**Monitoring report form for CDM project activity**
**(Version 06.0)**

*Complete this form in accordance with the instructions attached at the end of this form.*

| **MONITORING REPORT** | | |
|---|---|---|
| **Title of the project activity** | Catalytic $N_2O$ destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp. | |
| **UNFCCC reference number of the project activity** | 0765 | |
| **Version number of the PDD applicable to this monitoring report** | 4.2 | |
| **Version number of this monitoring report** | 01.1 | |
| **Completion date of this monitoring report** | 14/12/2018 | |
| **Monitoring period number** | 39th monitoring period | |
| **Duration of this monitoring period** | 06/08/2018 – 07/11/2018 | |
| **Monitoring report number for this monitoring report** | N/A | |
| **Project participants** | CARBON CDM Korea Ltd.<br>Hu-Chems Fine Chemical Corp.<br>RWE Power AG<br>Carbon Climate Protection GmbH | |
| **Host Party** | Republic of Korea | |
| **Sectoral scopes** | 5 – Chemical industries | |
| **Applied methodologies and standardized baselines** | ACM0019 Version 02.0 ($N_2O$ abatement from nitric acid production)<br><br>No standardized baselines applicable. | |
| **Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period** | Amount achieved before 1 January 2013 | Amount achieved from 1 January 2013 |
| | N/A | 269,199 $tCO_2e$ |
| **Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD** | 317,225 $tCO_2e$ | |

# SECTION A. Description of project activity

## A.1. General description of project activity

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The project participants have 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 Industries. The Host Party for the project activity is the Republic of Korea. The project activity includes development, design, engineering, procurement, finance, construction, operation and maintenance of a system for catalytic reduction of $N_2O$ in three nitric acid (furthermore called "NA") plants at Hu-Chems Fine Chemical Corp. (furthermore called "Hu-Chems").

In this project, three EnviNOx® systems for catalytic reduction and decomposition of $NO_x$ and $N_2O$ additionally to the equipment at the three NA manufacturing plants (Hu-Chems II, III + IV) were installed. The project activity reduces the GHG emissions, which would otherwise be released to the atmosphere, if the project was not implemented. The EnviNOx® process used in NA plants Hu-Chems II + III 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 Liquefied Petroleum Gas (LPG), of which the main constituent is propane ($C_3H_8$). The reactions take place over an iron zeolite catalyst bed. The EnviNOx® process used in NA plant Hu-Chems IV 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 and do not involve hydrocarbons.

## A.2. Location of project activity

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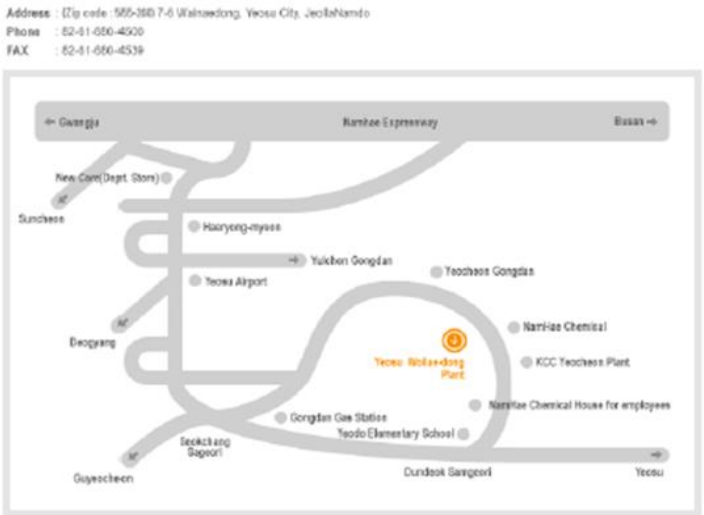
Country (Host): Republic of Korea
Province: Jeonam-do
Town: Yeosu-si, 7-6, Wollae-dong
Unique geographic coordinates: Longitude: 127.743198 E, Latitude: 34.848686 N

### A.3. Parties and project participants

| Parties involved | Project participants | Indicate if the Party involved wishes to be considered as project participant (Yes/No) |
|---|---|---|
| Republic of Korea (Host Party) | CARBON CDM Korea Ltd.<br>Hu-Chems Fine Chemical Corp. | No |
| Federal Republic Germany | RWE Power AG | No |
| Austria | Carbon Climate Protection GmbH | No |

### A.4. Reference to applied methodologies and standardized baselines

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Applied methodology: ACM0019 version 02.0 ("$N_2O$ abatement from nitric acid production")[1]

The methodology refers to the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" in its latest version[2]. Furthermore, the methodology refers to the "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion" in its latest version[3]. Thus, both tools are applied in this project activity.

No standardized baselines are used according to the applied methodology.

### A.5. Crediting period type and duration

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| | |
|---|---|
| Type of the crediting period: | Renewable (3 x 7 years)<br>The project is currently in its 2nd crediting period. |
| Starting date of the 2nd crediting period: | 22/01/2014 |
| End date of the 2nd crediting period: | 21/01/2021 |

## SECTION B. Implementation of project activity

### B.1. Description of implemented project activity

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

**General description:**

Nitrous oxide ($N_2O$) is an unwanted, invisible and previously neglected by-product of the manufacture of NA. 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 NA takes place in three main process steps as indicated by the following reactions:

1. Ammonia ($NH_3$) combustion to form nitric oxide (NO)[4]:

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

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

[1] http://cdm.unfccc.int/methodologies/DB/MNMFNF10VUEOJACEIRX3EHYC9QXGDC
[2] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v3.0.pdf
[3] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v3.pdf
[4] Ammonia is reacted with air on noble metal catalyst in the oxidation section of NA plants. Nitric oxide and water are formed in this process according to the above mentioned main equation.

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

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

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

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

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

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

- 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:

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

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:

$$C_3H_8 + 7\ N_2O \rightarrow 3\ CO + 4\ H_2O + 7\ N_2 \quad \text{or} \quad C_3H_8 + 10\ N_2O \rightarrow 3\ CO_2 + 4\ H_2O + 10\ N_2$$

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:

$$2\ C_3H_8 + 7\ O_2 \rightarrow 6\ CO + 8\ H_2O \quad \text{or} \quad C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$$

- 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:

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

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

**Project specific description:**

- Principles of the EnviNOx® process in NA plants Hu-Chems II + III

The EnviNOx® process 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:

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

Effectively almost all the $NO_x$ is removed. Some destruction of $N_2O$ also occurs. Second, the nitrous oxide is reduced with hydrocarbons over the iron zeolite according to such reactions as:

$$7\ N_2O + C_3H_8 \rightarrow 7\ N_2 + 4\ H_2O + 3\ CO$$
$$10\ N_2O + C_3H_8 \rightarrow 10\ N_2 + 4\ H_2O + 3\ CO_2$$
$$5\ O_2 + C_3H_8 \rightarrow 4\ H_2O + 3\ CO_2$$
$$7\ O_2 + 2\ C_3H_8 \rightarrow 8\ H_2O + 6\ CO$$

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:

$$2\ CO + O_2 \rightarrow 2\ CO_2$$

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 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 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:

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

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

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

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

- Technology employed by the project activity

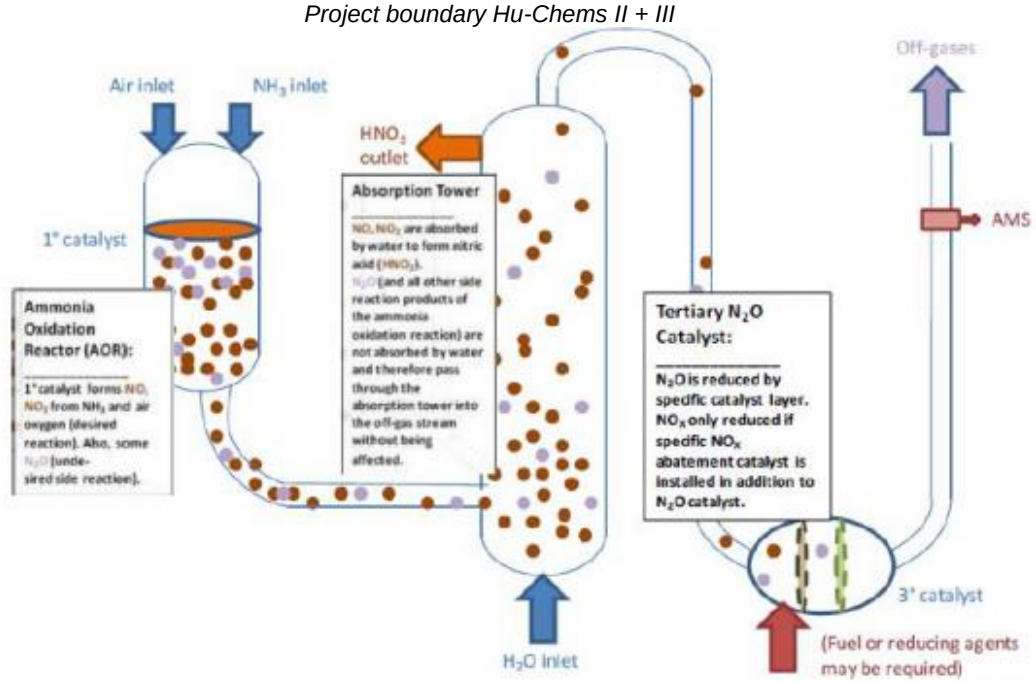
In this project, three EnviNOx® systems for catalytic reduction and decomposition of $NO_x$ and $N_2O$ additionally to the equipment at the three NA manufacturing plants were installed. The project activity reduces the GHG emissions, which would otherwise be released to the atmosphere, if the project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

- Location of the EnviNOx® systems

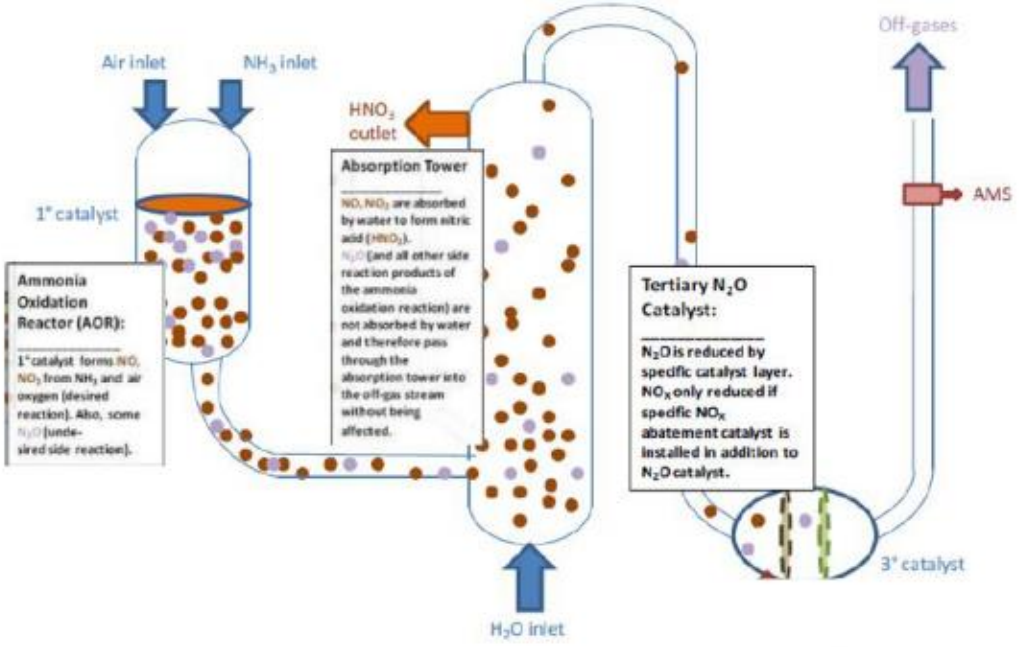
*Hu-Chems II*: The new EnviNOx® reactor (322-R-202) is located between the existing SCR DeNOx reactor (322-R-201) and the tail gas turbine (322-C-201-T2), which is the position with the highest tail gas temperature in the NA production process.
*Hu-Chems III*: The new EnviNOx® reactor (323-R-302) is located between the existing SCR DeNOx reactor (323-R-301) and the tail gas turbine (323-C-301-T2), which is the position with the highest tail gas temperature in the NA production process.
*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 NA production process. The SCR DeNOx reactor, which was in operation prior to the CDM project activity, has been de-commissioned.

The following figures show the spatial extent of the project boundary:

*Project boundary Hu-Chems II + III*




*Project boundary Hu-Chems IV*



**(b) Information on the implementation and actual operation of the project activity, including relevant dates**

The project covers three NA plants (three EnviNOx® systems respectively). The EnviNOx® system at Hu-Chems IV was installed in December 2006, the EnviNOx® systems at Hu-Chems II + III were installed in February and March 2007. The starting dates of operation of the project activity for each of the plant were as follows (1st crediting period of project activity):

- NA plant Hu-Chems II: 26 March 2007
- NA plant Hu-Chems III: 29 March 2007
- NA plant Hu-Chems IV: 9 January 2007

The project has been implemented and is operated as per the registered PDD with all physical features (technology, project equipment, monitoring and metering equipment) in place. Monitoring is done according to the applied methodology (ACM0019 v2) and registered monitoring plan. During this monitoring period several observations were made, which have been analysed in detail as described hereunder:

- Downtimes of NA plants & EnviNOx® systems

During the below mentioned periods, NA plants (and so the EnviNOx® systems) were out of operation due to the given reasons. No emission reductions were claimed during these downtimes:

| Plant | START | | END | | Description |
|---|---|---|---|---|---|
| | Date | Time | Date | Time | |
| II | 30/09/2018 | 03:00 | 30/09/2018 | 21:00 | NA plant shutdown (Emergency trip) |
| II | 26/10/2018 | 01:00 | 01/11/2018 | 20:00 | NA plant shutdown (Annual shutdown) |
| **Plant** | **START** | | **END** | | **Description** |
| | **Date** | **Time** | **Date** | **Time** | |
| III | 17/08/2018 | 04:00 | 17/08/2018 | 21:00 | NA plant shutdown (Evaporator leakage) |
| III | 21/10/2018 | 01:00 | 04/11/2018 | 20:00 | NA plant shutdown (Annual shutdown) |
| **Plant** | **START** | | **END** | | **Description** |
| | **Date** | **Time** | **Date** | **Time** | |
| IV | 22/10/2018 | 02:00 | 06/11/2018 | 05:00 | NA plant shutdown (Annual shutdown) |

