-Chems II

ER Calculation Parameters			
Parameter Name	Value in	Unit	Description
BE_y,II	98,175	tCO2e	Baseline Emissions
PE_y,II	2,746	tCO2e	Project Emissions
LE_y,II	0	tCO2e	Leakage Emissions
ER_y,II	95,429	tCO2e	Emission Reduction

Project Emission Parameters - Plant Hu-Chems II					
ID in AM0028 v1	ID in PDD	Parameter Name	Value	Unit	Description
P1	P4	PE_y,II	2,746	tCO_2e	Project Emissions
P2	P5	PE_ND,y,II	2,519	tCO_2e	Project Emissions from N2O not destroyed
P3	P6	PE_DF,y,II	227	tCO_2e	Project Emissions from destruction facility
P4	P7	PE_N2O,y,II	8.12	tN_2O	N2O not destroyed by facility
P5	P8	F_TG,i,II	81,042,096	Nm³	Volume flow tail gas at N2O destruction facility
			39,000	Nm^3/h	
P6	P9	CO_N2O,i,II	1.00E-07	tN_2O/Nm^3	N2O concentration at destruction facility outlet
P7	P10	M_i,II	10	sec	Measuring Interval
P8	-	PE_NH3,y,II	Not Applicable	tCO_2e	Emissions from ammonia use in destruction facility
P9	P11	PE_HC,y,II	227	tCO_2e	Emissions from hydrocarbon use in destruction facility
P10	-	Q_NH3, y,II	Not Applicable	tNH_3	N2O destruction facility: Project Ammonia input
P11	-	EF_NH3	Not Applicable	tCO_2e/tNH_3	Ammonia production GHG Emission Factor
P12	P12	HCE_C,y,II	227	tCO_2e	Converted hydrocarbon emissions
P13	-	HCE_NC, y,II	Not Applicable	tCO_2e	Non Converted Methane Emissions
P14	P13	Q_HC,y,II	37,788	Nm³ Propane	Hydrocarbon input (reducing agent)
P15	P14	ρ_HC,II	2.00E-03	tPropane/Nm³	Hydrocarbon density
P16	P15	EF_HC,II	3.0	$tCO_2/tPropane$	Hydrocarbon CO2 Emission Factor
P17	P16	OXID_HC,II	100	%	Hydrocarbon Oxidation Factor
P18	P17	Type_HC,II	Propane	-	Type of Hydrocarbon

Baseline Emission Parameters - Plant Hu-Chems II						
ID in AM0028 v1	ID in PDD	Parameter Name	Value		Unit	Description
B1	B1	P_HNO3,y,II	26,088		$tHNO_3$	Plant output of HNO3
B2	B2	QI_N2O,y,II	316.69		tN_2O	Quantity of N2O at inlet of destruction facility
B3	B3	CI_N2O,i,II	3.91E-06		tN_2O/m^3	N_2O concentration at N_2O destruction facility inlet
B4	B4	QR_N2O,y	Not Applicable		tN_2O	Regulation I: annual quantity N2O limited
B5	B5	RSE_N2O,y	Not Applicable		$tN_2O/tHNO_3$	Regulation II: N2O emissions per unit of nitric acid
B6	B6	CR_N2O	Not Applicable		tN_2O/Nm^3	Regulation III: N2O concentration in tail gas limited
B7	B7	P_HNO3,hist,II	116,800		t	Design capacity
B8	B8	T_g,hist,II	low	880.0	℃	Historical operating temperature range of the amm onia oxidation reactor
			high	910.0		
B9	B9	P_g,hist,II	low	5.00	barg	Historical operating pressure range of the ammonia oxidation reactor
			high	9.80		
B10	B10	T_g,II	899.7		℃	Actual operating temperature ammonia oxidation re actor
B11	B11	P_g,II	8.61		barg	Actual operating pressure ammonia oxidation reactor
B12	B12	Reg_Nox	200		ppmv	National Regulation on Nox emissions
B13	B13	G_sup,II	Johnson Matthey		-	Supplier of the ammonia oxidation catalyst
B14	B14	G_com,II	90%Pt, 5%Rh, 5%Pd		%	Compostion of the ammonia oxidation catalyst
B15	B15	G_sup,hist,II	Umicore and/or Johnson Matthey		-	Historical supplier of ammonia oxidation catalyst
B16	B16	G_com,hist,II	90%Pt, 5%Rh, 5%Pd		%	Historical composition of the ammonia oxidation catalyst
B17	B17	SE_N2O,II	0.012		$tN_2O/tHNO_3$	N2O emission rate per ton of nitric acid
B18	B18	A_OR,hist,II	91.82		tNH_3/day	Max. historical ammonia flow rate to the ammonia oxidation reactor
B19	B19	A_OR,d,II	82.31		tNH_3/day	Actual ammonia flow rate to the ammonia oxidation reactor

