



Monitoring report form (Version 03.2)

Monitoring report

Title of the project activity	N ₂ O Abatement Project of Capro Corporation
Reference number of the project activity	4665
Version number of the monitoring report	v.5
Completion date of the monitoring report	14/12/2013
Registration date of the project activity	09/06/2011
Monitoring period number and duration of this monitoring period	Period Number 3 Duration : 01/01/2012 – 08/06/2012 (160days)
Project participant(s)	Capro Corporation Hyosung Ebara Engineering Co., Ltd. Hyosung Corporation
Host Party(ies)	The Republic of Korea
Sectoral scope(s) and applied methodology(ies)	<ul style="list-style-type: none"> • Sectoral scope Scope No. 5, Chemical industries • Applied methodology AM0028(Version 05) N₂O destruction in the tail gas of Nitric Acid or Caprolactam Production Plants
Estimated amount of GHG emission reductions or net anthropogenic GHG removals by sinks for this monitoring period in the registered PDD	289,751 tCO ₂ e/period
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved in this monitoring period	317,236 tCO ₂ e in this monitoring period,

SECTION A. Description of project activity**A.1. Purpose and general description of project activity**

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- (a) Purpose of the project activity and the measures taken for GHG emission reductions;
The proposed project is to reduce N₂O emissions of the tail gas emitted from Caprolactam production process in Capro Corporation (hereinafter "Capro") by installing catalytic N₂O destruction system.
- (b) Brief description of the installed technology and equipments;
N₂O treatment system for this project is CRI N₂O abatement system, which is N₂O decomposition catalyst at the tail gas. Therefore, CRI system applies to tertiary treatment, which does not affect the existing yield of caprolactam as it just treats the tail gas. In addition, the catalyst system is remarkably efficient as CRI technology is direct N₂O decomposition process that does not require the addition of any reductant and its pressure drop is small.
- (c) Relevant dates for the project activity.

Relevant dates (dd/mm/yyyy)	The Actions for Implementation of Project activity
16/11/2010	Starting Construction of N ₂ O abatement system
20/04/2011	Commissioning start(Plant 1)
27/04/2011	Commissioning start(Plant 2)
02/05/2011	Completing Construction of N ₂ O abatement system and the N ₂ O abatement system started normal operation
23/05/2011 ~27/05/2011	Field Test for Quality Assurance of installation and calibration of AMS (QAL2)
09/06/2011	Registration date of this project, which means the starting date of the crediting period of this project.
26/09/2011 ~29/09/2011	Additional Field Test for Quality Assurance (QAL2) of installation and calibration of AMS
14/05/2012 ~17/05/2012	Annual surveillance test (AST) for Quality Assurance of AMS

- (d) Total emission reductions achieved in this monitoring period: 317,236 tonCO₂e

A.2. Location of project activity

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- (a) Host Parties
: The Republic of Korea
- (b) Region/State/Province, etc.
: Ulsan Metropolitan City
- (c) City/Town/Community etc.
: 402-1, Bugok-dong, Nam-gu
- (d) Physical/ Geographical Location
: The east longitude is about 129.3280 and the north latitude is about 35.4958

A.3. Parties and project participant(s)

Party involved (the host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
The Republic of Korea(host)	Private entity •Capro Corporation •Hyosung Ebara Engineering Co., Ltd. •Hyosung Corporation	No

A.4. Reference of applied methodology

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- (a) The applied methodology :
AM0028 "N₂O destruction in the tail gas of Nitric Acid or Caprolactam Production Plants" (Version 05.0)
- (b) Any tools to which the applied methodology refers :
"Version 05.2 of the"Tool for the demonstration and assessment of additionality"(Version 05.2)
- (c) other methodologies to which the applied methodology refers
: None

The methodology tool are available on the following website:

<http://cdm.unfccc.int/methodologies/PAmethodologies/approved>

A.5. Crediting period of project activity

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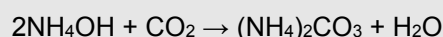
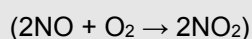
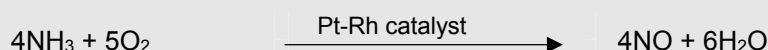
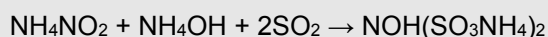
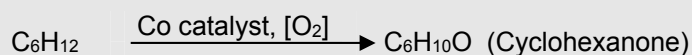
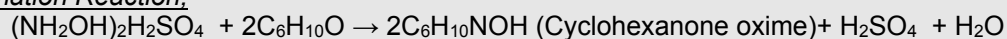
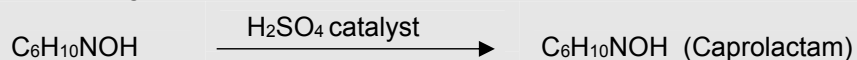
The type of Crediting Period		fixed
The starting date of the crediting period (dd/mm/yyyy)		09/06/2011
The length of the crediting period		10 years
Implemented Monitoring period	1 st	09/06/2011–31/08/2011 (84days)
	2 nd	01/09/2011 – 31/12/2011 (122days)
	3 rd (this monitoring period)	01/01/2012 - 08/06/2012 (160days)
	Accumulated number of days	366days

SECTION B. Implementation of project activity**B.1. Description of implemented registered project activity**

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(a) General Introduction

Caprolactam is produced by cyclohexane, ammonia, and sulphur as its primary raw materials, and Ammonium sulfate comes out as a by-product, which is supplied as nitrogen fertilizer and a chemical feedstock for industrial uses. In Capro, the main process of caprolactam production is as follows:

Hydroxylamine sulfate preparation :Ammonium carbonate preparationAmmonia oxidationAmmonium Nitrite Preparation;Hydroxylamine disulfonic ammonia Preparation;Hydroxylamine Sulfate Preparation;Cyclohexanone preparationOximation Reaction:Beckmann rearrangement:

Cyclohexanone oxime reacts with sulfuric acid catalyst to caprolactam as final product. The structural formula of Beckmann rearrangement is shown in Figure B1-1.

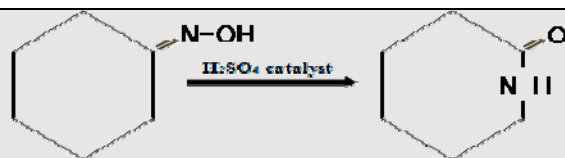


Figure B1-1. Structural formula of Beckmann rearrangement

The block flow diagram for existed caprolactam production process of Capro is shown in Figure B1-2.