- Relevant observations during the monitoring period

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

*Observations in NA plant & EnviNOx® system Hu-Chems II:*

| Date | Time | Date | Time | Observation, Reason & Conservative Action |
|---|---|---|---|---|
| 20/08/2018 | 09:00 | 20/08/2018 | 16:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 21/08/2018 | 09:00 | 21/08/2018 | 10:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 28/08/2018 | 09:00 | 28/08/2018 | 14:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Analyser check by HUCHEMS<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 31/08/2018 | 09:00 | 31/08/2018 | 12:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: AST performance by AIRTEC<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |

| | | | | |
|---|---|---|---|---|
| 20/09/2018 | 12:00 | 20/09/2018 | 14:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 21/09/2018 | 10:00 | 21/092018 | 12:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 27/09/2018 | 13:00 | 27/09/2018 | 14:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Analyser check by HUCHEMS<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 30/09/2018 | 21:00 | 30/09/2018 | 23:00 | Observation: $N_2O$ concentration out of range<br>Reason: No/low reducing agent input to EnviNOx® unit after NA plant shutdown<br>Conservative action: Recalculation of $v_{i,t,db}$ by equating $N_2O$ outlet concentration with inlet upper range |
| 30/09/2018 | 23:00 | 01/10/2018 | 01:00 | Observation: $N_2O$ concentration out of range<br>Reason: No/low reducing agent input to EnviNOx® unit after NA plant shutdown<br>Conservative action: Recalculation of $v_{i,t,db}$ by equating $N_2O$ outlet with $N_2O$ inlet concentration |
| 18/10/2018 | 12:00 | 18/10/2018 | 15:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check & quarterly inspection by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 01/11/2018 | 20:00 | 01/11/2018 | 23:00 | Observation: $N_2O$ concentration out of range<br>Reason: No/low reducing agent input to EnviNOx® unit after scheduled NA plant shutdown<br>Conservative action: Recalculation of $v_{i,t,db}$ by equating $N_2O$ outlet concentration with inlet upper range |
| 02/11/2018 | 02:00 | 06/11/2018 | 14:00 | Observation: Incorrect $N_2O$ outlet concentration range<br>Reason: Analyser range adjustment after NA plant start-up<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |

*Observations in NA plant & EnviNOx® system Hu-Chems III:*

| Date | Time | Date | Time | Observation, Reason & Conservative Action |
|---|---|---|---|---|
| 17/08/2018 | 21:00 | 17/08/2018 | 23:00 | Observation: $N_2O$ concentration out of range<br>Reason: No/low reducing agent input to EnviNOx® unit after NA plant shutdown<br>Conservative action: Recalculation of $v_{i,t,db}$ by equating $N_2O$ outlet concentration with inlet upper range |
| 20/08/2018 | 10:00 | 20/08/2018 | 15:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 21/08/2018 | 10:00 | 21/08/2018 | 11:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 30/08/2018 | 10:00 | 30/08/2018 | 11:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: AST performance by AIRTEC<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 20/09/2018 | 12:00 | 20/09/2018 | 14:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON |

| | | | | |
|---|---|---|---|---|
| | | | | Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 21/09/2018 | 10:00 | 21/09/2018 | 11:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 18/10/2018 | 10:00 | 18/10/2018 | 15:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check & quarterly inspection by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 20/10/2018 | 19:00 | 21/10/2018 | 01:00 | Observation: $N_2O$ concentration out of range<br>Reason: No/low reducing agent input to EnviNOx® unit before scheduled NA plant shutdown<br>Conservative action: Recalculation of $v_{i,t,db}$ by equating $N_2O$ outlet with $N_2O$ inlet concentration |
| 04/11/2018 | 20:00 | 06/11/2018 | 09:00 | Observation: Ammonia flow signal missing in CDM DCS (DeltaV)<br>Reason: Transmitter configuration is required after plant start-up<br>Conservative action: Recalculation of the $NH_3$ flow to AOR by applying the values monitored by the NA plant DCS |

*Observations in NA plant & EnviNOx® system Hu-Chems IV:*

| Date | Time | Date | Time | Observation, Reason & Conservative Action |
|---|---|---|---|---|
| 16/08/2018 | 13:00 | 16/08/2018 | 15:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: NOx analyser emergency check by EMERSON influenced $N_2O$ analyser<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 20/08/2018 | 13:00 | 20/08/2018 | 15:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 21/08/2018 | 10:00 | 21/08/2018 | 11:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 29/08/2018 | 09:00 | 29/08/2018 | 10:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: AST performance by AIRTEC<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 03/09/2018 | 11:00 | 03/09/2018 | 13:00 | Observation: $N_2O$ concentration out of range<br>Reason: Ammonia supply disturbance<br>Conservative action: Recalculation of $v_{i,t,db}$ by equating $N_2O$ outlet with $N_2O$ inlet concentration |
| 20/09/2018 | 14:00 | 20/09/2018 | 16:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 21/09/2018 | 11:00 | 21/09/2018 | 12:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 17/10/2018 | 14:00 | 17/10/2018 | 17:00 | Observation: Fluctuation of $N_2O$ concentration<br>Reason: Monthly health check & quarterly inspection by EMERSON<br>Conservative action: Recalculation of $v_{i,t,db}$ by applying max. value of MP (in accordance with ACM0019 v2 & the PDD) |
| 06/11/2018 | 05:00 | 06/11/2018 | 06:00 | Observation: $N_2O$ concentration out of range<br>Reason: No/low reducing agent input to EnviNOx® unit after scheduled NA plant shutdown |

| | | | | |
|---|---|---|---|---|
| | | | | Conservative action: Recalculation of $v_{i,t,db}$ by equating $N_2O$ outlet concentration with inlet upper range |

During the mentioned periods, the NA plants as well as the respective EnviNOx® system were in normal operation and emission reductions have been conservatively determined fully in line with the applied methodology and the monitoring plan – as described in section *C. Systematic Measures* of this MR.

- Calibration and maintenance

The maintenance methods and procedures as well as the calibration scheme for monitoring instruments used for CDM monitoring have been incorporated as part of ISO 9001 procedures and form an integral part of the systems and procedures of Hu-Chems. QA/QC of monitoring equipment is in full compliance with the monitoring methodology and the monitoring plan of the PDD. Details on exchange and/or calibration of instruments are mentioned under section *D.2*.

All measuring and analytical instruments are being calibrated as defined in the approved methodology ACM0019 v2 as well as the monitoring plan and according to the supplier recommendations (i.e. Emerson Process Management). As pointed out in section *C.*, Hu-Chems has mandated Emerson Process Management Korea (furthermore called "EPMK") to execute additional regular calibration services and regular general maintenance services to safeguard accuracy and availability of the monitoring instruments related to the CDM project. Services are adapted to the annual shutdown schedule of the NA plants; valid calibration records for all relevant monitoring instruments are available and submitted to the DOE for verification (see details section *D.2*).

As further pointed out in section *C.*, the project participants have contracted EPMK to execute monthly onsite health checks and/or quarterly onsite inspection visits. System components, sampling system, analysers/measurement devices and the automated monitoring system (AMS) required for the monitoring of the CDM project are covered by these contracts. Regular health check and inspection visit services, respectively, have been conducted by EPMK in August, September and October 2018 and attest good condition and availability of the system (i.e. sampling system, analyser as well as AMS hard- and software and total Delta V DCS system).

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

## B.2. Post-registration changes

### B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies or standardized baselines

>>
No such temporary deviations applied to this monitoring period.

### B.2.2. Corrections

>>
In the course of the verification of 35$^{th}$ monitoring period a post-registration change was submitted to the UNFCCC regarding the following corrections:

- New version number of PDD (→ version 4.2);
- Update of a TAG number;
- Update of parameter table $C_{H2O,t,db,n}$ (moisture content of the gaseous stream).

PRC submission date: 04/01/2018
PRC approval date: 09/03/2018

### B.2.3. Changes to the start date of the crediting period

>>
No such changes have applied to this monitoring period, neither to any previous monitoring periods in the 2nd crediting period.

### B.2.4. Inclusion of monitoring plan

>>
No such inclusion has applied to this monitoring period, neither to any previous monitoring periods.

### B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other applied standards or tools

>>
No such permanent changes have applied to this monitoring period.

### B.2.6. Changes to project design

>>
No such changes have applied to this monitoring period.

## SECTION C. Description of monitoring system

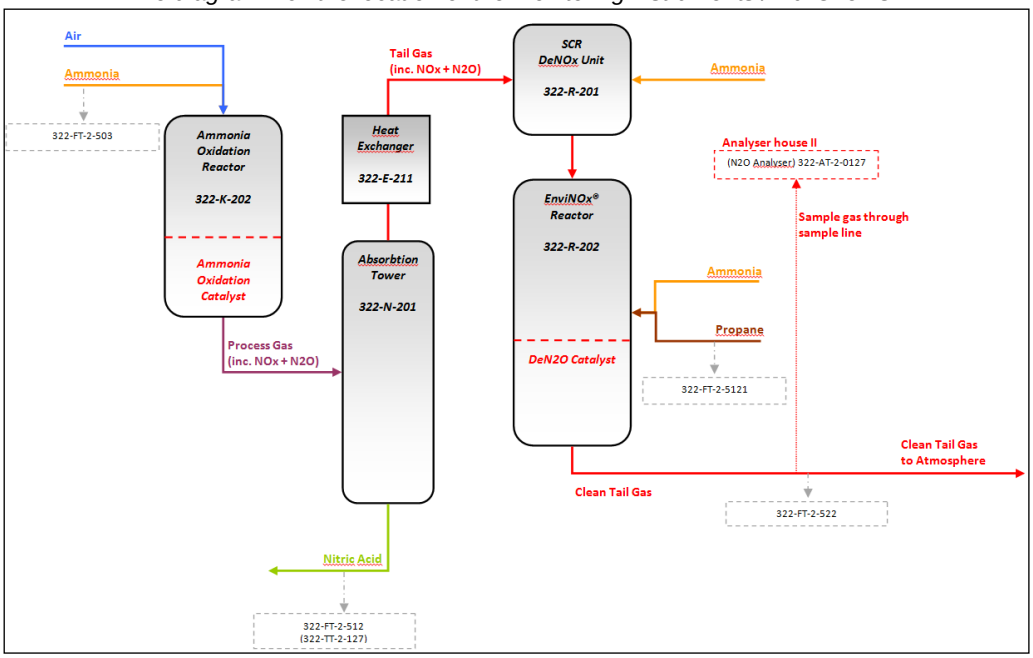
>>

#### (a) Information flow / data collection procedures

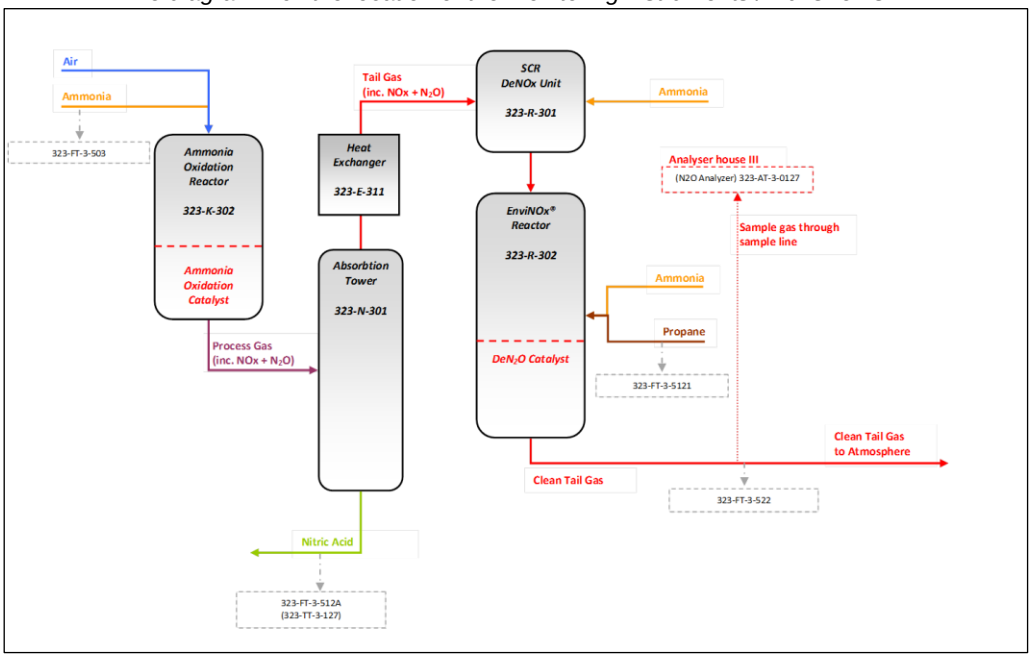
The instruments transmitters continuously provide a 4 – 20 mA analogue signal according to range and units configured. These signals are transmitted to I/O cards (analogue input/output cards) and collected by the Delta V processor. Resulting digital values are made available in the network to be further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

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

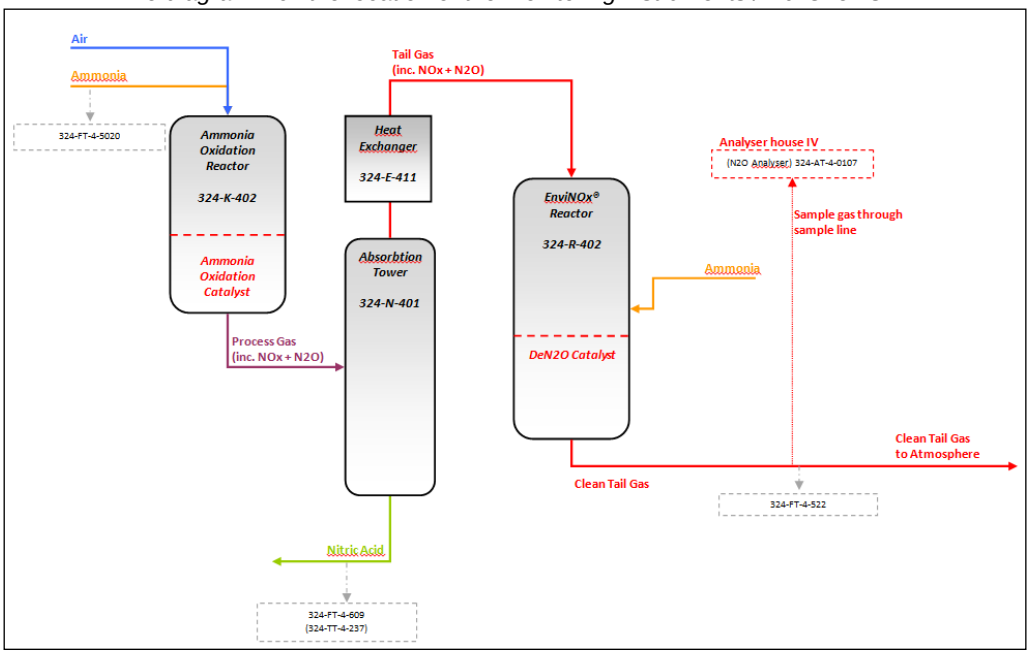
*Line diagram incl. the location of the monitoring instruments / Hu-Chems II*