Table 16: Overview on monitoring parameters Hu-Chems III

ER Calculation Parameters			
Parameter Name	Value in	Unit	Description
BE_y,III	103,301	tCO2e	Baseline Emissions
PE_y,III	2,267	tCO2e	Project Emissions
LE_y,III	0	tCO2e	Leakage Emissions
ER_y,III	101,034	tCO2e	Emission Reduction

Project Emission Parameters - Plant Hu-Chems III					
ID in AM0028 v1	ID in PDD	Parameter Name	Value	Unit	Description
P1	P18	PE_y,III	2,267	tCO_2e	Project Emissions
P2	P19	PE_ND,y,III	2,009	tCO_2e	Project Emissions from N2O not destroyed
P3	P20	PE_DF,y,III	258	tCO_2e	Project Emissions from destruction facility
P4	P21	PE_N2O,y,III	6.48	tN_2O	N2O not destroyed by facility
P5	P22	F_TG,i,III	88,107,239	Nm³	Volume flow tail gas at N2O destruction facility
			41,777	Nm^3/h	
P6	P23	CO_N2O,i,III	7.35E-08	tN_2O/Nm^3	N2O concentration at destruction facility outlet
P7	P24	M_i,III	10	sec	Measuring Interval
P8	-	PE_NH3,y,III	Not Applicable	tCO_2e	Emissions from ammonia use in destruction facility
P9	P25	PE_HC,y,III	258	tCO_2e	Emissions from hydrocarbon use in destruction facility
P10	-	Q_NH3, y,III	Not Applicable	tNH_3	N2O destruction facility: Project Ammonia input
P11	-	EF_NH3	Not Applicable	tCO_2e/tNH_3	Ammonia production GHG Emission Factor
P12	P26	HCE_C,y,III	258	tCO_2e	Converted hydrocarbon emissions
P13	-	HCE_NC, y,III	Not Applicable	tCO_2e	Non Converted Methane Emissions
P14	P27	Q_HC,y,III	42,969	Nm³ Propane	Hydrocarbon input (reducing agent)
P15	P28	ρ_HC,III	2.00E-03	tPropane/Nm³	Hydrocarbon density
P16	P29	EF_HC,III	3.0	$tCO_2/tPropane$	Hydrocarbon CO2 Emission Factor
P17	P30	OXID_HC,III	100	%	Hydrocarbon Oxidation Factor
P18	P31	Type_HC,III	Propane	-	Type of Hydrocarbon

Baseline Emission Parameters - Plant Hu-Chems III						
ID in AM0028 v1	ID in PDD	Parameter Name	Value		Unit	Description
B1	B20	P_HNO3,y,III	26,732		$tHNO_3$	Plant output of HNO3
B2	B21	QI_N2O,y,III	333.23		tN_2O	Quantity of N2O at inlet of destruction facility
B3	B22	CI_N2O,i,III	3.78E-06		tN_2O/m^3	N_2O concentration at N_2O destruction facility inlet
B4	B4	QR_N2O,y	Not Applicable		tN_2O	Regulation I: annual quantity N2O limited
B5	B5	RSE_N2O,y	Not Applicable		$tN_2O/tHNO_3$	Regulation II: N2O emissions per unit of nitric acid
B6	B6	CR_N2O	Not Applicable		tN_2O/m^3	Regulation III: N2O concentration in tail gas limited
B7	-	P_HNO3,hist,III	116,800		t	Design capacity
B8	B23	T_g,hist,III	low	880.0	℃	Historical operating temperature range of the amm onia oxidation reactor
			high	910.0		
B9	B24	P_g,hist,III	low	5.00	barg	Historical operating pressure range of the ammonia oxidation reactor
			high	9.80		
B10	B25	T_g,III	899.1		℃	Actual operating temperature ammonia oxidation re actor
B11	B26	P_g,III	9.15		barg	Actual operating pressure ammonia oxidation reactor
B12	B12	Reg_Nox	200		ppmv	National Regulation on Nox emissions
B13	B27	G_sup,III	Johnson Matthey		-	Supplier of the ammonia oxidation catalyst
B14	B28	G_com,III	90%Pt, 5%Rh, 5%Pd		%	Compostion of the ammonia oxidation catalyst
B15	B29	G_sup,hist,III	Umicore and/or Johnson Matthey		-	Historical supplier of ammonia oxidation catalyst
B16	B30	G_com,hist,III	90%Pt, 5%Rh, 5%Pd		%	Historical composition of the ammonia oxidation catalyst
B17	B31	SE_N2O,III	0.012		$tN_2O/tHNO_3$	N2O emission rate per ton of nitric acid
B18	B32	A_OR,hist,III	92.57		tNH_3/day	Max. historical ammonia flow rate to the ammonia oxidation reactor
B19	B33	A_OR,d,III	85.52		tNH_3/day	Actual ammonia flow rate to the ammonia oxidation reactor