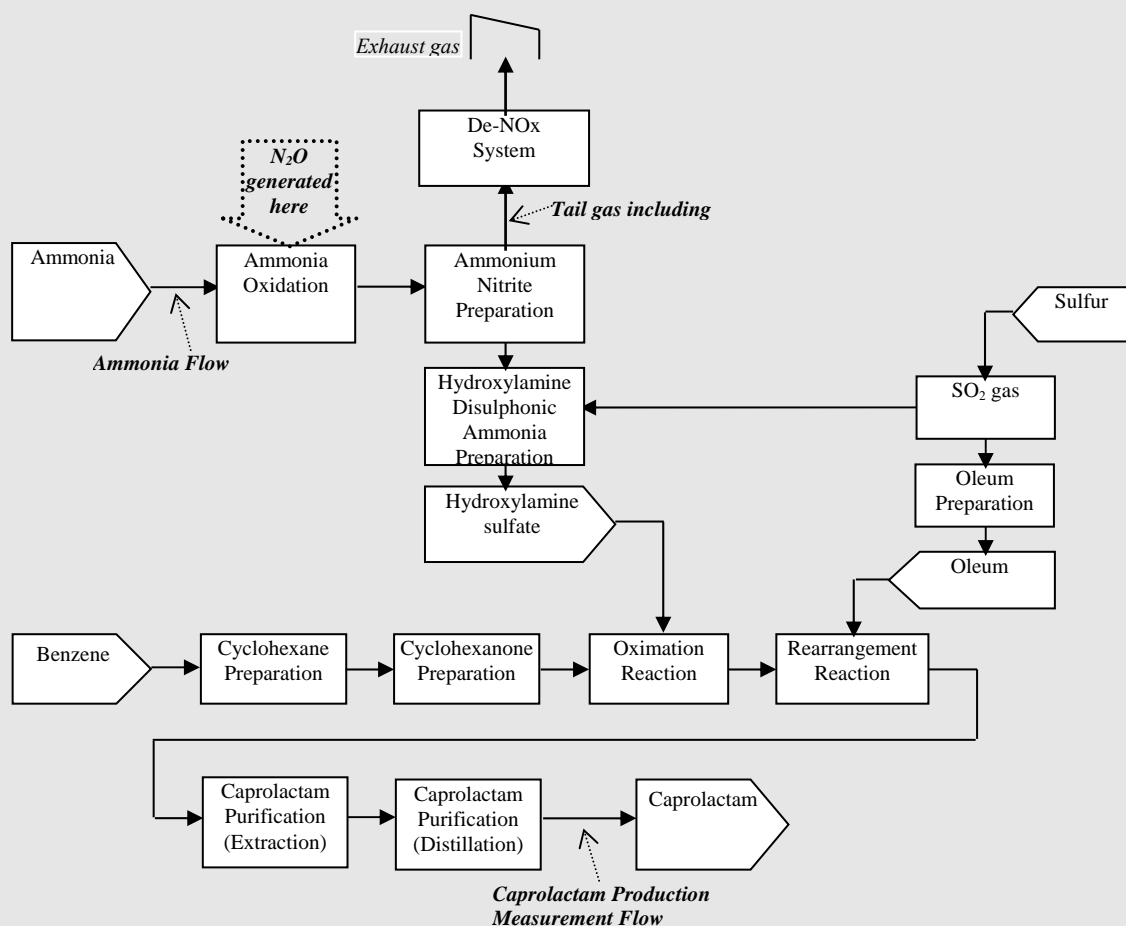


Figure B1-2. Block flow diagram for caprolactam production process

Ammonia oxidation reaction is necessary to generate NO and NO₂, which are going to be the reactants for Ammonium nitrite. (This Ammonium nitrite will induce Hydroxylamine sulphate, and finally caprolactam will be produced, through the complicated reaction pathway, as previous stated at the paragraph to explain the main process of caprolactam production.)

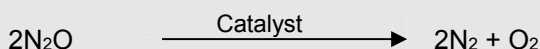
Nitrous oxide (N₂O) is generated as an undesired by-product through the side reaction of Ammonia oxidation as follows:



In this project, two plants (Plant I, Plant II) are included. In each plant, there are two of the Ammonium Oxidation Reactors (AORs), the ammonia gas is equally fed to the both of AORs through the one line with one flow meter. Input ammonia is oxidized by passing through the Pt-Rh Catalyst gauze located in AOR.

(b) Description of the installed technology, technical processes and equipments:

De-N₂O system for this project is to destruct the N₂O included in tail gas by catalyst without any reducing agent.



The catalytic reactor designed by Hyosung Ebara Engineering Co. was derived from RTO (Regenerative Thermal Oxidizer), to save the energy required for catalytic reaction to decompose N₂O, and this N₂O destruction facility is the so-called "Regenerative Catalytic System". Where, liquefied natural gas (LNG, hereafter "natural gas") is put in to this system as a fuel, not reducing agent, to supply the energy required for the de-N₂O catalytic reaction. Catalyst is provided by CRI.

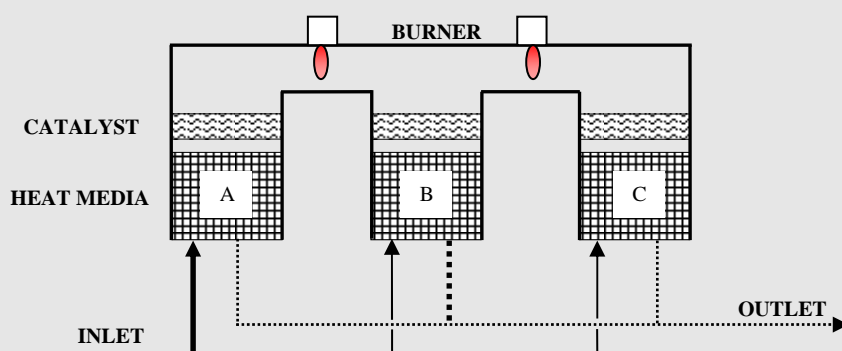


Figure B1-3. Overview of Regenerative Catalytic System

The principle of performance can be step-wisely described with Figure B1-3 as follows: At the inlet of De-N₂O system, in-flowed tail-gas is heated up to 550°C by going to heat media A (previously heated), before N₂O included in the heated tail is decomposed while that tail gas is pass through catalytic bed located on the top of heat storage media A. And then, N₂O in the once treated tail gas is decomposed again by the next catalyst bed and the heat storage media B, to which the heat hold in two-times-treated tail gas is transfer. After this, two-times-treated tail gas is going out. Next, tail gas is injected in to the heat media B which is charged with heat transferred from the outflow according to the way explain just above. And the tail gas passed through the heat storage media B and the upper catalyst bed is going to the other catalyst bed and the heat media C. Finally, the tail gas from the plant goes to the media C heated by the previous outflow, this tail gas is flowed reversely to the media B and comes out. In this way, tail gas in-and-out is continuously rotated. The same De-N₂O processes have been applied to Plant I and II.

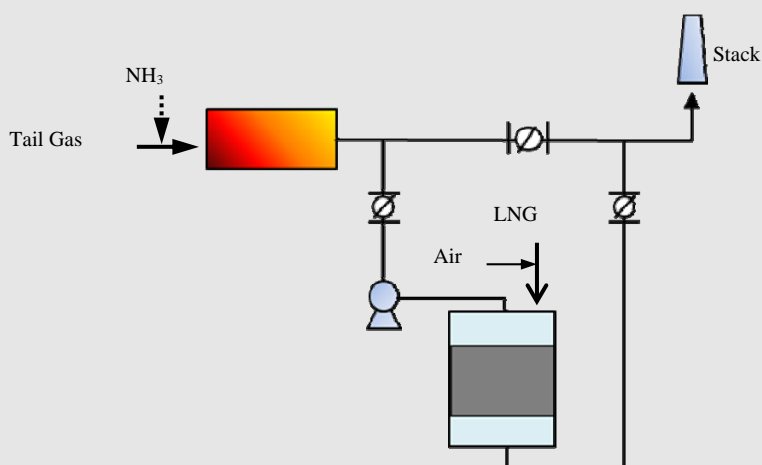


Figure B1-4. Overview of the De-N₂O process in Plant I and II

(c) Information on the implementation and actual operation of the project activity

The information on the implementation and actual operation of the project activity including relevant dates is summarized as following table

Table B1-1. The information on the implementation and actual operation of the project activity

The information on the implementation and actual operation of the project activity	Relevant dates (dd/mm/yyyy)	
	Plant I	Plant II
Starting Construction of N ₂ O abatement system	16/11/2010	16/11/2010
Commissioning start	20/04/2011	27/04/2011
Starting continued normal operation	02/05/2011	02/05/2011
Regular Overhaul (period 2)	08/10/2011 ~20/10/2011	None

In order to avoid that the operation of the caprolactam production plant is manipulated in a way to increase the N₂O generation, thereby increasing the CERs, the operating temperature and pressure of the ammonia oxidation reactor (AOR), and NH₃ input to the AOR, have been monitored every working day. During the monitoring period 3, the actual average daily AOR operation conditions are monitored as below Table B1-2

Table B1-2. Summary of the AOR operation data

Plant I		$T_{g,a}$ (°C)	$T_{g,b}$ (°C)	P_{g-1} (Pa)	$A_{OR,d-1}$ (NH ₃ /d)
	Permit range in PDD	656.57~731.66	662.08~743.92	43,320~98,564	42.250 (maximum)
	Actual average in period 3	702.11	732.15	88,231	38.67
	The number of days outside permit range	0	0	0	0
Plant II		$T_{g,c}$ (°C)	$T_{g,d}$ (°C)	P_{g-2} (Pa)	$A_{OR,d-2}$ (NH ₃ /d)
	Permit range in PDD	738.95~774.85	734.53~770.57	79,317~96,381	44.557 (maximum)
	Actual average in period3	758.25	750.03	88,746	42.30
	The number of days outside permit range	0	0	0	0

The all of catalysts for ammonia oxidation reaction used during the crediting period are the same as those described in registered PDD.