*Line diagram incl. the location of the monitoring instruments / Hu-Chems III*



*Line diagram incl. the location of the monitoring instruments / Hu-Chems IV*

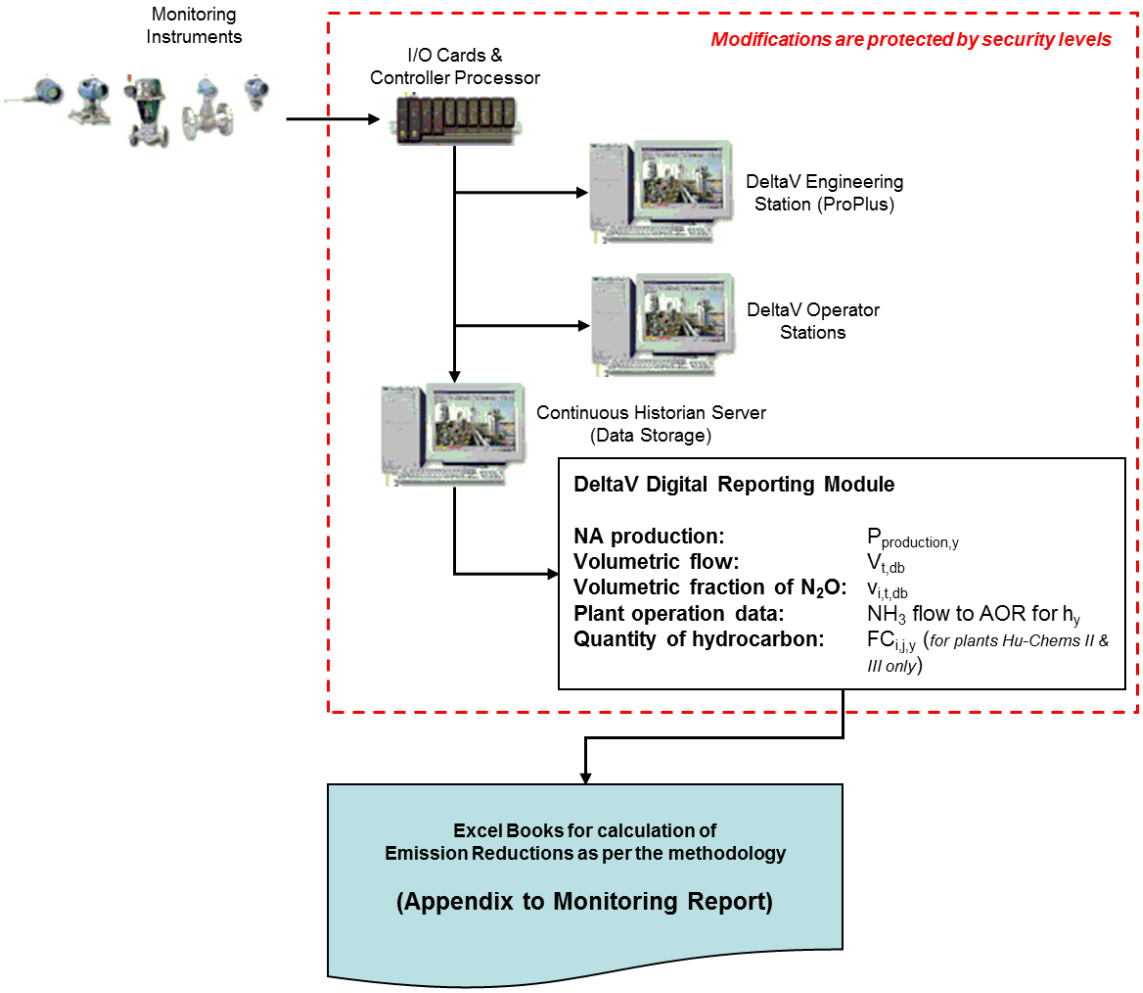



The reporting module of the Delta V system automatically generates aggregated daily reports (separately for each plant as applicable) based on the stored raw data from the continuous historian server. Daily reports contain following kinds of data relevant for calculation of claimed emission reductions and at the required intervals:

- NA production ($P_{production,y}$)
- Operating parameters of the NA plants ($NH_3$ flow to AOR for determining $h_y$)
- Volumetric flow of the gaseous stream ($V_{t,db}$)
- Volumetric fraction of $N_2O$ in the gaseous stream ($v_{i,t,db}$)
- Quantity of hydrocarbon ($FC_{i,j,y}$) – for plants Hu-Chems II and III only

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

*Information flow diagram*




The description of the information flow (incl. data generation, aggregation, recording, calculation and reporting) fully complies with the applied methodology (ACM0019 v2), the PDD and monitoring plan.

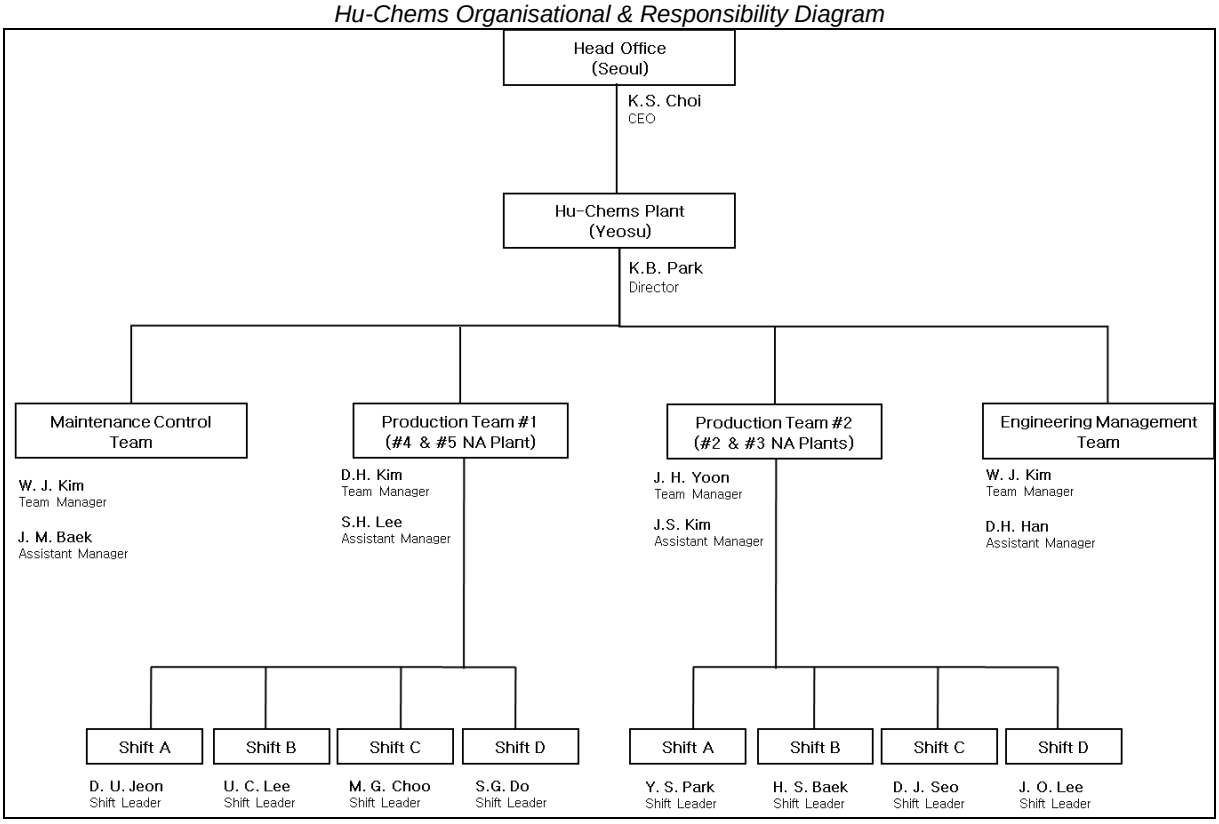
**(b) Roles and responsibilities of personnel**

Project operator is Hu-Chems Fine Chemical Corp. Hu-Chems operates several production units, which produce fine chemical products. Hu-Chems is ISO 9001 and 14001 certified and received the Korean safety and health management system certificate (KGS 18001 & OHSAS 18001). 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.

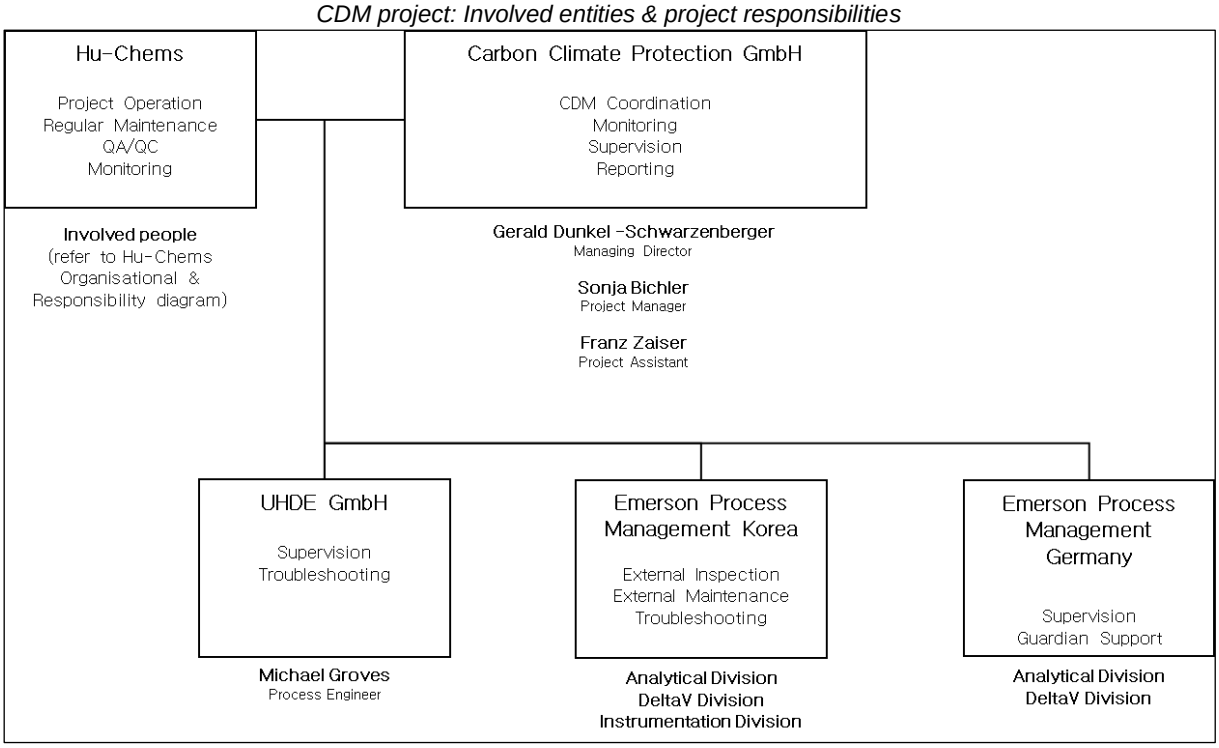
The operating and maintenance personal of the EnviNOx® system has been trained by the technology provider UHDE and the supplier of the digital process control system (Delta V, M/s. process management), further Hu-Chems has established internal training plans on the CDM procedures, operation of the EnviNOx®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

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

*Hu-Chems Organisational & Responsibility Diagram*




*CDM project: Involved entities & project responsibilities*




**(c) Back up plans / Emergency procedures for monitoring system**
**Back up plan for measuring system / Periodic observations of AMS**

- <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 and events are exported and therefore digital available (Excel Files) and can be analysed and evaluated. Malfunction of system components is indicated on the operator console in the control room as an alarm. Occurrence of such an alarm requires the operator to immediately take measures to remedy the problem. This is done by informing Hu-Chems instrument department and CARBON. It is then decided whether the problem can be fixed immediately by them or whether external support is required.

- Back up – regular onsite inspection

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

- Back up – system support & preventive maintenance → Delta V

The Delta V automatic measuring system (AMS) used for plant operation and CDM monitoring was designed by EMERSON, the main supplier of components related to the monitoring system. In order to ensure maximum availability of the Delta V AMS and to prevent deficient handling of data, Hu-Chems has contracted EPMK to execute monthly onsite health checks and/or quarterly onsite inspection visits. Furthermore a 24-hours emergency service and the 24-hours Delta V 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 Delta V AMS and related technical components. Health check reports and inspection visit reports are available and submitted to the DOE for verification.

- Back up – support & preventive maintenance → EnviNOx®, analyser, instruments

Main instruments for CDM monitoring (i.e. sampling system, continuously measuring non-dispersive-infrared (NDIR) analyser used for $N_2O$ detection, etc.) were designed and supplied by EMERSON, the main supplier of components related to the monitoring system. In order to enable high levels of availability and accuracy of instruments, Hu-Chems has contracted EPMK to execute monthly onsite health checks and/or quarterly onsite 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. Exception handling for CDM monitoring instruments is covered by the 24-hours emergency service with guaranteed short-term onsite availability of EMERSON experts. Health check reports and inspection visit reports are available and submitted to the DOE for verification.
Supervision is done based on the daily reports by the technology provider Uhde and EMERSON.

- Back up – calibration & general maintenance → instruments

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

- Back up – onsite 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 analysers), flow sensors and several electrical parts for the analysers. An overview on available parts is made available to the DOE for verification.

- Back up – certified standard gases

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

- Back up – procedures

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

| Organization | Action | Frequency | Output |
|---|---|---|---|
| Delta V | Events & Alarm List | Continuously | Txt & Excel files |
| Hu-Chems | Shift Inspection | 3 times per day | Protocol/Check List |
| Hu-Chems | Daily Inspection | Daily | Protocol/Check List |
| UHDE | Supervision | Daily | Plausibility check |
| EPMK | Health check of AMS System (Hardware & Software) | Monthly | Health Check Reports |
| EPMK | Health Check of Sampling & Analyser system | Monthly | Health Check Reports |
| EPMK | Inspection check of AMS System (Hardware & Software) | Quarterly | Inspection Check Reports |
| EPMK | Inspection check of Sampling & Analyser system | Quarterly | Inspection Check Reports |
| EPMK & suppliers | General Maintenance & Calibration Service of instruments | Regularly, adopted to annual shutdown schedule of plants | Service Reports & Calibration records |

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

**(d) Systematic measures for QA for monitoring data during analyser down times**

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

Specifically, if data for either the $N_2O$ concentration or the volume flow of the stack gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour is replaced with the maximum value of $N_2O$ concentration or volume flow of the tail gas observed during the monitoring period. If data for neither the $N_2O$ concentration nor the volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of $N_2O$ calculated during the monitoring period is applied to any such hour. In such cases, values observed during five operating hours before and after a plant start-up and shutdown are not used for the determination of the maximum values.