Table 17: Overview on monitoring parameters Hu-Chems IV

ER Calculation Parameters			
Parameter Name	Value in	Unit	Description
BE_y,IV	198,621	tCO2e	Baseline Emissions
PE_y,IV	3,449	tCO2e	Project Emissions
LE_y,IV	0	tCO2e	Leakage Emissions
ER_y,IV	195,172	tCO2e	Emission Reduction

Project Emission Parameters - Plant Hu-Chems IV					
ID in AM0028 v1	ID in PDD	Parameter Name	Value	Unit	Description
P1	P32	PE_y,IV	3,449	tCO_2e	Project Emissions
P2	P33	PE_ND,y,IV	3,449	tCO_2e	Project Emissions from N2O not destroyed
P3	P34	PE_DF,y,IV	0	tCO_2e	Project Emissions from destruction facility
P4	P35	PE_N2O,y,IV	11.12	tN_2O	N2O not destroyed by facility
P5	P36	F_TG,i,IV	337,688,892	Nm³	Volume flow tail gas at N2O destruction facility
			156,700	Nm^3/h	
P6	P37	CO_N2O,i,IV	3.29E-08	tN_2O/Nm^3	N2O concentration at destruction facility outlet
P7	P38	M_i,IV	10	sec	Measuring Interval
P8	-	PE_NH3,y,IV	Not Applicable	tCO_2e	Emissions from ammonia use in destruction facility
P9	-	PE_HC,y,IV	Not Applicable	tCO_2e	Emissions from hydrocarbon use in destruction facility
P10	-	Q_NH3, y,IV	Not Applicable	tNH_3	N2O destruction facility: Project Ammonia input
P11	-	EF_NH3	Not Applicable	tCO_2e/tNH_3	Ammonia production GHG Emission Factor
P12	-	HCE_C,y,IV	Not Applicable	tCO_2e	Converted hydrocarbon emissions
P13	-	HCE_NC, y,IV	Not Applicable	tCO_2e	Non Converted Methane Emissions
P14	-	Q_HC,y,IV	Not Applicable	Nm³ Propane	Hydrocarbon input (reducing agent)
P15	-	ρ_HC,IV	Not Applicable	tPropane/Nm³	Hydrocarbon density
P16	-	EF_HC,IV	Not Applicable	$tCO_2/tPropane$	Hydrocarbon CO2 Emission Factor
P17	-	OXID_HC,IV	Not Applicable	%	Hydrocarbon Oxidation Factor
P18	-	Type_HC,IV	Not Applicable	-	Type of Hydrocarbon

Baseline Emission Parameters - Plant Hu-Chems IV						
ID in AM0028 v1	ID in PDD	Parameter Name	Value		Unit	Description
B1	B34	P_HNO3,y,IV	111,787		$tHNO_3$	Plant output of HNO3
B2	B35	QI_N2O,y,IV	640.71		tN_2O	Quantity of N2O at inlet of destruction facility
B3	B36	CI_N2O,i,IV	1.90E-06		tN_2O/m^3	N_2O concentration at N_2O destruction facility inlet
B4	B4	QR_N2O,y	Not Applicable		tN_2O	Regulation I: annual quantity N2O limited
B5	B5	RSE_N2O,y	Not Applicable		$tN_2O/tHNO_3$	Regulation II: N2O emissions per unit of nitric acid
B6	B6	CR_N2O	Not Applicable		tN_2O/Nm^3	Regulation III: N2O concentration in tail gas limited
B7	B37	P_HNO3,hist,IV	467,200		t	Design capacity
B8	B38	T_g,hist,IV	low	860.0	℃	Historical operating temperature range of the amm onia oxidation reactor
			high	910.0		
B9	B39	P_g,hist,IV	low	2.20	barg	Historical operating pressure range of the ammonia oxidation reactor
			high	4.40		
B10	B40	T_g,IV	885.6		℃	Actual operating temperature ammonia oxidation re actor
B11	B41	P_g,IV	3.59		barg	Actual operating pressure ammonia oxidation reactor
B12	B12	Reg_Nox	200		ppmv	National Regulation on Nox emissions
B13	B42	G_sup,IV	Johnson Matthey		-	Supplier of the ammonia oxidation catalyst
B14	B43	G_com,IV	95%Pt, 5%Rh		%	Compostion of the ammonia oxidation catalyst
B15	B44	G_sup,hist,IV	Umicore and/or Johnson Matthey		-	Historical supplier of ammonia oxidation catalyst
B16	B45	G_com,hist,IV	95%Pt, 5%Rh and/or 92%Pt, 8%Rh		%	Historical composition of the ammonia oxidation catalyst
B17	B46	SE_N2O,IV	0.006		$tN_2O/tHNO_3$	N2O emission rate per ton of nitric acid
B18	B47	A_OR,hist,IV	355.50		tNH_3/day	Max. historical ammonia flow rate to the ammonia oxidation reactor
B19	B48	A_OR,d,IV	348.05		tNH_3/day	Actual ammonia flow rate to the ammonia oxidation reactor