Table B1-3 The status of ammonia oxidation catalysts installed in AOR

		Plant I	Plant II
Historical supplier of AOR catalyst $G_{com,hist}$		Pt(90%): Rh(10%)	Pt(90%): Rh(10%)
Historical composition of AOR catalyst $G_{sup,hist}$		Johnson Matthey	Johnson Matthey
in period 3	The composition (G_{com})	Pt(90%): Rh(10%)	Pt(90%): Rh(10%)
	Supplier (G_{sup})	Johnson Matthey	Johnson Matthey

In the case of a nitric acid plant or a caprolactam plant using the Raschig process, baseline emissions are limited to the design capacity of the existing nitric acid or caprolactam production plant. If the actual production of caprolactam ($P_{product}$) exceeds the design capacity ($P_{product,max}$) then emissions related to the production above $P_{product,max}$ will not be claimed for the baseline scenario. Therefore $P_{product}$ of each plant should be monitored.

All of the data for production of caprolactam for period 3 were listed in detail in the emission reductions calculation spreadsheet.

Table B1-4. The information of Caprolactam production

The actual production for 1 st year	Each period (ton/period)	Period	Duration	Days	Plant I	Plant II
		1st	09/06/2011 – 31/08/2011	84	13764.22	14415.80
		2nd	01/09/2011 – 31/12/2011	122	17035.04	20618.53
		3rd	01/01/2012 – 08/06/2012	160	24260.29	28071.06
	P_{product} (ton/yr)	Total	09/06/2011 – 08/06/2012	366	55059.55	63105.39
Design Capacity in PDD , $P_{\text{product,max}}$ (ton/yr)					63,307	64,965

The actual production of caprolactam (P_{product}) did not exceed the design capacity ($P_{\text{product,max}}$) .

(d) Events or situations occurred during the monitoring

(1) Events of Plant I

Events information

Sites	No.	Date (dd/mm/yy) & Time		description
		from	to	
N ₂ O Abatement System (NAS)	1	26/01/2012, 09:50	26/01/2012, 13:40	Solenoid valves to open outlet damper in NAS were replaced.
	2	28/01/2012, 04:22	28/01/2012, 08:40	Limit Shaft were replaced.
	3	07/02/2012, 06:10	07/02/2012, 09:30	Solenoid valves to open inlet damper in NAS were replaced.
	4	05/03/2012, 13:20	05/03/2012, 14:41	Solenoid valves to open outlet damper in NAS were replaced.
	5	23/03/2012, 10:30	23/03/2012, 16:13	DIS sheet of actuator was broken off and repaired.
	6	29/03/2012, 08:21	29/03/2012, 13:48	Damper sealing plate of actuator in purge damper was out of order and repaired.
	7	25/04/2012, 13:49	25/04/2012, 20:36	Failure in DCU(Data Communication Unit)
	8	16/05/2012, 11:00	16/05/2012, 13:00	Solenoid valves to open inlet damper in NAS were replaced.
	9	26/05/2012, 10:22	26/05/2012, 18:14	Solenoid valves to open inlet damper in NAS were replaced.
	10	03/06/2012, 17:45	03/06/2012, 21:54	Solenoid valves to open inlet damper in NAS were replaced.
Product Facility	11	14/02/2012, 10:07	14/02/2012, 11:32	Production suspension because of ammonia trip
	12	15/05/2012, 10:15	16/05/2012, 12:40	Leaking form economizer tube, which was repaired.
	13	07/06/2012, 05:02	08/06/2012, 13:12	Overhaul of air blower

Action to the events

For the events related N₂O Abatement System (NAS), the data on N₂O concentration ($C_{\text{N}_2\text{O}-1}$, $\text{CO}_{\text{N}_2\text{O}-1}$) and volume flow rate ($F_{\text{TL}-1}$, $F_{\text{TE}-1}$) measured at the inlet and exit of the destruction facility in Plant 1 are cancelled. However, the data of the natural gas input ($Q_{\text{NG}-1}$) and CH₄ concentration ($\text{CO}_{\text{CH}_4-1}$) measured at destruction facility outlet in Plant I are accepted to adopt a conservative manner.

For the events resulted from the malfunctions, inspections, and blackout of product facility in plant I, it is deleted that not only the data indicating AOR operation conditions ($A_{\text{OR},d-1}$, P_{g-1} , T_{g-a} , T_{g-b}), and productivity of the caprolactam ($P_{\text{product}-1}$), but also the data on N₂O concentration ($C_{\text{N}_2\text{O}-2}$, $\text{CO}_{\text{N}_2\text{O}-2}$) and volume flow rate ($F_{\text{TL}-1}$, $F_{\text{TE}-1}$) which are measured in N₂O Abatement System (NAS) in plant I.

Sites	No.	Relevant Time to Data cancelling		Parameters of the cancelled data
		from	to	
N ₂ O Abatement System (NAS)	1	26/01/2012, 09:00	26/01/2012, 14:00	<ul style="list-style-type: none"> N₂O concentrations (C_{IN2O-1}, CO_{N2O-1}) volume flow rate (F_{TI-1}, F_{TE-1})
	2	28/01/2012, 04:00	28/01/2012, 09:00	
	3	07/02/2012, 06:00	07/02/2012, 10:00	
	4	05/03/2012, 13:00	05/03/2012, 15:00	
	5	23/03/2012, 10:00	23/03/2012, 17:00	
	6	29/03/2012, 08:00	29/03/2012, 14:00	
	7	25/04/2012, 13:00	25/04/2012, 21:00	
	8	16/05/2012, 11:00	16/05/2012, 13:00	
	9	26/05/2012, 10:00	26/05/2012, 19:00	
	10	03/06/2012, 17:00	03/06/2012, 22:00	
Product Facility	11	14/02/2012, 10:00	14/02/2012, 12:00	<ul style="list-style-type: none"> N₂O concentrations (C_{IN2O-1}, CO_{N2O-1}) volume flow rate (F_{TI-1}, F_{TE-1}) AOR operation conditions ($A_{OR,d-1}$, P_{g-1}, T_{g-a}, T_{g-b}) Plant output of caprolactam ($P_{product-1}$)
	12	15/05/2012, 10:00	16/05/2012, 13:00	
	13	07/06/2012, 05:00	08/06/2012, 14:00	

(2) Events of Plant II

Events information

Sites	No.	Date (dd/mm/yy) & Time		description
		from	to	
N ₂ O Abatement System (NAS)	1	16/02/2012, 21:35	17/02/2012, 06:32	Valve actuator was replaced
	2	29/03/2012, 13:00	29/03/2012, 17:50	Damper sealing plate of actuator in purge damper was out of order, and repaired.
	3	25/04/2012, 13:49	25/04/2012, 20:46	Failure in DCU(Data Communication Unit)
	4	06/06/2012, 15:22	06/06/2012, 19:44	Solenoid valves to open outlet damper in NAS were replaced.
Product Facility	5	13/01/2012, 08:02	13/01/2012, 15:32	Gas blower was broken
	6	18/04/2012, 18:00	18/04/2012, 20:00	Regular washing to the gas pre-heater for SCR operation
	7	07/05/2012, 13:40	07/05/2012, 15:40	Washing the tube of the gas pre-heater for SCR operation

Action to the events

For the events related N₂O Abatement System (NAS), the data on N₂O concentration (C_{N_2O-2} , CO_{N_2O-2}) and volume flow rate (F_{TI-2} , F_{TE-2}) measured at the inlet and exit of the destruction facility in Plant II are cancelled. However, the data of the natural gas input (Q_{NG-2}) and CH₄ concentration (CO_{CH_4-2}) measured at destruction facility outlet in Plant II are accepted to adopt a conservative manner.