## SECTION D. Data and parameters

### D.1. Data and parameters fixed ex ante

#### (a) Data and parameters fixed ex-ante and relevant for all three plants

| Data/Parameter | $EF_{new,y}$ |
|---|---|
| Unit | kg $N_2O$/t $HNO_3$ |
| Description | Baseline $N_2O$ emission factor for nitric acid production in year *y* (related to 100 per cent pure acid) |
| Source of data | According to PDD and methodology ACM0019 v2 |
| Value(s) applied | See table below |
| Choice of data or measurement methods and procedures | N/A |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | The decrease in the value for the baseline emission factor over time is to reflect the technological development. |

| Year | Emission factor (kg $N_2O$/t $HNO_3$) |
|---|---|
| 2014 | 3.50 |
| 2015 | 3.40 |
| 2016 | 3.20 |
| 2017 | 3.00 |
| 2018 | 2.80 |
| 2019 | 2.70 |
| 2020 | 2.50 |
| 2021 | 2.50 |

| Data/Parameter | $GWP_{N2O}$ |
|---|---|
| Unit | t $CO_2e$/t $N_2O$ |
| Description | Global warming potential of $N_2O$ valid for the commitment period |
| Source of data | Relevant decisions by the CMP, according to PDD and methodology ACM0019 v2 |
| Value(s) applied | **298** |
| Choice of data or measurement methods and procedures | None |
| Purpose of data/parameter | Calculation of baseline and project emissions |
| Additional comments | N/A |

#### (b) Data and parameters fixed ex-ante and relevant only for plant Hu-Chems II

| Data/Parameter | $Operating\ pressure_{II}$ |
|---|---|
| Unit | kPa |
| Description | Operating pressure of the ammonia burner of Hu-Chems II |
| Source of data | Manufacturer's specifications |
| Value(s) applied | **872** (equivalent to 8.72 barg) |
| Choice of data or measurement methods and procedures | N/A |

| | |
|---|---|
| Purpose of data/parameter | The parameter is used to determine whether the NA plant operates at a low, medium or high pressure. |
| Additional comments | N/A |

| **Data/Parameter** | **$EF_{historical,II}$** |
|---|---|
| Unit | kg $N_2O$/t $HNO_3$ |
| Description | Historical baseline emission factor of the nitric acid plant of Hu-Chems II |
| Source of data | Historical information from issuance reports of CDM-PDD documents |
| Value(s) applied | **12.09** |
| Choice of data or measurement methods and procedures | Plants that used AM0028 in the first crediting period shall use the lowest baseline emission factor obtained in one calendar year, from 1 January to 31 December, obtained during the first crediting period.<br><br>Plant Hu-Chems II used AM0028 v1 in the first crediting period, accordingly, the lowest baseline emission factor obtained in one calendar year, from 1 January to 31 December, obtained during the first crediting period, is used.<br><br>The calculation of $EF_{historical,II}$ is based on actual data of overall historical baseline emission factors obtained in one calendar year of the NA plant of the first crediting period from issuance reports. |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | This value will remain constant over the second and third crediting period. |

| **Data/Parameter** | **$EF_{default,y,II}$** |
|---|---|
| Unit | kg $N_2O$/t $HNO_3$ |
| Description | Default emission factor according to the operating pressure of the ammonia burner in year *y* (related to 100 per cent pure acid) of Hu-Chems II |
| Source of data | According to PDD and methodology ACM0019 v2 |
| Value(s) applied | Since plant Hu-Chems II is a high-pressure plant, corresponding values given in the methodology apply over the crediting period: |
| Choice of data or measurement methods and procedures | N/A |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | The decrease in the value for the baseline emission factor over time is to reflect the technological development. |

| **Year** | **High pressure (Over 600 kPa)** |
|---|---|
| 2014 | 12.40 |
| 2015 | 12.20 |
| 2016 | 12.00 |
| 2017 | 11.80 |
| 2018 | 11.60 |
| 2019 | 11.40 |
| 2020 | 11.20 |
| 2021 | 11.00 |

| **Data/Parameter** | **$P_{product,max,II}$** |
|---|---|
| Unit | t product (→ t $HNO_3$) |
| Description | Design capacity of nitric acid production during the first crediting period of Hu-Chems II |
| Source of data | Manufacturer's specifications |
| Value(s) applied | **116,800** (365 days) → 30,080 (94 days) |

| | |
|---|---|
| Choice of data or measurement methods and procedures | N/A |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | This parameter is only for project activities applying case 1 as per ACM0019 v2, i.e. for NA plants that have used AM0028 or AM0034 in the first crediting period. |

### (c) Data and parameters fixed ex-ante and relevant only for plant Hu-Chems III

| **Data/Parameter** | **Operating pressure$_{III}$** |
|---|---|
| Unit | kPa |
| Description | Operating pressure of the ammonia burner of Hu-Chems III |
| Source of data | Manufacturer's specifications |
| Value(s) applied | **872** (equivalent to 8.72 barg) |
| Choice of data or measurement methods and procedures | N/A |
| Purpose of data/parameter | The parameter is used to determine whether the NA plant operates at a low, medium or high pressure. |
| Additional comments | N/A |

| **Data/Parameter** | **$EF_{historical,III}$** |
|---|---|
| Unit | kg $N_2O$/t $HNO_3$ |
| Description | Historical baseline emission factor of the nitric acid plant of Hu-Chems III |
| Source of data | Historical information from issuance reports of CDM-PDD documents |
| Value(s) applied | **11.26** |
| Choice of data or measurement methods and procedures | Plants that used AM0028 in the first crediting period shall use the lowest baseline emission factor obtained in one calendar year, from 1 January to 31 December, obtained during the first crediting period.<br><br>Plant Hu-Chems III used AM0028 v1 in the first crediting period, accordingly, the lowest baseline emission factor obtained in one calendar year, from 1 January to 31 December, obtained during the first crediting period, is used.<br><br>The calculation of $EF_{historical,III}$ is based on actual data of overall historical baseline emission factors obtained in one calendar year of the NA plant of the first crediting period from issuance reports. |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | This value will remain constant over the second and third crediting period. |

| **Data/Parameter** | **$EF_{default,y,III}$** |
|---|---|
| Unit | kg $N_2O$/t $HNO_3$ |
| Description | Default emission factor according to the operating pressure of the ammonia burner in year *y* (related to 100 per cent pure acid) of Hu-Chems III |
| Source of data | According to PDD and methodology ACM0019 v2 |

| | |
|---|---|
| Value(s) applied | Since plant Hu-Chems III is a high-pressure plant, corresponding values given in the methodology apply over the crediting period: |

| Year | High pressure (Over 600 kPa) |
|---|---|
| 2014 | 12.40 |
| 2015 | 12.20 |
| 2016 | 12.00 |
| 2017 | 11.80 |
| 2018 | 11.60 |
| 2019 | 11.40 |
| 2020 | 11.20 |
| 2021 | 11.00 |

| | |
|---|---|
| Choice of data or measurement methods and procedures | N/A |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | The decrease in the value for the baseline emission factor over time is to reflect the technological development. |

| **Data/Parameter** | **$P_{product,max,III}$** |
|---|---|
| Unit | t product (→ t $HNO_3$) |
| Description | Design capacity of nitric acid production during the first crediting period of Hu-Chems III |
| Source of data | Manufacturer's specifications |
| Value(s) applied | **116,800** (365 days) → 30,080 (94 days) |
| Choice of data or measurement methods and procedures | N/A |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | This parameter is only for project activities applying case 1 as per ACM0019 v2, i.e. for NA plants that have used AM0028 or AM0034 in the first crediting period. |

### (d) Data and parameters fixed ex-ante and relevant only for plant Hu-Chems IV

| **Data/Parameter** | **Operating $pressure_{IV}$** |
|---|---|
| Unit | kPa |
| Description | Operating pressure of the ammonia burner of Hu-Chems IV |
| Source of data | Manufacturer's specifications |
| Value(s) applied | **335** (equivalent to 3.35 barg) |
| Choice of data or measurement methods and procedures | N/A |
| Purpose of data/parameter | The parameter is used to determine whether the NA plant operates at a low, medium or high pressure. |
| Additional comments | N/A |

| **Data/Parameter** | **$EF_{historical,IV}$** |
|---|---|
| Unit | kg $N_2O$/t $HNO_3$ |
| Description | Historical baseline emission factor of the nitric acid plant of Hu-Chems IV |
| Source of data | Historical information from issuance reports of CDM-PDD documents |
| Value(s) applied | **5.70** |

| | |
|---|---|
| Choice of data or measurement methods and procedures | Plants that used AM0028 in the first crediting period shall use the lowest baseline emission factor obtained in one calendar year, from 1 January to 31 December, obtained during the first crediting period.<br><br>Plant Hu-Chems IV used AM0028 v1 in the first crediting period, accordingly, the lowest baseline emission factor obtained in one calendar year, from 1 January to 31 December, obtained during the first crediting period, is used.<br><br>The calculation of $EF_{historical,IV}$ is based on actual data of overall historical baseline emission factors obtained in one calendar year of the NA plant of the first crediting period from issuance reports. |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | This value will remain constant over the second and third crediting period. |

| **Data/Parameter** | **$EF_{default,y,IV}$** |
|---|---|
| Unit | kg $N_2O$/t $HNO_3$ |
| Description | Default emission factor according to the operating pressure of the ammonia burner in year *y* (related to 100 per cent pure acid) of Hu-Chems IV |
| Source of data | According to PDD and methodology ACM0019 v2 |
| Value(s) applied | Since plant Hu-Chems IV is a medium pressure plant, corresponding values given in the methodology apply over the crediting period: |

| Year | Medium pressure (200 – 600 kPa) |
|---|---|
| 2014 | 8.20 |
| 2015 | 8.00 |
| 2016 | 7.80 |
| 2017 | 7.60 |
| 2018 | 7.40 |
| 2019 | 7.20 |
| 2020 | 7.00 |
| 2021 | 6.80 |

| | |
|---|---|
| Choice of data or measurement methods and procedures | N/A |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | The decrease in the value for the baseline emission factor over time is to reflect the technological development. |

| **Data/Parameter** | **$P_{product,max,IV}$** |
|---|---|
| Unit | t product (→ t $HNO_3$) |
| Description | Design capacity of nitric acid production during the first crediting period of Hu-Chems IV |
| Source of data | Manufacturer's specifications |
| Value(s) applied | **467,200** (365 days) → 120,320 (94 days) |
| Choice of data or measurement methods and procedures | N/A |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | This parameter is only for project activities applying case 1 as per ACM0019 v2, i.e. for NA plants that have used AM0028 or AM0034 in the first crediting period. |

**(e) Parameters fixed ex-ante from "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" and relevant for all three plants**

| **Data/Parameter** | **$R_u$** |
|---|---|
| Unit | Pa.m³/kmol.K |
| Description | Universal ideal gases constant |
| Source of data | Tool to determine the mass flow of a greenhouse gas in a gaseous stream |
| Value(s) applied | **8,314** |
| Choice of data or measurement methods and procedures | Specified in the tool |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | N/A |

| **Data/Parameter** | **$MM_i$** |
|---|---|
| Unit | kg/kmol |
| Description | Molecular mass of greenhouse gas i |
| Source of data | Tool to determine the mass flow of a greenhouse gas in a gaseous stream |
| Value(s) applied | **Compound** / **Structure** / **Molecular mass (kg/kmol)**: Nitrous oxide / $N_2O$ / 44.02 |
| Choice of data or measurement methods and procedures | Specified in the tool |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | N/A |

| **Data/Parameter** | **$P_n$** |
|---|---|
| Unit | Pa |
| Description | Total pressure at normal conditions |
| Source of data | Tool to determine the mass flow of a greenhouse gas in a gaseous stream |
| Value(s) applied | **101,325** |
| Choice of data or measurement methods and procedures | Specified in the tool |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | This parameter is used to determine the mass flow of the $N_2O$ in the tail gas. |

| **Data/Parameter** | **$T_n$** |
|---|---|
| Unit | K |
| Description | Temperature at normal conditions |
| Source of data | Tool to determine the mass flow of a greenhouse gas in a gaseous stream |
| Value(s) applied | **273.15** |
| Choice of data or measurement methods and procedures | Specified in the tool |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | This parameter is used to determine the mass flow of the $N_2O$ in the tail gas. |

## D.2. Data and parameters monitored

Describing parameters sometimes mention “Annual”, “Yearly” or “in year y” as it is defined in the methodology ACM0019 v2, respective tools and the Monitoring Plan and it refers to the respective parameter during or related to a year “y”. It shall be considered that “Annual”, “Yearly” and “year y” is understood as the monitoring period covered by this report unless otherwise described.

### (a) Data and parameters monitored and relevant only for plant Hu-Chems II

| **Data/Parameter** | **$P_{production,y,II}$** |
|---|---|
| Unit | $tHNO_3$ |
| Description | Nitric acid produced in year *y* of Hu-Chems II |
| Measured/calculated/ default | Measured |
| Source of data | Production reports (based on measurements from project participants)<br><br>NA flow and density are measured with a coriolis flow meter, temperature with a temperature measurement and concentration is determined based on measured parameters. Values are sent to the DCS (control room), and the NA production (as 100% $HNO_3$) is calculated based on mass flow and $HNO_3$ concentration. Final production values are exported in production reports through the Delta V system. Please refer to section *C. Information Flow* of this MR. |
| Value(s) of monitored parameter | **24,618**<br>An excel book containing recorded hourly values is attached to this MR. |
| Monitoring equipment | Meter location: Located in the NA line, downstream of the absorption tower (322-N-201). Please refer to section *C Line diagram* of this MR.<br><br>**322-FT-2-512**<br>Type: Coriolis Flowmeter<br>Accuracy class: ± 0.35%<br>Calibration frequency: 60 months<br>Serial number: 14325173<br>Date of last calibration: 12/08/2016 (Validity: 11/08/2021)<br><br>**322-TI-2-127**<br>Type: Temperature Converter<br>Accuracy class: ± 0.15% of span<br>Calibration frequency: 48 months<br>Serial Number: 51305907-175<br>Date of last calibration: 23/08/2017 (Validity: 22/08/2021) |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: 10 seconds<br>Recording: Hourly |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system of this MR and respective subitems Back Up Plans for measuring systems / Periodic observation of the AMS and Systematic measures for QA for monitoring data during analyser down times.* |
| Purpose of data/parameter | Calculation of baseline emissions |

| | |
|---|---|
| Additional comments | $P_{NA,h,II}$ (NA produced in hour h of Hu-Chems II) represents the hourly value of $P_{production,y,II}$ and is used for determining $h_{r,y,II}$ as per applied methodology. |

| **Data/Parameter** | **$h_{y,II}$** |
|---|---|
| Unit | h |
| Description | Number of hours of operation in year *y* of Hu-Chems II |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **2,075**<br>An excel book containing recorded hourly values is attached to this MR. |
| Monitoring equipment | Meter location: Located in the ammonia supply line, upstream of the ammonia oxidation reactor (322-K-202). Please refer to section *C. Line diagram* of this MR.<br><br>**322-FT-2-503**<br>Type: Differential pressure transmitter<br>Accuracy class: ± 0.5% of span<br>Calibration frequency: 48 months<br>Serial number: 2052133<br>Date of last calibration: 24/08/2017 (Validity: 23/08/2021)<br><br>**322-TT-2-103**<br>Type: Temperature transmitter<br>Accuracy class: ± 0.15% of span<br>Calibration frequency: 48 months<br>Serial number: 1809806<br>Date of last calibration: 24/08/2017 (Validity: 23/08/2021)<br><br>**322-PT-2-303**<br>Type: Pressure transmitter<br>Accuracy class: ± 0.1% of span<br>Calibration frequency: 48 months<br>Serial number: 2052135<br>Date of last calibration: 24/08/2017 (Validity: 23/08/2021) |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: 10 seconds<br>Recording: Hourly |
| Calculation method (if applicable) | The flow of $NH_3$ to the ammonia oxidation reactor indicates the operational status. In case, the volume flow of $NH_3$ to the ammonia oxidation reactor lies above the threshold of 500 $Nm^3/h$ during an hour, the reactor is considered in operation during the hour. |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of baseline and project emissions |
| Additional comments | Records to be maintained during project's lifetime |

| **Data/Parameter** | **$h_{r,y,II}$** |
|---|---|
| Unit | h |

| | |
|---|---|
| Description | For tertiary $N_2O$ abatement, Number of hours (*h*) in year *y* where the abatement system is by-passed, underperforming or failed of Hu-Chems II |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **15** |
| Monitoring equipment | NA plant Hu-Chems II has used AM0028 in the first crediting period, accordingly the abatement system is deemed to be by-passed, not working or failed in the hour h in year y if:<br>$F_{N2O,tailgas,h,II} > EF_{existing,y,II} \times P_{NA,h,II}$<br>The parameters mentioned above are determined and measured/monitored as explained in the respective sections of this MR:<br>• $P_{NA,h,II}$ – determination is based on monitored parameter $P_{production,y,II}$<br>• $F_{N2O,tail\ gas,h,II}$ – determination is based on monitored parameters $V_{t,db,n,II}$, $v_{i,t,db,II}$ and $C_{H2O,t,db,n,II}$<br>• $EF_{existing,y,II}$ – determination is based on ex-ante determined parameters $EF_{historical,II}$ and $EF_{default,y,II}$ |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: Hourly<br>Recording: Hourly |
| Calculation method (if applicable) | (Refer to "Monitoring equipment" above) |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of baseline and project emissions |
| Additional comments | Records to be maintained during project's lifetime.<br>The parameter $P_{NA,h,II}$ as used in the formula (NA produced in hour h of Hu-Chems II) represents the hourly value of $P_{production,y,II}$. |

<u>Parameters from "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"</u>

| **Data/Parameter** | **$V_{t,db,II}$** |
|---|---|
| Unit | $m^3$ dry gas/h |
| Description | Volumetric flow of the gaseous stream in time interval t on a dry basis of Hu-Chems II |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **45,974**<br>The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to this MR. |

| | |
|---|---|
| Monitoring equipment | Meter location: Located in the stack at the end of the tail gas line<br><br>**322-FT-2-522**<br>Type: Annubar / Differential pressure transmitter<br>Accuracy class: ± 2% of span<br>Serial number: 1240833<br>Calibration frequency: 60 months (QAL 2 reference measurement)<br>Date of last QAL 2: 27/09/2017 – 29/09/2017 (Validity: 26/09/2022)<br>Date of last AST: 30/08/2018 – 31/08/2018 |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: Every 1 second<br>Recording: Hourly |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*). Calibration against a primary device provided by an independent accredited laboratory follows EN 14181 requirements (QAL 2 reference measurement).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | Option A parameter according to the applied *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream".*<br>The volumetric flow is determined and expressed at normal conditions ($P_n$ = 101,325 Pa; $T_n$ = 273.15 K) according to applied methodology. Monitoring of actual conditions ($P_{t,II}$, $T_{t,II}$) is therefore not necessary, as per the applied methodology.<br>Dry basis flow measurement, since gaseous stream is considered to be dry (refer to parameter $C_{H2O,t,db,n,II}$). |

| **Data/Parameter** | $v_{i,t,db,II}$ |
|---|---|
| Unit | m³ gas i/m³ dry gas (→ m³ $N_2O$ / m³ dry gas) |
| Description | Volumetric fraction of greenhouse gas i in a time interval t on a dry basis of Hu-Chems II |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **$7.85*10^{-5}$**<br>The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to this MR. |

| | |
|---|---|
| Monitoring equipment | Meter location: Sample take-off is located in the tail gas line, downstream of the EnviNO$_X$® reactor (322-R-202), and leads (via sample gas line) to the locked analyser house II (located closely to EnviNOx® reactor of Hu-Chems II), where the analyser is installed. Please refer to section *C. Line diagram* of this MR.<br><br>**322-AT-2-0127**<br>Type: NDIR Analyser<br>Accuracy class: ±1% (zero/span)<br>Serial number: 990861497812<br>Calibration frequency: 60 months (QAL 2 reference measurement)<br>Date of last QAL 2: 27/09/2017 – 29/09/2017 (Validity: 26/09/2022)<br>Date of last AST: 30/08/2018 – 31/08/2018 |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: Every 1 second<br>Recording: Hourly |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*). Calibration against a primary device provided by an independent accredited laboratory follows EN 14181 requirements (QAL 2 reference measurement).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*.<br><br>EPMK has been mandated to conduct monthly analyser health checks and quarterly inspection checks to ensure good instrument condition. |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | The volumetric fraction of $N_2O$ is determined and expressed at normal conditions ($P_n$ = 101,325 Pa; $T_n$ = 273.15 K) according to the applied methodology. Monitoring of actual conditions ($P_{t,II}$, $T_{t,II}$) is therefore not necessary, as per the applied methodology. |

| **Data/Parameter** | **$C_{H2O,t,db,n,II}$** |
|---|---|
| Unit | mg $H_2O/m^3$ dry gas |
| Description | Moisture content of the gaseous stream at normal conditions, in time interval t of Hu-Chems II |
| Measured/calculated/ default | Measured |
| Source of data | Measurements according to the USEPA CF42 method 4 – Gravimetric determination of water content (Measurement Report) |
| Value(s) of monitored parameter | **11,000** (equivalent to 0.011 kg $H_2O/m^3$ dry gas) |
| Monitoring equipment | As per USEPA CF42 method 4 – Gravimetric determination of water content |
| Measuring/reading/recording frequency | As per the PDD, measurements coincide with the Annual Surveillance Test or the calibration of the flow meter for the gaseous stream (QAL 2), both associated with requirements of the EN 14181 standard. Repeated measurements were conducted during last AST. |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | According to USEPA CF 42 method 4 |
| Purpose of data/parameter | Calculation of project emissions |

| | |
|---|---|
| Additional comments | As per the applied "Tool to determine the mass flow of a greenhouse gas in a gaseous stream ", the flow and volumetric fraction may be measured on a dry basis or wet basis. The tool covers the possible measurement combinations, providing six different calculation options to determine the mass flow of a particular greenhouse gas (Option A to F).<br><br>As described in the PDD, the option chosen for this project activity is Option A, requiring to demonstrate, that the gaseous stream is dry, whereas the tool suggests two ways to do this:<br>(a) Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg $H_2O/m^3$ dry gas; or<br>(b) Demonstrate that the temperature of the gaseous stream ($T_t$) is less than 60°C (333.15 K) at the flow measurement point.<br><br>In the case of this project activity, the first option (a) has been chosen.<br><br>The measured values as noted above show that the moisture content of the gaseous stream is significantly below the maximum threshold value of 0.05 kg $H_2O/m^3$ dry gas. |

Since the volumetric fraction of $N_2O$ and the volumetric flow of the gaseous stream are determined and expressed at normal conditions ($P_n$ = 101,325 Pa; $T_n$ = 273.15 K), the actual conditions ($P_{t,II}$, $T_{t,II}$) are not required to be monitored, as per the applied methodology.

Parameters from "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion"

| **Data/Parameter** | **$FC_{i,j,y,II}$** |
|---|---|
| Unit | t/yr |
| Description | Quantity of fuel type i combusted in process j during the year y of Hu-Chems II |
| Measured/calculated/ default | Measured |
| Source of data | Onsite measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **80.11**<br>An excel book containing recorded hourly values is attached to this MR. |
| Monitoring equipment | Meter location: Located in the propane gas line, upstream of the Envi$NO_X$® reactor (322-R-202). Please refer to section *C. Line diagram* of this MR.<br><br>**322-FT-2-5121**<br>Type: Coriolis flowmeter<br>Accuracy class: ± 0.35%<br>Calibration frequency: 60 months<br>Serial number: 14126211<br>Date of last calibration: 18/08/2017 (Validity: 17/08/2022) |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: Every 10 seconds<br>Recording: Hourly |
| Calculation method (if applicable) | N/A |

| | |
|---|---|
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>As far as feasible, the consistency of metered fuel consumption quantities is cross-checked for plausibility by an annual energy balance that is based on purchased quantities and stock changes.<br><br>Furthermore, as far as feasible, where the purchased fuel invoices can be identified specifically for the CDM project (and the specific plant, respectively), the metered fuel consumption quantities are cross-checked with available purchase invoices from the financial records.<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | The fuel (exactly: hydrocarbon used as reducing agent) applied in the plant is LPG with a major mass fraction of propane (expected level above 95%). |

| **Data/Parameter** | $w_{C,i,y,II}$ |
|---|---|
| Unit | tC/t |
| Description | Weighted average mass fraction of carbon in fuel type i in year y of Hu-Chems II |
| Measured/calculated/ default | Measured (by hydrocarbon supplier) |
| Source of data | Certificate of hydrocarbon supplier |
| Value(s) of monitored parameter | **0.82** |
| Monitoring equipment | Composition of the delivered hydrocarbon is measured by the supplier and provided on specific certificates. |
| Measuring/reading/recording frequency | Measuring: In order to assure conservativeness a certificate from the hydrocarbon supplier is requested at least on a yearly basis. |
| Calculation method (if applicable) | Composition of delivered hydrocarbon is available on specific certificates provided by the supplier. The mass fraction of carbon is obtained regularly, from which weighted average annual values are calculated. |
| QA/QC procedures | It is verified, if the applied value is within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | Applicable where Option A of the "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion" is used.<br>The fuel (exactly: hydrocarbon used as reducing agent) applied in the plant is LPG with a major mass fraction of propane (about 95%). |

### (b) Data and parameters monitored and relevant only for plant Hu-Chems III

| **Data/Parameter** | $P_{production,y,III}$ |
|---|---|
| Unit | $tHNO_3$ |
| Description | Nitric acid produced in year *y* of Hu-Chems III |
| Measured/calculated/ default | Measured |

| | |
|---|---|
| Source of data | Production reports (based on measurements from project participants)<br><br>NA flow and density are measured with a coriolis flow meter, temperature with a temperature measurement and concentration is determined based on measured parameters. Values are sent to the DCS (control room), and the NA production (as 100% $HNO_3$) is calculated based on mass flow and $HNO_3$ concentration. Final production values are exported in production reports through the Delta V system. Please refer to section *C. Information Flow* of this MR. |
| Value(s) of monitored parameter | **22,323**<br>An excel book containing recorded hourly values is attached to this MR. |
| Monitoring equipment | Meter location: Located in the NA line, downstream of the absorption tower (323-N-301). Please refer to section *C. Line diagram* of this MR.<br><br>**323-FT-3-512**<br>Type: Coriolis Flowmeter<br>Accuracy class: ± 0.35%<br>Calibration frequency: 60 months<br>Serial number: 14266864<br>Date of last calibration: 18/08/2017 (Validity: 17/08/2022)<br><br>**323-TI-3-127**<br>Type: Temperature Converter<br>Accuracy class: ± 0.15% of span<br>Calibration frequency: 48 months<br>Serial Number: 51309204-125<br>Date of last calibration: 26/07/2018 (Validity: 25/07/2022) |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: 10 seconds<br>Recording: Hourly |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | The parameter $P_{NA,h,III}$ (NA produced in hour h of Hu-Chems III) represents the hourly value of $P_{production,y,III}$ and is used for determining $h_{r,y,III}$ as per the applied methodology. |

| **Data/Parameter** | **$h_{y,III}$** |
|---|---|
| Unit | h |
| Description | Number of hours of operation in year *y* of Hu-Chems III |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **1,884**<br>An excel book containing recorded hourly values is attached to this MR. |

| | |
|---|---|
| Monitoring equipment | Meter location: Located in the ammonia supply line, upstream of the ammonia oxidation reactor (323-K-302). Please refer to section *C. Line diagram* of this MR.<br><br>**323-FT-3-503**<br>Type: Differential pressure transmitter<br>Accuracy class: ± 0.5% of span<br>Calibration frequency: 48 months<br>Serial number: 2052134<br>Date of last calibration: 25/07/2018 (Validity: 24/07/2022)<br><br>**323-TT-3-103**<br>Type: Temperature transmitter<br>Accuracy class: ± 0.15% of span<br>Calibration frequency: 48 months<br>Serial number: 1809794<br>Date of last calibration: 26/07/2018 (Validity: 25/07/2022)<br><br>**323-PT-3-303**<br>Type: Pressure transmitter<br>Accuracy class: ± 0.1% of span<br>Calibration frequency: 48 months<br>Serial number: 2052136<br>Date of last calibration: 27/07/2018 (Validity: 26/07/2022) |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: 10 Seconds<br>Recording: Hourly |
| Calculation method (if applicable) | The flow of $NH_3$ to the ammonia oxidation reactor indicates the operational status. In case, the volume flow of $NH_3$ to the ammonia oxidation reactor lies above the threshold of 500 $Nm^3/h$ during an hour, the reactor is considered in operation during the hour. |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems* / *Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of baseline and project emissions |
| Additional comments | Records to be maintained during project's lifetime. |

| **Data/Parameter** | **$h_{r,y,III}$** |
|---|---|
| Unit | h |
| Description | For tertiary $N_2O$ abatement, Number of hours (*h*) in year *y* where the abatement system is by-passed, underperforming or failed of Hu-Chems III |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **9** |

| | |
|---|---|
| Monitoring equipment | NA plant Hu-Chems III has used AM0028 in the first crediting period, accordingly the abatement system is deemed to be by-passed, not working or failed in the hour h in year y if:<br>$F_{N2O,tailgas,h,III} > EF_{existing,y,III} \times P_{NA,h,III}$<br>The parameters mentioned above are determined and measured/monitored as explained in the respective sections of this MR:<br>• $P_{NA,h,III}$ – determination is based on the monitored parameter $P_{production,y,III}$<br>• $F_{N2O,tail\ gas,h,III}$ – determination is based on the monitored parameters $V_{t,db,n,III}$, $v_{i,t,db,III}$ and $C_{H2O,t,db,n,III}$<br>• $EF_{existing,y,III}$ – determination is based on the ex-ante determined parameters $EF_{historical,III}$ and $EF_{default,y,III}$ |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: Hourly<br>Recording: Hourly |
| Calculation method (if applicable) | (Refer to "Monitoring equipment" above) |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of baseline and project emissions |
| Additional comments | Records to be maintained during project's lifetime.<br>The parameter $P_{NA,h,III}$ as used in the formula (NA produced in hour h of Hu-Chems III) represents the hourly value of $P_{production,y,III.}$ |