For the events resulted from the malfunctions, inspections, and blackout of product facility in plant II, it is deleted that not only the data indicating AOR operation conditions ($A_{OR,d-2}$, P_{g-2} , T_{g-c} , T_{g-d}), and productivity of the caprolactam ($P_{product-2}$), but also the data on N₂O concentration (C_{N_2O-2} , CO_{N_2O-2}) and volume flow rate (F_{TI-2} , F_{TE-2}) which are measured in N₂O Abatement System (NAS) in plant II.

Sites	No.	Relevant Time to Data cancelling		Parameters of the cancelled data
		from	to	
N ₂ O Abatement System (NAS)	1	16/02/2012, 21:00	17/02/2012, 07:00	<ul style="list-style-type: none"> N₂O concentrations (C_{N_2O-1}, CO_{N_2O-1}) volume flow rate (F_{TI-1}, F_{TE-1})
	2	29/03/2012, 13:00	29/03/2012, 18:00	
	3	25/04/2012, 13:00	25/04/2012, 21:00	
	4	06/06/2012, 15:00	06/06/2012, 20:00	
Product Facility	5	13/01/2012, 08:00	13/01/2012, 16:00	<ul style="list-style-type: none"> N₂O concentrations (C_{N_2O-1}, CO_{N_2O-1}) volume flow rate (F_{TI-1}, F_{TE-1}) AOR operation conditions ($A_{OR,d-1}$, P_{g-1}, T_{g-a}, T_{g-b}) Plant output of caprolactam ($P_{product-1}$)
	6	18/04/2012, 18:00	18/04/2012, 20:00	
	7	07/05/2012, 13:00	07/05/2012, 16:00	

The above events occurred during this monitoring period did not impact the applicability of the methodology.

B.2. Post registration changes**B.2.1. Temporary deviations from registered monitoring plan or applied methodology**

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None

B.2.2. Corrections

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None

B.2.3. Permanent changes from registered monitoring plan or applied methodology

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None

B.2.4. Changes to project design of registered project activity

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None

B.2.5. Changes to start date of crediting period

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None

B.2.6. Types of changes specific to afforestation or reforestation project activity

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N/A

SECTION C. Description of monitoring system

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(a) Monitoring points to be measured

(1) Monitoring Points in Plant I

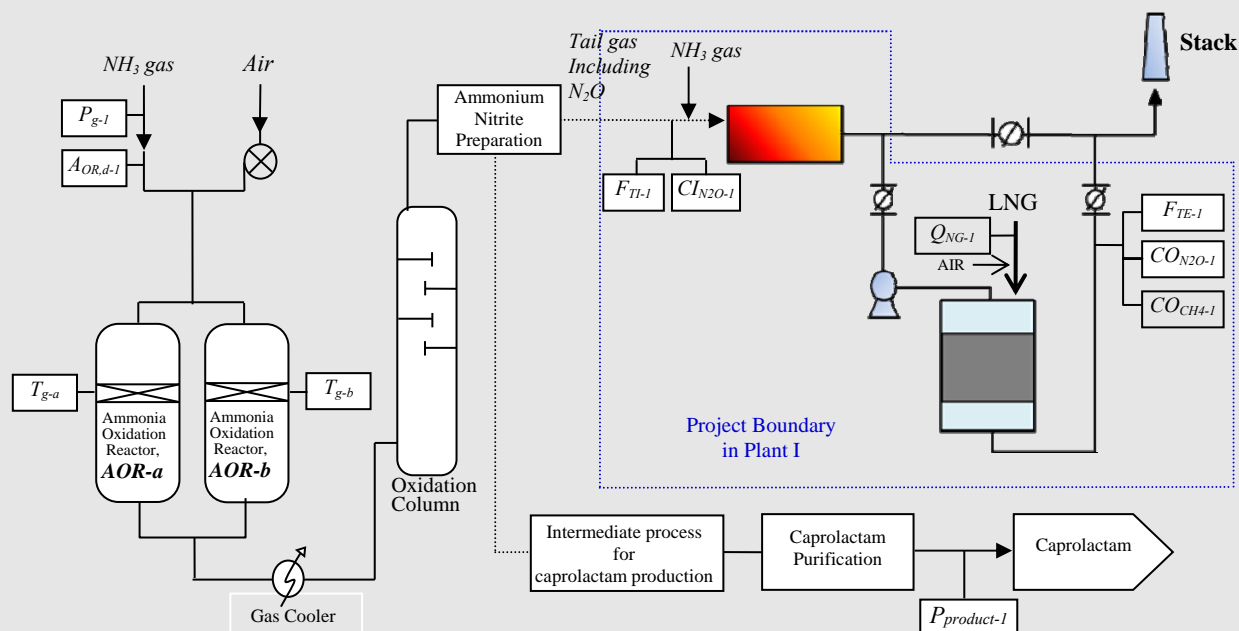


Figure C1. Monitoring Points in Plant I

Parameter	Description	Tag No.
$A_{OR,d-1}$	Actual ammonia flow rate to AOR in Plant I	FIC-1201
P_{g-1}	Actual operating pressure of the AOR-a, b in Plant I	PI-1205
T_{g-a}	Actual operating temperature of the AOR-a in Plant I	TI-1204
T_{g-b}	Actual operating temperature of the AOR-b in Plant I	TI-1206
F_{TL-1}	Volume flow rate at the inlet of the destruction facility in Plant 1	FI-1521
F_{TE-1}	Volume flow rate at the exit of the destruction facility in Plant 1	FI-1522
CI_{N2O-1}	N_2O concentration at destruction facility inlet in Plant I	AI-1521
CO_{N2O-1}	N_2O concentration at destruction facility outlet in Plant I	AI-1522(a)
Q_{NG-1}	Additional natural gas input for re-heating the tail gas in Plant I	FI-1523
CO_{CH4-1}	CH_4 concentration at destruction facility outlet in Plant I	AI-1522(b)
$P_{product-1}$	Plant output of caprolactam in Plant I	FR-7705

Some tag numbers of measuring devices were specified to avoid confusion, because the same tag number had been allocated to two kind of different measuring devices described in PDD. Therefore new tag numbers were given to be clearly identified as follows:

	Parameters	Tag No. in PDD	Actual Tag No. in Period3
Plant I	CO_{N2O-1}	AI-1522	AI-1522(a)
	CO_{CH4-1}	AI-1522	AI-1522(b)

(2) Monitoring Points in Plant II

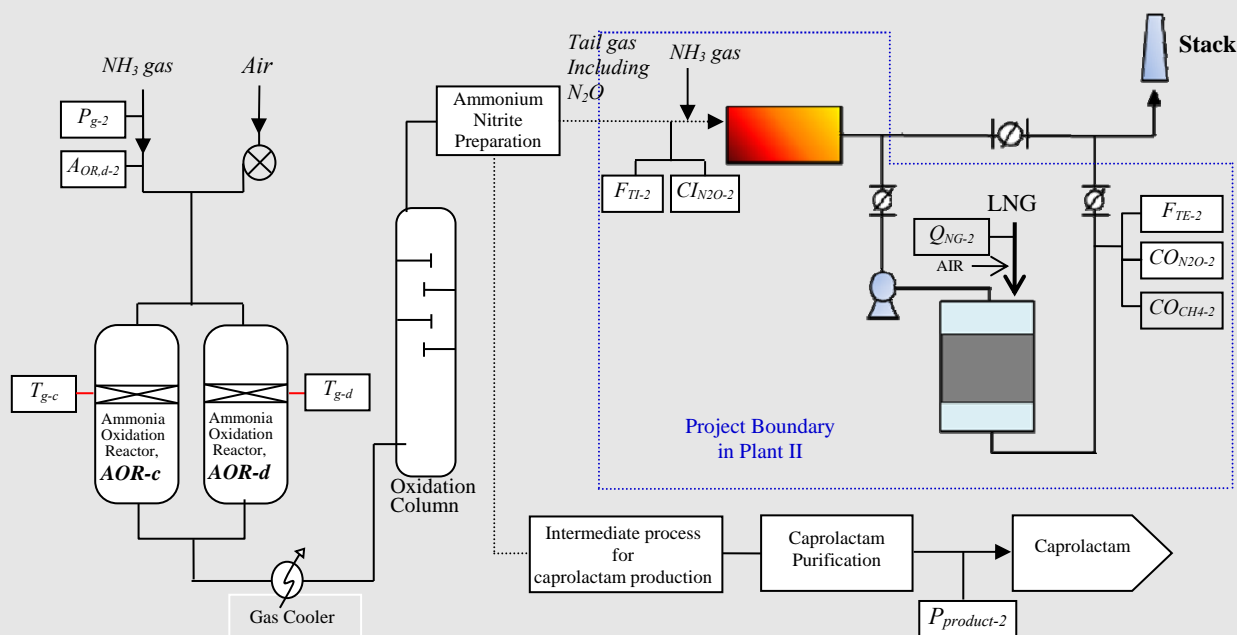


Figure C2. Monitoring Points in Plant II

Parameter	Description	Tag No.
$A_{OR,d-2}$	Actual ammonia flow rate to AOR in Plant II	2FIC-1201
P_{g-2}	Actual operating pressure of the AOR-c, d in Plant II	2PI-1205
T_{g-c}	Actual operating temperature of the AOR-c in Plant II	2TI-1204
T_{g-d}	Actual operating temperature of the AOR-d in Plant II	2TI-1206
F_{TI-2}	Volume flow rate at the inlet of the destruction facility in Plant II	2FI-1521
F_{TE-2}	Volume flow rate at the exit of the destruction facility in Plant II	2FI-1522
CI_{N2O-2}	N_2O concentration at destruction facility inlet in Plant II	2AI-1521
CO_{N2O-2}	N_2O concentration at destruction facility outlet in Plant II	2AI-1522(a)
Q_{NG-2}	Additional natural gas input for re-heating the tail gas in Plant II	2FI-1523
CO_{CH4-2}	CH_4 concentration at destruction facility outlet in Plant II	2AI-1522(b)
$P_{product-2}$	Plant output of caprolactam in Plant II	2FI-7705

Some tag numbers of measuring devices were specified to avoid confusion, because the same tag number had been allocated to two kind of different measuring devices described in PDD. Therefore new tag numbers were given to be clearly identified as follows:

	Parameters	Tag No. in PDD	Actual Tag No. in Period3
Plant II	CO_{N2O-2}	2AI-1522	2AI-1522(a)
	CO_{CH4-2}	2AI-1522	2AI-1522(b)

(b) Data collection procedure

The data of the AOR operating parameters (A_{OR} , T_g , P_g) and the productivity of caprolactam are logged and stored by the existed DCS (Distributed Control System) which has been independently operated for Plant I and II before starting this project. Besides, DAS (Data Acquisition System) is newly installed to log the relevant data to the N_2O decomposition amount and CH_4 emission by operating N_2O abatement system. DAS consists of an 'Electronic Evaluation Unit (EEU)' and two of 'Data Communication Units (DCUs)' located at Plant I and II.

Major function of DCU is to record the raw measurement data from Automated Measuring System (AMS), and to transmit those to EEU. DCU can store temporarily the record of raw measurement data with the ring memory of 16days minute values. In addition, the data of AOR operation and caprolactam productivity are delivered from DCS and recorded by DCU respectably, and then transmitted to EEU. QNG is measured by Flow meter separately installed from AMS and COCH₄ are also measured at the outlet by dual channel-NDIR by which the concentration of N_2O and CH_4 is measured separately. Therefore it is aggregated, recorded and stored by EEU that not only the AMS data but also the AOR data and productivity data. However, if there is a discrepancy between the DCS data and the EEU and/or DCU data, DCS data should be taken.

EEU satisfies the requirements described in AM0028 / Version 05 as below:

- (a) Evaluation unit needs to take into account registration, mean average determination, validation, and evaluation;
- (b) The system and concept of emission data processing needs to be described;
- (c) Protocols and out-prints are required.

With EEU, these raw measurement data transmitted from DCUs are integrated after the measurement uncertainty determined by QAL 2 test is subtracted from them. Then, those are converted to the average values at the end of the every integration interval (1 hour), and validated. Negatively validated average values are set to zero. Validated average values outside the valid calibration range are to be stored with the associated time and with their status and are to be logged on EEU at the end of the day and year. EEU has the storage capacity of 5year-ring memory.

The calibration curve for the measuring instrument is determined using a standard reference method. The validity of the calibration curve is proved by EEU. The validity range for the calibration is specified in the calibration report. This calibration reports are printed and kept for back-up.

External hard disk drive (HDD) is installed for back-up and long storage of the data and relevant reports for verification, replaced by new one every 4 years, old HDDs are kept holding with attention during the 10years of crediting period and 2 additional years according to AM0028 / Version 05.

Table C.1 The information of the data collection and storage devices except DCS

		Supplier	Model No.	Serial No.
DCU(Data Communication Unit)	Plant I	DURAG	D-EMS 500 KE	1301581
	Plant II	DURAG	D-EMS 500 KE	1301582
EEU (Electronic Evaluation Unit)		DURAG	D-EMS 2000 SWE	1301567
External Hard disk drive(HDD) for backup		DURAG	D-EMS 2000 RED	1301578

The role of the new PC for back-up is to display and record the hourly data from EEU, the monthly data of supplied LNG, and the other information including the events list, working diary and so on.