Parameters from "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"

| **Data/Parameter** | **$V_{t,db,III}$** |
|---|---|
| Unit | $m^3$ dry gas/h |
| Description | Volumetric flow of the gaseous stream in time interval t on a dry basis of Hu-Chems III |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **46,715**<br>The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to this MR. |
| Monitoring equipment | Meter location: Located in the stack at the end of the tail gas line.<br><br>**323-FT-3-522**<br>Type: Annubar / Differential pressure transmitter<br>Accuracy class: ± 2% of span<br>Calibration frequency: 60 months (QAL 2 reference measurement)<br>Serial number: 1240832<br>Date of last QAL 2: 06/ – 08/09/2016 (Validity: 05/09/2021)<br>Date of penultimate AST: 31/08/2017 – 01/09/2017<br>Date of last AST: 29/08/2018 – 30/08/2018 |

| | |
|---|---|
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: Every 1 second<br>Recording: Hourly |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*). Calibration against a primary device provided by an independent accredited laboratory follows EN 14181 requirements (QAL 2 reference measurement).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | Option A parameter according to the applied *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"*.<br>The volumetric flow is determined and expressed at normal conditions ($P_n$ = 101,325 Pa; $T_n$ = 273.15 K) according to the applied methodology.<br>Monitoring of actual conditions ($P_{t,III}$, $T_{t,III}$) is therefore not necessary as per the applied methodology.<br>Dry basis flow measurement, since gaseous stream is considered to be dry (refer to parameter $C_{H2O,t,db,n,III}$). |

| **Data/Parameter** | **$v_{i,t,db,III}$** |
|---|---|
| Unit | m³ gas i/m³ dry gas (→ m³ $N_2O$ / m³ dry gas) |
| Description | Volumetric fraction of greenhouse gas i in a time interval t on a dry basis of Hu-Chems III |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **$4.47*10^{-5}$**<br>The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to this MR. |
| Monitoring equipment | Meter location: Sample take-off is located in the tail gas line, downstream of the EnviNO$_X$® reactor (323-R-302) and leads (via sample gas line) to the locked analyser house III (located closely to EnviNOx® reactor of Hu-Chems III), where the analyser is installed. Please refer to *section C. Line diagram* of this MR.<br><br>**323-AT-3-0127**<br>Type: NDIR Analyser<br>Accuracy class: ±1% (zero/span)<br>Calibration frequency: 60 months (QAL 2 reference measurement)<br>Serial number: 990861497815<br>Date of last QAL 2: 06/ – 08/09/2016 (Validity: 05/09/2021)<br>Date of penultimate AST: 31/08/2017 – 01/09/2017<br>Date of last AST: 29/08/2018 – 30/08/2018 |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: Every 1 second<br>Recording: Hourly |
| Calculation method (if applicable) | N/A |

| | |
|---|---|
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*). Calibration against a primary device provided by an independent accredited laboratory follows EN 14181 requirements (QAL 2 reference measurement).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*.<br><br>EPMK has been mandated to conduct monthly analyser health checks and quarterly inspection checks to ensure good instrument condition. |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | The volumetric fraction of $N_2O$ is determined and expressed at normal conditions ($P_n$ = 101,325 Pa; $T_n$ = 273.15 K) according to the applied methodology. Monitoring of actual conditions ($P_{t,III}$, $T_{t,III}$) is therefore not necessary as per the applied methodology. |

| **Data/Parameter** | **$C_{H2O,t,db,n,III}$** |
|---|---|
| Unit | mg $H_2O/m^3$ dry gas |
| Description | Moisture content of the gaseous stream at normal conditions, in time interval t of Hu-Chems III |
| Measured/calculated/ default | Measured |
| Source of data | Measurements according to the USEPA CF42 method 4 – Gravimetric determination of water content (Measurement Report) |
| Value(s) of monitored parameter | **10,000** (equivalent to 0.010 kg $H_2O/m^3$ dry gas) |
| Monitoring equipment | As per USEPA CF42 method 4 – Gravimetric determination of water content |
| Measuring/reading/recording frequency | As per the PDD, measurements coincide with the Annual Surveillance Test or the calibration of the flow meter for the gaseous stream (QAL 2), both associated with requirements of the EN 14181 standard. Repeated measurements were conducted during last AST. |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | According to USEPA CF 42 method 4 |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | As per the applied "Tool to determine the mass flow of a greenhouse gas in a gaseous stream", the flow and volumetric fraction may be measured on a dry or wet basis. The tool covers the possible measurement combinations, providing six different calculation options to determine the mass flow of a particular greenhouse gas (option A to F). As described in the PDD, the option chosen for this project activity is option A, requiring to demonstrate, that the gaseous stream is dry, whereas the tool suggests two ways to do this:<br>(a) Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg $H_2O/m^3$ dry gas; or<br>(b) Demonstrate that the temperature of the gaseous stream ($T_t$) is less than 60°C (333.15 K) at the flow measurement point.<br>In the case of this project activity, the first option (a) has been chosen.<br><br>The measured values as noted above show that the moisture content of the gaseous stream is significantly below the maximum threshold value of 0.05 kg $H_2O/m^3$ dry gas. |

Since the volumetric fraction of $N_2O$ and the volumetric flow of the gaseous stream are both determined and expressed at normal conditions ($P_n$ = 101,325 Pa; $T_n$ = 273.15 K), the actual conditions ($P_{t,III}$, $T_{t,III}$) are not required to be monitored, as per the applied methodology.

Parameters from "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion"

| **Data/Parameter** | **$FC_{i,j,y,III}$** |
|---|---|
| Unit | t/yr |
| Description | Quantity of fuel type i combusted in process j during the year y of Hu-Chems III |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **77.07**<br>An excel book containing recorded hourly values is attached to this MR. |
| Monitoring equipment | Meter location: Located in the propane gas line, upstream of the Envi$NO_X$® reactor (323-R-302). Please refer to section *C. Line diagram* of this MR.<br><br>**323-FT-3-5121**<br>Type: Coriolis flow meter<br>Accuracy class: ± 0.35%<br>Calibration frequency: 60 months<br>Serial number: 14125454<br>Date of last calibration: 12/08/2016 (Validity: 11/08/2021) |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: Every 10 seconds<br>Recording: Hourly |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>As far as feasible, the consistency of metered fuel consumption quantities is cross-checked for plausibility by an annual energy balance that is based on purchased quantities and stock changes. Furthermore and as far as feasible, where the purchased fuel invoices can be identified specifically for the CDM project (and the specific plant, respectively), the metered fuel consumption quantities are cross-checked with available purchase invoices from the financial records.<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | The fuel (exactly: hydrocarbon used as reducing agent) applied in the plant is LPG with a major mass fraction of propane (expected levels above 95%). |

| **Data/Parameter** | **$w_{C,i,y,III}$** |
|---|---|
| Unit | tC/t |
| Description | Weighted average mass fraction of carbon in fuel type i in year y of Hu-Chems III |

| | |
|---|---|
| Measured/calculated/ default | Measured (by hydrocarbon supplier) |
| Source of data | Certificate of hydrocarbon supplier |
| Value(s) of monitored parameter | **0.82** |
| Monitoring equipment | Composition of the delivered hydrocarbon is measured by the supplier and provided on specific certificates. |
| Measuring/reading/recording frequency | Measuring: In order to assure conservativeness a certificate from the hydrocarbon supplier is requested at least on a yearly basis. |
| Calculation method (if applicable) | Composition of delivered hydrocarbon is available on specific certificates provided by the supplier. The mass fraction of carbon is obtained regularly, from which weighted average annual values are calculated. |
| QA/QC procedures | It is verified, if the applied value is within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | Applicable where Option A of the "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion" is used.<br>The fuel (exactly: hydrocarbon used as reducing agent) applied in the plant is LPG with a major mass fraction of propane (about 95%). |

### (c) Data and parameters monitored and relevant only for plant Hu-Chems IV

| **Data/Parameter** | **$P_{production,y,IV}$** |
|---|---|
| Unit | $tHNO_3$ |
| Description | Nitric acid produced in year *y* of Hu-Chems IV |
| Measured/calculated/ default | Measured |
| Source of data | Production reports (based on measurements from project participants)<br><br>The NA flow and density are measured with a coriolis flow meter, temperature with a temperature measurement and concentration is determined based on measured parameters. Values are sent to the DCS (control room), and the NA production (as 100% $HNO_3$) is calculated based on mass flow and $HNO_3$ concentration. Final production values are exported in production reports through the Delta V System. Please refer to section *C. Information Flow* of this MR. |
| Value(s) of monitored parameter | **74,440**<br>An excel book containing recorded hourly values is attached to this MR. |
| Monitoring equipment | Meter location: Located in the NA line, downstream of the absorption tower (324-N-401). Please refer to section *C. Line diagram* of this MR.<br><br>**324-FT-4-609**<br>Type: Coriolis Flowmeter<br>Accuracy class: ± 0.35%<br>Calibration frequency: 60 months<br>Serial number: 14735413<br>Date of last calibration: 18/10/2017 (Validity: 17/10/2022)<br><br>**324-TT-4-237**<br>Type: Temperature Transmitter<br>Accuracy class: ± 0.15% of span<br>Calibration frequency: 48 months<br>Serial number: 966595<br>Date of last calibration: 17/04/2018 (Validity: 16/04/2022) |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: 10 seconds<br>Recording: Hourly |

| | |
|---|---|
| Calculation method (if applicable) | N/A |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of baseline emissions |
| Additional comments | The parameter $P_{NA,h,IV}$ (NA produced in hour h of Hu-Chems IV) represents the hourly value of $P_{production,y,IV}$ and is used for determining $h_{r,y,IV}$ as per the applied methodology. |

| **Data/Parameter** | **$h_{y,IV}$** |
|---|---|
| Unit | h |
| Description | Number of hours of operation in year *y* of Hu-Chems IV |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **1,893**<br>An excel book containing recorded hourly values is attached to this MR. |
| Monitoring equipment | Meter location: Located in the ammonia supply line, upstream of the ammonia oxidation reactor (324-K-402). Please refer to section *C. Line diagram* of this MR.<br><br>**324-FT-4-5020**<br>Type: Coriolis flowmeter<br>Accuracy class: ± 0.35%<br>Calibration frequency: 60 months<br>Serial number: 14137655<br>Date of last calibration: 27/05/2014 (Validity: 26/05/2019) |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: 10 seconds<br>Recording: Hourly |
| Calculation method (if applicable) | The flow of $NH_3$ to the ammonia oxidation reactor indicates the operational status. In case, the volume flow of $NH_3$ to the ammonia oxidation reactor lies above the threshold of 500 $Nm^3/h$ during an hour, the reactor is considered in operation during the hour. |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of baseline and project emissions |
| Additional comments | Records to be maintained during project's lifetime. |

| **Data/Parameter** | **$h_{r,y,IV}$** |
|---|---|
| Unit | h |
| Description | For tertiary $N_2O$ abatement, Number of hours (*h*) in year *y* where the abatement system is by-passed, underperforming or failed of Hu-Chems IV |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **3** |
| Monitoring equipment | NA plant Hu-Chems IV has used AM0028 in the first crediting period, accordingly the abatement system is deemed to be by-passed, not working or failed in the hour h in year y if:<br>$F_{N2O,tailgas,h,IV} > EF_{existing,y,IV} \times P_{NA,h,IV}$<br>The parameters mentioned in the formula are determined and measured as explained in the respective sections of this MR:<br>• $P_{NA,h,IV}$ – determination is based on the monitored parameter $P_{production,y,IV}$<br>• $F_{N2O,tail\ gas,h,IV}$ – determination is based on the monitored parameters $V_{t,db,IV}$, $v_{i,t,db,IV}$ and $C_{H2O,t,db,n,IV}$<br>• $EF_{existing,y,IV}$ – determination is based on the ex-ante determined parameters $EF_{historical,IV}$ and $EF_{default,y,IV}$ |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: Hourly<br>Recording: Hourly |
| Calculation method (if applicable) | (Refer to "Monitoring equipment" above) |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>Please to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of baseline and project emissions |
| Additional comments | Records to be maintained during project's lifetime.<br>The parameter $P_{NA,h,IV}$ as used in the formula (NA produced in hour h of Hu-Chems IV) represents the hourly value of $P_{production,y,IV}$. |