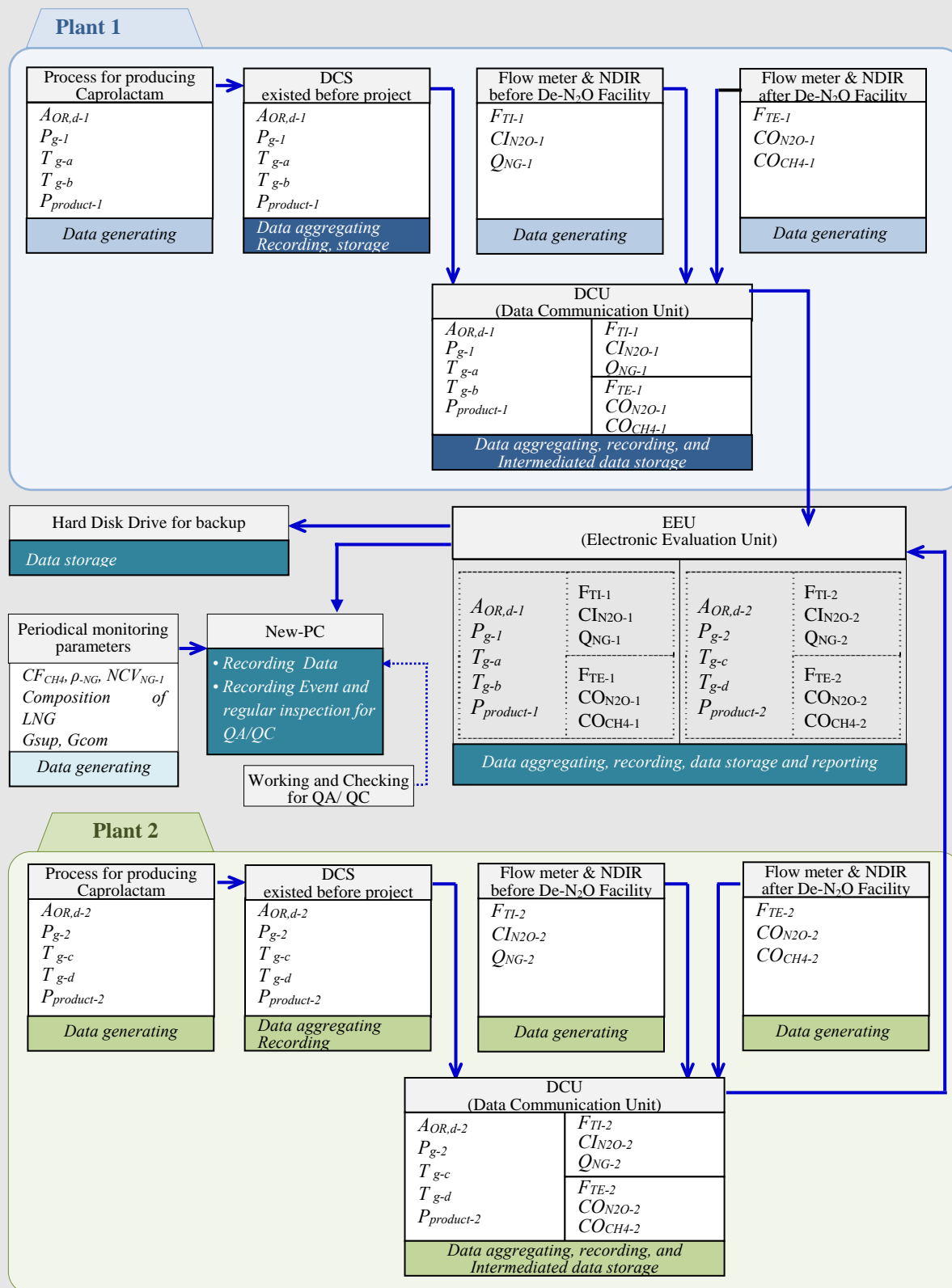
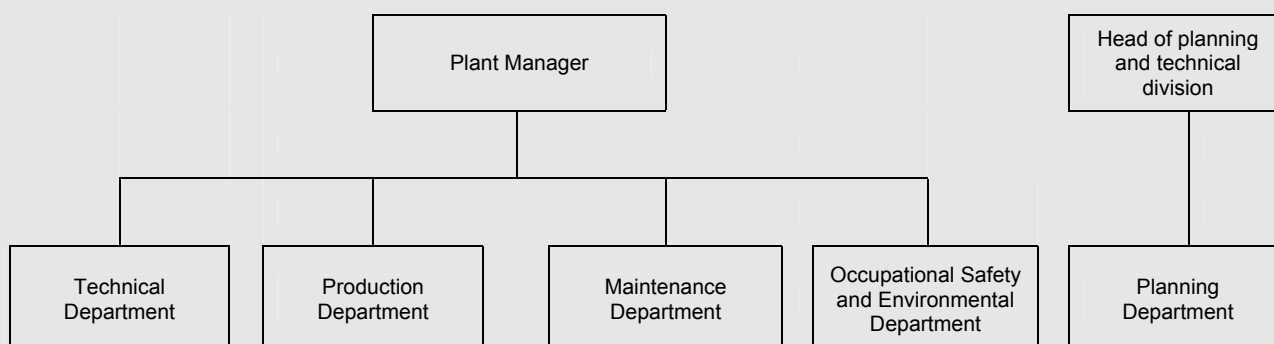


Figure C3. Data Collecting Flow

(c) Organizational structure, roles and responsibilities of personnel**(1) Organization Structure****Figure C4.** The scheme of the operational and management structure**(2) Roles and responsibilities of personnel****Plant Manager**

The Plant Manager takes overall responsibility for the operation and maintenance of the N₂O monitoring system. In addition, the Plant Manager has authority to approve monitoring report provided by the Technical Department.

Production Department

The responsible Production Engineers in Production Department are in charge of the operation and supervision of N₂O monitoring system that will be implemented to record plant operation data.

Technical Department

Monitoring engineers in Technical Department are responsible for collecting, validating and processing the data to determine GHG emission reduction and making report periodically. Moreover, the monitoring engineer is in charge of archiving the data as well. The monitoring engineers archive all required data and reports for verification.

Maintenance Department

Maintenance Department is responsible for maintaining and repairing the instrument associated with this project. Calibration for instruments is concerned by maintenance department as well.

Occupational Safety and Environment Department

The OSHES Department plays a role for indicating the direction and managing according to the monitoring plan.

Planning Department

Planning Department conducts the internal audit of N₂O monitoring system periodically.

(d) Emergency procedures for the monitoring system

In case of the data deviation, following procedures are taken.

- (a) Production Engineer in Production Department identifies whether the deviation results from processing or other factors such as temperature and pressures.
- (b) Production engineer compares the deviated data with other parameter data if the deviation results from processing.
- (c) If the reason for the data deviation is not identified, production engineer informs Maintenance Department to correct the error after inspecting all gauges and analyzers.

If the data deviation is not covered by procedures above, Technical Department makes the decision to correct figures or to abandon the data. In addition, any data correction is in compliance with the applied methodology and done in a conservative bias

When the malfunction of measuring instruments is occurred, following procedures are taken.

- (a) If production engineer recognizes the malfunction of measuring instruments, he informs person in Maintenance Department of this abnormal situation.
- (b) Maintenance Department estimates whether performing repairing action to solve problem is appropriate or not.
- (c) If it is decided that self-repairing by Maintenance Department is appropriate, self-repairing is carried out. However, if the instrument is out of repair, Maintenance Department requests external institution specialized in repairing to have it serviced.

If measuring devices have to be replaced, related supporting evidences should be checked and kept by Maintenance Department, in order to demonstrate that the quality of the replaced measuring devices is the same as the quality grade of existed devices, before the copies of the supporting evidences to replaced devices should be delivered to and kept in the Technical Department.

Specially, if any malfunction situation of the measuring devices composing AMS(Automated measuring system) is continued during the 8hrs after it is detected, Maintenance Department should request the service of official measuring agency to measuring the N₂O concentration or flow rate at the monitoring points of inlet and outlet of N₂O decomposition system. If the services by the official measuring agency cannot be taken for some unavoidable reason, it will be taken instead of measuring by the external official measuring agency that the AMS data measured at the most similar operating condition among those of the recent 1 month just before the abnormal situation is happen, with the conservative understanding of that the N₂O concentration of inlet is replaced with the lowest number, and that of outlet is with highest one.

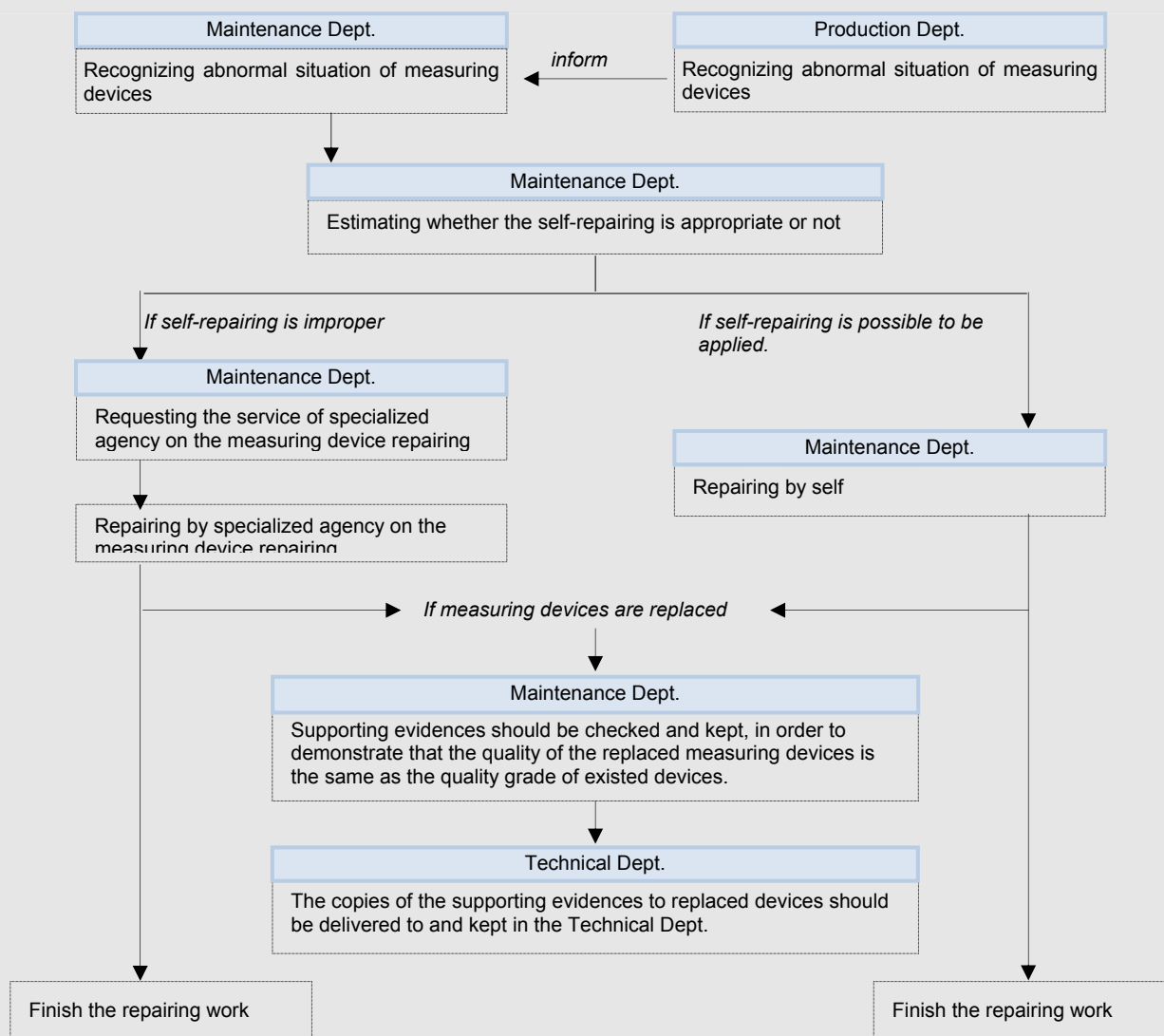


Figure C5. Emergency Procedures for malfunctions of measuring devices in general

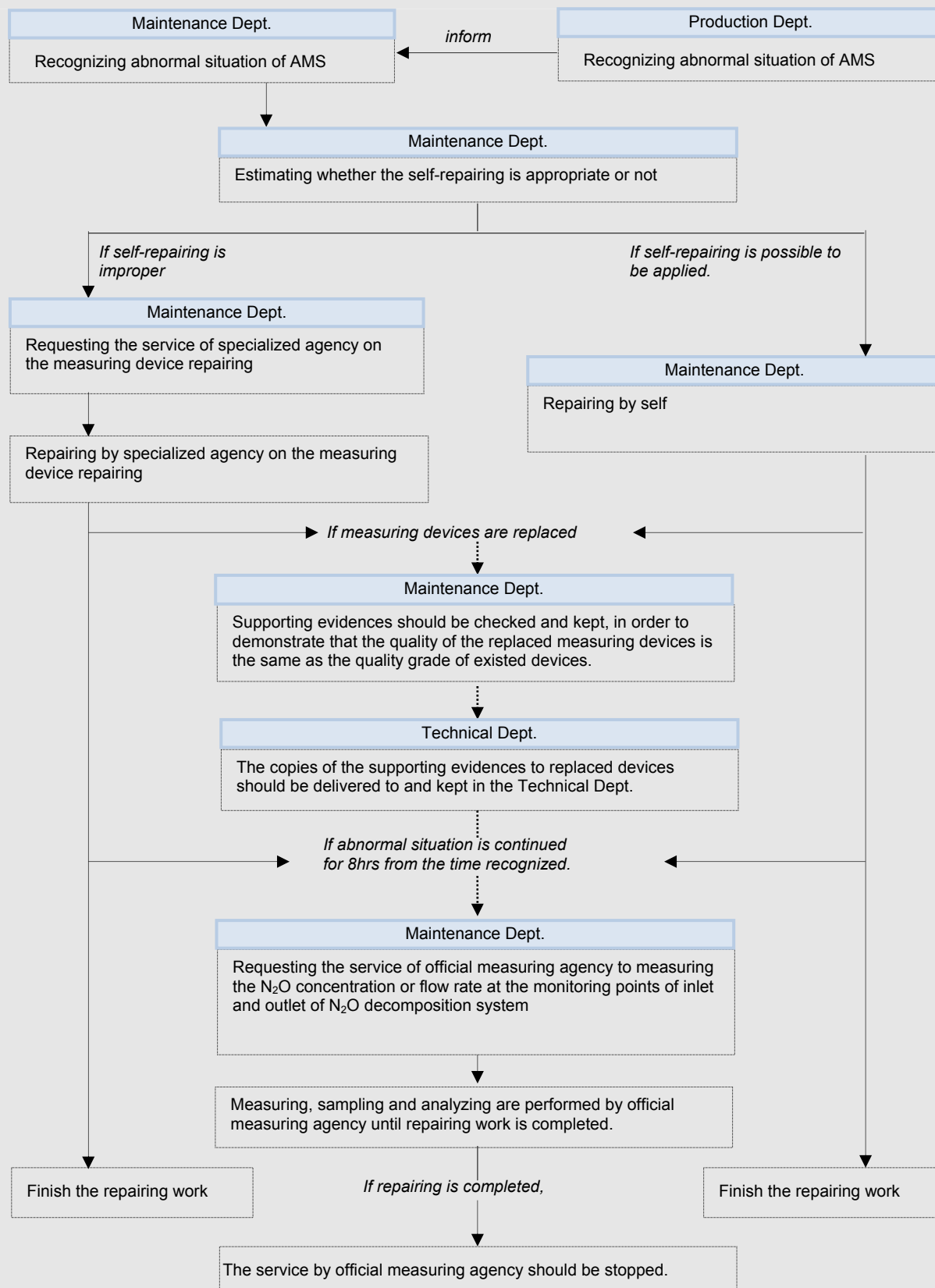
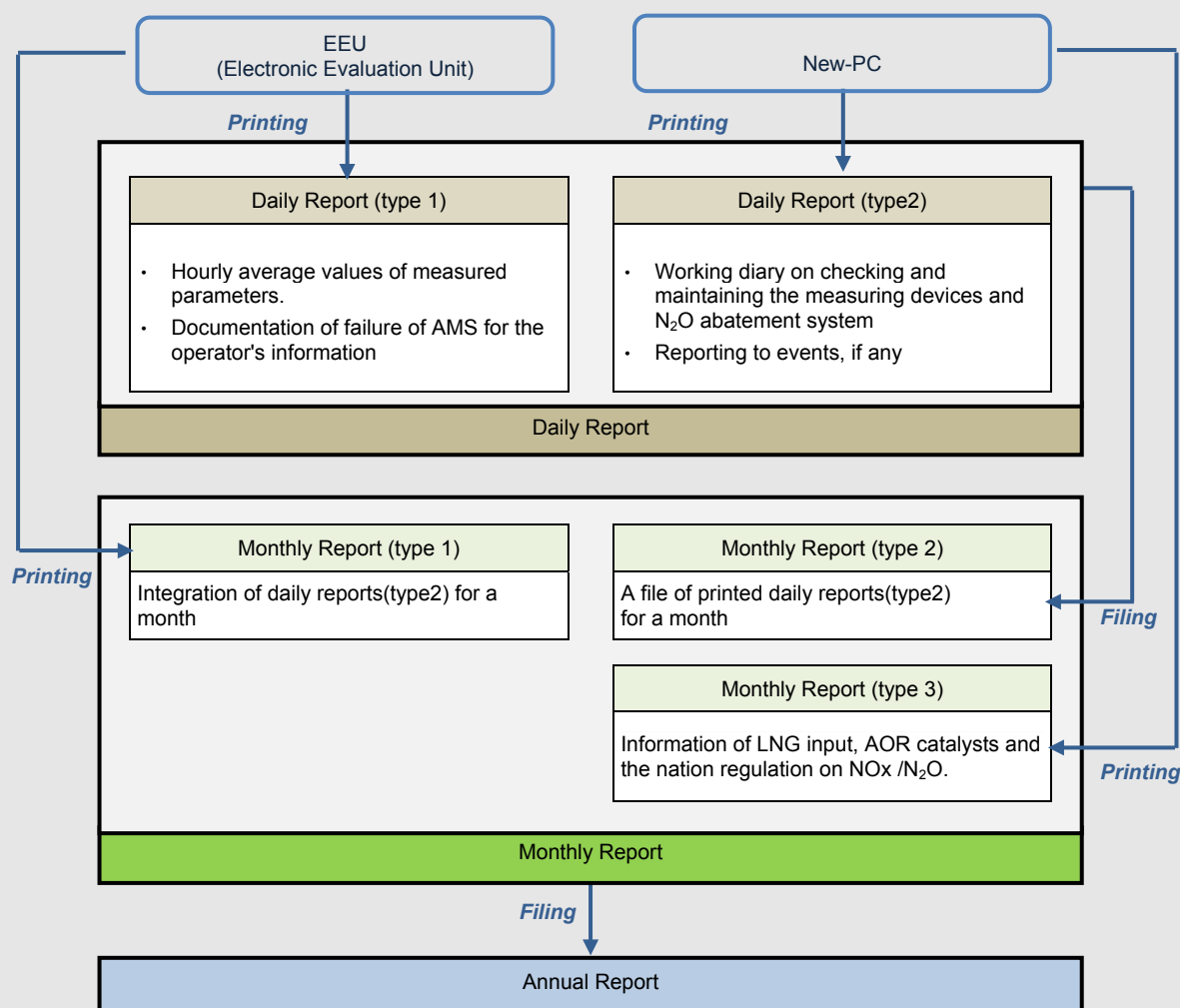