<u>Parameters from "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"</u>

| **Data/Parameter** | **$V_{t,db,IV}$** |
|---|---|
| Unit | $m^3$ dry gas/h |
| Description | Volumetric flow of the gaseous stream in time interval t on a dry basis of Hu-Chems IV |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **172,746**<br>The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to this MR. |

| | |
|---|---|
| Monitoring equipment | Meter location: Located in the stack at the end of the tail gas line.<br><br>**324-FT-4-522**<br>Type: Annubar / Differential pressure transmitter<br>Accuracy class: ± 2% of span<br>Calibration frequency: 60 months (QAL 2 reference measurement)<br>Serial number: 1240834<br>Date of last QAL 2: 28/ – 30/08/2017 (Validity: 27/08/2022)<br>Date of last AST: 28/08/2018 – 30/08/2018 |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: Every 1 second<br>Recording: Hourly |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C.*).<br><br>QA/QC procedure consider requirements as per EN 14181 – Calibration against a primary device provided by an independent accredited laboratory follows EN 14181 requirements (QAL 2 reference measurement).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*. |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | Option A parameter according to the applied *"Tool to determine the mass flow of a greenhouse gas in a gaseous stream"*.<br>The volumetric flow is determined and expressed at normal conditions ($P_n$ = 101,325 Pa; $T_n$ = 273.15 K) according to the applied methodology.<br>Monitoring of actual conditions ($P_{t,IV}$, $T_{t,IV}$) is therefore not necessary, as per the applied methodology.<br>Dry basis flow measurement, since gaseous stream is considered to be dry (refer to parameter $C_{H2O,t,db,n,IV}$). |

| **Data/Parameter** | $\mathbf{v_{i,t,db,IV}}$ |
|---|---|
| Unit | $m^3$ gas i/$m^3$ dry gas (→ $m^3$ $N_2O$ / $m^3$ dry gas) |
| Description | Volumetric fraction of greenhouse gas i in a time interval t on a dry basis of Hu-Chems IV |
| Measured/calculated/ default | Measured |
| Source of data | Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.) |
| Value(s) of monitored parameter | **$5.64*10^{-5}$**<br>The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to this MR. |

| | |
|---|---|
| Monitoring equipment | Meter location: Sample take-off is located in the tail gas line, downstream of the EnviNO$_X$® reactor (324-R-402) and leads (via sample gas line) to the locked analyser house IV (located closely to the EnviNOx® reactor of Hu-Chems plant IV), where the analyser is installed. Please refer to section *C. Line diagram* of this MR.<br><br>**324-AT-4-0107**<br>Type: NDIR Analyser<br>Accuracy class: ±1% (zero/span)<br>Calibration frequency: 60 months (QAL 2 reference measurement)<br>Serial number: 990861497818<br>Date of last QAL 2: 28/ – 30/08/2017 (Validity: 27/08/2022)<br>Date of last AST: 28/08/2018 – 30/08/2018 |
| Measuring/reading/recording frequency | Measuring: Continuously<br>Reading: Every 1 second<br>Recording: Hourly |
| Calculation method (if applicable) | N/A |
| QA/QC procedures | The quality assurance and quality control procedures, in terms of equipment operation and maintenance for monitoring instruments used for CDM Monitoring have been incorporated as part of the ISO 9001 and ISO 14001 procedures of Hu-Chems. Accordingly, calibration and maintenance are part of regular QA/QC of the NA plant (please refer to section *C*).<br><br>QA/QC procedure consider requirements as per EN 14181 – Calibration against a primary device provided by an independent accredited laboratory follows EN 14181 requirements (QAL 2 reference measurement).<br><br>Please refer to section *C. Back Up plans / Emergency procedures for monitoring system* of this MR and respective subitems *Back Up Plans for measuring systems / Periodic observation of the AMS* and *Systematic measures for QA for monitoring data during analyser down times*.<br><br>EMPK has been mandated to conduct monthly analyser health checks and quarterly inspection checks to ensure good instrument condition. |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | The volumetric fraction of $N_2O$ is determined and expressed at normal conditions ($P_n$ = 101,325 Pa; $T_n$ = 273.15 K) according to the applied methodology. Monitoring of actual conditions ($P_{t,IV}$, $T_{t,IV}$) is therefore not necessary, as per the applied methodology. |

| **Data/Parameter** | **$C_{H2O,t,db,n,IV}$** |
|---|---|
| Unit | mg $H_2O/m^3$ dry gas |
| Description | Moisture content of the gaseous stream at normal conditions, in time interval t of Hu-Chems IV |
| Measured/calculated/ default | Measured |
| Source of data | Measurements according to the USEPA CF42 method 4 – Gravimetric determination of water content (Measurement Report) |
| Value(s) of monitored parameter | **8,000** (equivalent to 0.008 kg $H_2O/m^3$ dry gas) |
| Monitoring equipment | As per USEPA CF42 method 4 – Gravimetric determination of water content |
| Measuring/reading/recording frequency | As per the PDD, measurements coincide with the Annual Surveillance Test or the calibration of the flow meter for the gaseous stream (QAL 2), both associated with requirements of the EN 14181 standard. Repeated measurements were conducted during last AST. |
| Calculation method (if applicable) | N/A |

| | |
|---|---|
| QA/QC procedures | According to USEPA CF 42 method 4 |
| Purpose of data/parameter | Calculation of project emissions |
| Additional comments | As per the applied "Tool to determine the mass flow of a greenhouse gas in a gaseous stream ", the flow and volumetric fraction may be measured on a dry or wet basis. The tool covers the possible measurement combinations, providing six different calculation options to determine the mass flow of a particular greenhouse gas (option A to F). As described in the PDD, the option chosen for this project activity is option A, requiring to demonstrate, that the gaseous stream is dry, whereas the tool suggests two ways to do this:<br>(a) Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg $H_2O/m^3$ dry gas; or<br>(b) Demonstrate that the temperature of the gaseous stream ($T_t$) is less than 60°C (333.15 K) at the flow measurement point.<br>In the case of this project activity, the first option (a) has been chosen.<br><br>The measured values as noted above show that the moisture content of the gaseous stream is significantly below the maximum threshold value of 0.05 kg $H_2O/m^3$ dry gas. |

Since the volumetric fraction of $N_2O$ and the volumetric flow of the gaseous stream are both determined and expressed at normal conditions ($P_n$ = 101,325 Pa; $T_n$ = 273.15 K), the actual conditions ($P_{t,IV}$, $T_{t,IV}$) are not required to be monitored, as per the applied methodology.

### D.3. Implementation of sampling plan

>>
Not applicable for the project activity.

## SECTION E. Calculation of emission reductions or net anthropogenic removals

All references to formulae and methods used are in compliance with ACM0019 v2, applicable tools and the project documentation (PDD, monitoring plan) and are transparently shown in the excel books attached to this MR. The excel books contain recorded monitored data, a comprehensive calculation of baseline emissions, project emissions and emission reductions with actual values (formulae of calculation are shown in the spreadsheet for ease of assessment).

### E.1. Calculation of baseline emissions or baseline net removals

>>
Overall baseline emissions for the project activity are calculated as sum over the separately determined, plant specific baseline emissions as per following equation:

$$BE_y = BE_{y,II} + BE_{y,III} + BE_{y,IV}$$

Where:

| | | |
|---|---|---|
| $BE_y$ | = | Baseline emissions in year *y* (t $CO_2e$) |
| $BE_{y,II}$ | = | Baseline emissions of plant Hu-Chems II in year y (t $CO_2e$) |
| $BE_{y,III}$ | = | Baseline emissions of plant Hu-Chems III in year y (t $CO_2e$) |
| $BE_{y,IV}$ | = | Baseline emissions of plant Hu-Chems IV in year y (t $CO_2e$) |

The values for the present period are:

| $BE_y$ | $BE_{y,II}$ | $BE_{y,III}$ | $BE_{y,IV}$ |
|---|---|---|---|
| $tCO_2e$ | $tCO_2e$ | $tCO_2e$ | $tCO_2e$ |
| 285,274 | 84,485 | 74,546 | 126,243 |

Plant specific baseline emissions are calculated separately for each NA plant as per provisions of the methodology & PDD, using the same set of equations for each plant as shown below, unless described otherwise.

$$BE_y = \begin{pmatrix} min\{P_{production,y}\,;P_{product,max}\} \times EF_{existing,y} + \\ max\{P_{production,y} - P_{product,max};\,0\} \times EF_{new,y} \end{pmatrix} \times \frac{(h_y - h_{r,y})}{h_y} \times GWP_{N2O} \times 10^{-3}$$

Where:

| | | |
|---|---|---|
| $BE_y$ | = | Baseline emissions in year *y* (t $CO_2e$) |
| $P_{product,max}$ | = | Design capacity (t $HNO_3$) |
| $P_{production,y}$ | = | Production of nitric acid in year *y* (t $HNO_3$) |
| $EF_{existing,y}$ | = | $N_2O$ emission factor for nitric acid plants that have used AM0028 or AM0034 in the first crediting period in year *y* (kg $N_2O$/t $HNO_3$) |
| $EF_{new,y}$ | = | Baseline $N_2O$ emission factor for nitric acid production in year *y* (kg $N_2O$/t $HNO_3$) |
| $GWP_{N2O}$ | = | Global Warming Potential of $N_2O$ valid for the commitment period |
| $h_y$ | = | Number of hours in year *y* during which the plant was in operation (*h*) |
| $h_{r,y}$ | = | Number of hours (*h*) in year *y* where:<br>(a) For secondary $N_2O$ abatement: the abatement system was not installed, underperforming or failed;<br>(b) For tertiary $N_2O$ abatement: the abatement system is by-passed, underperforming or failed |

The values for the present period are:

| $BE_{y,II}$ *) | $EF_{existing,y,II}$ | $EF_{new,y}$ | $P_{production,y,II}$ | $P_{product,max,II}$ | $h_{y,II}$ | $h_{r,y,II}$ | $GWP_{N2O}$ |
|---|---|---|---|---|---|---|---|
| $tCO_2e$ | $kgN_2O$ / $tHNO_3$ | $kgN_2O$ / $tHNO_3$ | $tHNO_3$ | $tHNO_3$ | h | h | $tCO_2e$ / $tN_2O$ |
| 84,485 | 11.60 | 2.80 | 24,618 | 30,080 | 2,075 | 15 | 298 |

| $BE_{y,III}$ *) | $EF_{existing,y,III}$ | $EF_{new,y}$ | $P_{production,y,III}$ | $P_{product,max,III}$ | $h_{y,III}$ | $h_{r,y,III}$ | $GWP_{N2O}$ |
|---|---|---|---|---|---|---|---|
| $tCO_2e$ | $kgN_2O$ / $tHNO_3$ | $kgN_2O$ / $tHNO_3$ | $tHNO_3$ | $tHNO_3$ | h | h | $tCO_2e$ / $tN_2O$ |
| 74,546 | 11.26 | 2.80 | 22,323 | 30,080 | 1,884 | 9 | 298 |

| $BE_{y,IV}$ *) | $EF_{existing,y,IV}$ | $EF_{new,y}$ | $P_{production,y,IV}$ | $P_{product,max,IV}$ | $h_{y,IV}$ | $h_{r,y,IV}$ | $GWP_{N2O}$ |
|---|---|---|---|---|---|---|---|
| $tCO_2e$ | $kgN_2O$ / $tHNO_3$ | $kgN_2O$ / $tHNO_3$ | $tHNO_3$ | $tHNO_3$ | h | h | $tCO_2e$ / $tN_2O$ |
| 126,243 | 5.70 | 2.80 | 74,440 | 120,320 | 1,893 | 3 | 298 |

*) Values are conservatively rounded down.

The plant specific $N_2O$ emission factor for NA plants that have used AM0028 or AM0034 in the first crediting period ($EF_{existing,y}$) is calculated based on following equation:

$$EF_{existing,y} = min\{EF_{historical}; EF_{default,y}\}$$

Where:

| | | |
|---|---|---|
| $EF_{existing,y}$ | = | $N_2O$ emission factor for nitric acid plants that have used AM0028 or AM0034 in the first crediting period in year *y* (kg $N_2O$/t $HNO_3$) |
| $EF_{historical}$ | = | Historical baseline emission factor of the nitric acid plant (kg $N_2O$/t $HNO_3$) |
| $EF_{default,y}$ | = | Default emission factor according to the operating pressure of the ammonia burner in year *y* (kg $N_2O$/t $HNO_3$) |

The values for the present period are:

| **$EF_{existing,y,II}$** | **$EF_{historical,II}$** | **$EF_{default,y,II}$ (high pressure)** |
|---|---|---|
| kg$N_2O$ / t$HNO_3$ | kg$N_2O$ / t$HNO_3$ | kg$N_2O$ / t$HNO_3$ |
| 11.60 | 12.09 | 11.60 |

| **$EF_{existing,y,III}$** | **$EF_{historical,III}$** | **$EF_{default,y,III}$ (high pressure)** |
|---|---|---|
| kg$N_2O$ / t$HNO_3$ | kg$N_2O$ / t$HNO_3$ | kg$N_2O$ / t$HNO_3$ |
| 11.26 | 11.26 | 11.60 |

| **$EF_{existing,y,IV}$** | **$EF_{historical,IV}$** | **$EF_{default,y,IV}$ (medium pressure)** |
|---|---|---|
| kg$N_2O$ / t$HNO_3$ | kg$N_2O$ / t$HNO_3$ | kg$N_2O$ / t$HNO_3$ |
| 5.70 | 5.70 | 7.40 |

## E.2. Calculation of project emissions or actual net removals

>>

Overall project emissions for the project activity are calculated as sum over the separately determined, plant specific project emissions, as per following equation:

$$PE_y = PE_{y,II} + PE_{y,III} + PE_{y,IV}$$

Where:

| | | |
|---|---|---|
| $PE_y$ | = | Project emissions in year *y* (t $CO_2e$) |
| $PE_{y,II}$ | = | Project emissions of plant Hu-Chems II in year y (t $CO_2e$) |
| $PE_{y,III}$ | = | Project emissions of plant Hu-Chems III in year y (t $CO_2e$) |
| $PE_{y,IV}$ | = | Project emissions of plant Hu-Chems IV in year y (t $CO_2e$) |

The values for the present period are:

| **$PE_y$** | **$PE_{y,II}$** | **$PE_{y,III}$** | **$PE_{y,IV}$** |
|---|---|---|---|
| t$CO_2e$ | t$CO_2e$ | t$CO_2e$ | t$CO_2e$ |
| 16,075 | 3,674 | 2,011 | 10,390 |

Plant specific project emissions are calculated separately for each NA plant as per provisions of the methodology & PDD, using the same set of several equations for each plant as shown below, unless described otherwise.

$$PE_y = PE_{N2O,y} + PE_{CO2,tertiary,y}$$

Where:

| | | |
|---|---|---|
| $PE_y$ | = | Project emissions in year *y* (t $CO_2e$) |
| $PE_{N2O,y}$ | = | Project emissions of $N_2O$ from the project plant in year *y* (t $CO_2e$) |
| $PE_{CO2,tertiary,y}$ | = | Project emissions of $CO_2$ from the operation of the tertiary $N_2O$ abatement facility in year *y* (t $CO_2$) |

The values for the present period are:

| $PE_{y,II}$ | $PE_{N2O,y,II}$ | $PE_{CO2,tertiary,y,II}$ |
|---|---|---|
| t $CO_2e$ | t $CO_2e$ | t $CO_2e$ |
| 3,674 | 3,434 | 240 |

| $PE_{y,III}$ | $PE_{N2O,y,III}$ | $PE_{CO2,tertiary,y,III}$ |
|---|---|---|
| t $CO_2e$ | t $CO_2e$ | t $CO_2e$ |
| 2,011 | 1,780 | 231 |

| $PE_{y,IV}$ | $PE_{N2O,y,IV}$ | $PE_{CO2,tertiary,y,IV}$ |
|---|---|---|
| t $CO_2e$ | t $CO_2e$ | t $CO_2e$ |
| 10,390 | 10,390 | 0 |

The project emissions of $N_2O$ from the project plant ($PE_{N2O,y}$) are the emissions from the $N_2O$ contained in the tail gas stream of the plant, which is released to the atmosphere. Accordingly, the plant specific $PE_{N2O,y}$ are determined as follows:

$$PE_{N2O,y} = \sum_{1}^{h_y - h_{r,y}} F_{N2O,tail\ gas,h} \times GWP_{N2O} \times 10^{-3}$$

Where:

| | | |
|---|---|---|
| $PE_{N2O,y}$ | = | Project emissions of $N_2O$ from the project plant in year *y* (t $CO_2e$) |
| $GWP_{N2O}$ | = | Global warming potential of $N_2O$ valid for the commitment period |
| $F_{N2O,tail\ gas,h}$ | = | Mass flow of $N_2O$ in the gaseous stream of the tail gas in the hour *h* (kg $N_2O$/h) |
| $h_y$ | = | Number of hours in year *y* during which the plant was in operation (*h*) |
| $h_{r,y}$ | = | Number of hours (*h*) in year *y* where:<br>(a) For secondary $N_2O$ abatement. Abatement system was not installed, underperforming or failed;<br>(b) For tertiary $N_2O$ abatement. The abatement system is by-passed, underperforming or failed |

The values for the present period are:

| $PE_{N2O,y,II}$ *) | $F_{N2O,tail\ gas,h,II}$ | $h_{y,II}$ | $h_{r,y,II}$ | $GWP_{N2O}$ |
|---|---|---|---|---|
| $tCO_2e$ | $kgN_2O$ | h | h | $tCO_2$ / $tN_2O$ |
| 3,434 | 11,523 | 2,075 | 15 | 298 |

| $PE_{N2O,y,III}$ *) | $F_{N2O,tail\ gas,h,III}$ | $h_{y,III}$ | $h_{r,y,III}$ | $GWP_{N2O}$ |
|---|---|---|---|---|
| $tCO_2e$ | $kgN_2O$ | h | h | $tCO_2$ / $tN_2O$ |
| 1,780 | 5,973 | 1,884 | 9 | 298 |

| $PE_{N2O,y,IV}$ *) | $F_{N2O,tail\ gas,h,IV}$ | $h_{y,IV}$ | $h_{r,y,IV}$ | $GWP_{N2O}$ |
|---|---|---|---|---|
| $tCO_2e$ | $kgN_2O$ | h | h | $tCO_2$ / $tN_2O$ |
| 10,390 | 34,864 | 1,893 | 3 | 298 |

*) Values are conservatively rounded up.

The amount of $N_2O$ emissions from the tail gas stream of the plant (= $F_{N2O,tailgas,h}$) is determined by using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" and hence the following provisions apply:

(a) Throughout the crediting periods of the project activity, the $N_2O$ concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is to be installed and maintained throughout the crediting period based on the European Norm 14181 or any more recent update of that standard;

(b) The monitoring system should provide separate hourly average values for the $N_2O$ concentration and the volume or mass flow of the tail gas based on two seconds (or shorter) interval readings that are recorded and stored electronically. These $N_2O$ data sets shall be identified by means of a unique time/date key indicating when exactly the values were observed;

(c) The correction factors derived from the calibration curve of the QAL2 audit for the monitoring components as determined during the QAL2-test in accordance with EN14181 must be applied to both the $N_2O$ concentration and the volume or mass flow of the tail gas. This can either be applied automatically to the raw data recorded by the data storage system at the plant or it can be applied to the calculated hourly averages as part of the calculation of project emissions;

(d) If data for either the $N_2O$ concentration or the volume or mass flow of the tail gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour shall be replaced with the maximum value of $N_2O$ concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the $N_2O$ concentration nor the volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of $N_2O$ calculated during the monitoring period shall be applied to any such hour. Values observed during five operating hours before and after a plant start-up and shutdown shall not be used for the determination of the maximum values;

(e) In the case that the $N_2O$ concentration and the volume or mass flow of the tail gas and by-pass are automatically converted to normal conditions by the AMS during the monitoring process, the parameters $P_t$ and $T_t$ do not need to be monitored except, if applicable, for the purpose of determining the moisture content in the gaseous stream.

As described in the PDD according to the applied tool the mass flow of greenhouse gas i in the gaseous stream in time interval t ($F_{i,t}$) is calculated based on measurements of

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

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

As stated in the PDD, the option chosen for this project activity is option A, which requires demonstrating that the gaseous stream is dry, whereas the tool suggests two options to do this:

(a) Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg $H_2O/m^3$ dry gas; or
(b) Demonstrate that the temperature of the gaseous stream ($T_t$) is less than 60°C (333.15 K) at the flow measurement point.

The measured values in plants Hu-Chems II, III and IV relevant to this monitoring period are below the maximum threshold value of 0.05 kg $H_2O/m^3$ dry gas. Therefore, Option A of the tool (measurement options: volume flow of gaseous stream on dry basis, volumetric fraction on dry or wet basis) is applied. Hence, the mass flow of greenhouse gas i ($F_{i,t}$)[5] is determined as follows:

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

With

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

Where:

| | | |
|---|---|---|
| $F_{i,t}$ | = | Mass flow of greenhouse gas i in the gaseous stream in time interval t (kg gas/h) |
| $V_{t,db}$ | = | Volumetric flow of the gaseous stream in time interval t on a dry basis ($m^3$ dry gas/h) |
| $v_{i,t,db}$ | = | Volumetric fraction of greenhouse gas i in the gaseous stream in a time interval t on a dry basis ($m^3$ gas i/$m^3$ dry gas) |
| $\rho_{i,t}$ | = | Density of greenhouse gas i in the gaseous stream in time interval t (kg gas i/$m^3$ gas i) |
| $P_t$ | = | Absolute pressure of the gaseous stream in time interval t (Pa) |
| $MM_i$ | = | Molecular mass of greenhouse gas i (kg/kmol) |
| $R_u$ | = | Universal ideal gases constant (Pa.$m^3$/kmol.K) |
| $T_t$ | = | Temperature of the gaseous stream in time interval t (K) |

When applying normal conditions and as described in the PDD, the density at normal conditions ($P_t = P_n$ = 101,325 Pa; $T_t = T_n$ = 273.15 K) was determined to be constantly 1.96 kg/$m^3$ [6]. Respective parameters need not to be monitored according to the applied methodology.

[5] $F_{i,t}$ corresponds to the parameter $F_{N2O,tail\ gas,h}$ of the methodology ACM0019 v2.
[6] $\rho_{i,t} = (P_n \times MM_i) / (T_n \times R_u)$ = 1.96 kg/$m^3$

For calculation of $F_{N2O,tailgas,h}$, as well as application of calibration curves or corrections to data in case of observations & events (as described in section *B.1.*) on an hourly basis, please refer to the excel books, which are attached to this MR.

The project emissions from the operation of the tertiary $N_2O$ abatement facility ($PE_{CO2,tertiary,y}$) only need to be considered, if a tertiary $N_2O$ abatement facility is installed under the project activity and if fossil fuels are used to operate the facility or re-heat the gas after the facility. Specifically, to this project activity, this situation applies to NA plants Hu-Chems II and III, where propane (supplied as LPG) is used as reducing agent in the tertiary $N_2O$ abatement facilities. No fossil fuel is used in NA plant Hu-Chems IV. Hence, the following set of equations is applied exclusively for NA plants Hu-Chems II and III, whereas the value for NA plant Hu-Chems IV is set to zero due to inapplicability of this emission source (associated parameters are not monitored accordingly).

$$PE_{CO2,tertiary,y} = PE_{FF,y}$$

Where:

| | | |
|---|---|---|
| $PE_{CO2,tertiary,y}$ | = | Project emissions of $CO_2$ from the operation of the tertiary $N_2O$ abatement facility in year y (t $CO_2$) |
| $PE_{FF,y}$ | = | Project emissions related to fossil fuel input to the destruction facility and/or re-heater in year y (t $CO_2$) |

For determination of $PE_{FF,y}$, the "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion" shall be sued to calculate the project emissions related to fossil fuels used in year y. Specific guidance on the use of the tool are:

(a) The parameter $PE_{FC,j,y}$ used in the "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion" corresponds to the parameter $PE_{FF,y}$ in the methodology ACM0019 v2, and
(b) The element process *j* in the tool corresponds to the consumption of fossil fuels for the operation of the tertiary $N_2O$ abatement facility and/or the re-heating of the tail gas.

The values for the present period are:

| **$PE_{CO2,tertiary,y,II} = PE_{FF,y,II} = PE_{FC,j,y,II}$** |
|---|
| $tCO_2/yr$ |
| 240 |

| **$PE_{CO2,tertiary,y,III} = PE_{FF,y,III} = PE_{FC,j,y,III}$** |
|---|
| $tCO_2/yr$ |
| 231 |

According to the applied tool $CO_2$ emissions from fossil fuel combustion in process j are calculated based on the quantity of fuels combusted and the $CO_2$ emission coefficient of those fuels, as follows:

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y}$$

Where:

| | | |
|---|---|---|
| $PE_{FC,j,y}$ | = | Are the $CO_2$ emissions from fossil fuel combustion in process *j* during the year *y* ($tCO_2$/yr) |
| $FC_{i,j,y}$ | = | Is the quantity of fuel type *i* combusted in process *j* during the year *y* (t/yr) |
| $COEF_{i,y}$ | = | Is the $CO_2$ emission coefficient of fuel type *i* in year *y* ($tCO_2$/t) |
| *i* | = | Are the fuel types combusted in process *j* during the year *y* |

Option A of the "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion" is applied as the chemical composition of the used fossil fuel (i.e. LPG) is provided by the fuel supplier. According to this option A the $CO_2$ emission coefficient $COEF_{i,y}$ is calculated based on the chemical composition of the fossil fuel type *i*, using the following approach:

$$COEF_{i,y} = w_{C,i,y} \times 44/12$$ $FC_{i,j,y}$ is measured in a mass unit

Where:

| | | |
|---|---|---|
| $COEF_{i,y}$ | = | Is the $CO_2$ emission coefficient of fuel type *i* ($t CO_2$/t) |
| $w_{C,i,y}$ | = | Is the weighted average mass fraction of carbon in fuel type *i* in year *y* (t C/t) |
| *i* | = | Are the fuel types combusted in process *j* during the year *y* |

The values for the present period are:

| $PE_{CO2,tertiary,y,II}$ | $FC_{i,j,y,II}$ | $COEF_{i,y,II}$ |
|---|---|---|
| $tCO_2$/yr | t/yr | $tCO_2$/t |
| 240 | 80.11 | 3.00 |

| $PE_{CO2,tertiary,y,III}$ | $FC_{i,j,y,III}$ | $COEF_{i,y,III}$ |
|---|---|---|
| $tCO_2$/yr | t/yr | $tCO_2$/t |
| 231 | 77.07 | 3.00 |

## E.3. Calculation of leakage emissions

>>

According to the applied methodology ACM0019 v2 any leakage emissions sources are deemed to be negligible.

## E.4. Calculation of emission reductions or net anthropogenic removals

| | Baseline GHG emissions or baseline net GHG removals ($t CO_2e$) | Project GHG emissions or actual net GHG removals ($t CO_2e$) | Leakage GHG emissions ($t CO_2e$) | GHG emission reductions or net anthropogenic GHG removals ($t CO_2e$) | | |
|---|---|---|---|---|---|---|
| | | | | Before 01/01/2013 | From 01/01/2013 | Total amount |
| **Total** | 285,274 | 16,075 | 0 | N/A | 269,199 | 269,199 |

## E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

| Amount achieved during this monitoring period (t $CO_2e$) | Amount estimated ex ante (t $CO_2e$) |
|---|---|
| 269,199 | 317,225 |

## E.6. Remarks on increase in achieved emission reductions

>>

Actual emission reductions achieved during this monitoring period are lower than values estimated in ex-ante calculation of the registered PDD. Please find below the assessment for each plant:

| Comparison of ER with PDD values: Hu-Chems II | |
|---|---|
| Emission reduction estimation per year according to PDD | 267,008 $tCO_2e$ |
| Corresponding PDD estimation for this monitoring period (rounded) | 68,764 $tCO_2e$ |
| Actual calculation of emission reduction in this monitoring period | 80,811 $tCO_2e$ |

Actual emission reductions in plant Hu-Chems II were above the ex-ante PDD estimation for this monitoring period due to shorter NA plant shutdown periods than expected.

| Comparison of ER with PDD values: Hu-Chems III | |
|---|---|
| Emission reduction estimation per year according to PDD | 291,595 $tCO_2e$ |
| Corresponding PDD estimation for this monitoring period (rounded) | 75,096 $tCO_2e$ |
| Actual calculation of emission reduction in this monitoring period | 72,535 $tCO_2e$ |

Actual emission reductions in plant Hu-Chems III were below the ex-ante PDD estimation for this monitoring period.

| Comparison of ER with PDD values: Hu-Chems IV | |
|---|---|
| Emission reduction estimation per year according to PDD | 673,174 $tCO_2e$ |
| Corresponding PDD estimation for this monitoring period (rounded) | 173,365 $tCO_2e$ |
| Actual calculation of emission reduction in this monitoring period | 115,853 $tCO_2e$ |

Actual emission reductions in plant Hu-Chems IV were below the ex-ante PDD estimation for this monitoring period.

# Appendix 1. Social Fund

As described in the PDD a Social Fund was established by the project participants. This fund contributes to the social benefit of the people living in the area of the project activity by financing projects and social activities.

Payments from the CDM Project to the Social Fund in year 2017 were 1,004,349,000 WON (~ 780,000 Euro).

# Appendix 2. Excel book for claiming Emission Reductions

Excel books containing monitored data and calculations of baseline emissions, project emissions and emission reductions and additional checks and information is attached:

- HUC-0765_II_MP39_UNFCCC_v1.1_CONFIDENTIAL.xlsx
- HUC-0765_III_MP39_UNFCCC_v1.1_CONFIDENTIAL.xlsx
- HUC-0765_IV_MP39_UNFCCC_v1.0_CONFIDENTIAL.xlsx
- HUC-0765_ALL_MP39_UNFCCC_v1.1_CONFIDENTIAL.xlsx

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## Document information

| *Version* | *Date* | *Description* |
|---|---|---|
| 06.0 | 7 June 2017 | Revision to:<br>• Ensure consistency with version 01.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN);<br>• Make editorial improvements. |
| 05.1 | 4 May 2015 | Editorial revision to correct version numbering. |
| 05.0 | 1 April 2015 | Revisions to:<br>• Include provisions related to delayed submission of a monitoring plan;<br>• Provisions related to the Host Party;<br>• Remove reference to programme of activities;<br>• Overall editorial improvement. |
| 04.0 | 25 June 2014 | Revisions to:<br>• Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0));<br>• Include provisions related to standardized baselines;<br>• Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1;<br>• Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*;<br>• Editorial improvement. |
| 03.2 | 5 November 2013 | Editorial revision to correct table in page 1. |
| 03.1 | 2 January 2013 | Editorial revision to correct table in section E.5. |
| 03.0 | 3 December 2012 | Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11). |
| 02.0 | 13 March 2012 | Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20). |
| 01.0 | 28 May 2010 | EB 54, Annex 34. Initial adoption. |

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