Figure C6. Emergency Procedures for malfunction of AMS

(e) **Reporting**

- **Daily report** consists of the parts printed out from EEU and from New-PC. EEU report is to show the data generated by AMS and related to the AOR operation condition and to the productivity of caprolactam. Daily value of each parameter is calculated based on hourly average or hourly total value on the EEU report. The situation of the AMS failure is also documented on the EEU report. The other hand, new-PC daily report is about checking and maintaining the measuring device and N₂O abatement system, and about monitoring events.
- **Monthly report** integrates the data and information in daily reports. LNG information is also reported monthly. Periodical monitoring parameters such as the composition and supplier of AOR catalysts, the national regulation on NO_x and N₂O are checked by monthly report too.
- **Annual report** is a bunch of monthly report files.

**Figure C7.** The consists of the periodical reports

(f) Quality Assurance of AMS(Automated measuring system)

AMS(Automated measuring system) has been applied to measure the amount of N₂O emission at the two monitoring points of the inlet and outlet of N₂O destruction facility of each plant involved in this project. By AMS, the concentration of N₂O and the volume flow rate of tail gas are measured simultaneously(F_{TI}, C_{IN2O}, and F_{TE}, C_{ON2O}) at same basis (wet or dry), and these values are expressed on the same basis (wet or dry) with correcting to normal conditions (101.324kPa, 0deg C) through the algorithm based on procedures of EN14181.

“European Norm EN14181: Quality assurance of automated measuring systems, 2004” is selected as a guidance document to the Quality Assurance and Control procedure of the AMS for this project. This means that the three levels of quality assurance tests(QAL1, QAL2 and QAL3) and one annual functional test must be carried out regarding the selection, installation, and operation of AMS under the monitoring methodology in AM0028(ver.05).

Quality assurance of tested AMS (:QAL1)

The quality assurance of tested AMS was accomplished with that the flow meters and N₂O gas analyzers having the performance certificate with calculation uncertainty were selected as summarized in following tables.

Table C.2 (a) Information of the quality assurance of tested AMS located in Plant I

Para- meters	Type	model	serial number	Standard for Performance certification	Certificate No.	The date of Certificate Issued (dd/mm/yyyy)	Approved Methods to calculate of uncertainty
F _{TI-1}	Ultrasonic flow meter	D-FL 200 System	HEAD A: 1217007 HEAD B: 1217008 EVALUATION UNIT : 1216861 CASE OF EVALUATION : 1216999	MCERTS	Sira MC 060072/01	22/05/2007	-
C _{IN2O-1}	Non- dispersion infrared absorption analyzer (NDIR)	ULTRAMAT 6	AO-748	TUV	Report Nr. 1290727	May 2009	-
				TUV	BB-EG1- KAR Gr02X	29/07/2003	EN 50016 EN 60079-14 Guidelines for explosion protection of GB Chemie(GRG 104)
				FM Approvals	3016050	15/07/2003	-
				CSA INTERNATIONAL	1431560	17/04/2003	-
F _{TE-1}	Ultrasonic flow meter	D-FL 200 System	HEAD A: 1217009 HEAD B: 1217010 EVALUATION UNIT : 1216862 CASE OF EVALUATION : 1217001	MCERTS	Sira MC 060072/01	22/05/2007	-
C _{ON2O-1}	NDIR	ULTRAMAT 6	AO-750	TUV	Report Nr. 1290727	May 2009	-
				TUV	BB-EG1- KAR Gr02X	29/09/2003	EN 50016 EN 60079-14 Guidelines for explosion protection of GB Chemie(GRG 104)
				FM Approvals	3016050	15/07/2003	-
				CSA INTERNATIONAL	1431560	17/04/2003	-

Table C.2 (b) Information of the quality assurance of tested AMS located in Plant II

Para- meters	Type	model	serial number	Standard for Performance certification	Certificate No.	The date of Certificate Issued (dd/mm/yyyy)	Approved Methods to calculate of uncertainty
F _{TI-2}	Ultrasonic Flow meter	D-FL 200 System	HEAD A: 1217011 HEAD B: 1217012 EVALUATION UNIT : 1216866 CASE OF EVALUATION : 1217002	MCERTS	Sira MC 060072/01	22/05/2007	-
C _{N2O-2}	NDIR	ULTRAMAT 6	AO-749	TUV	Report Nr. 1290727	May 2009	-
				TUV	BB-EG1- KAR Gr02X	29/09/2003	EN 50016 EN 60079-14 Guidelines for explosion protection of GB Chemie(GRG 104)
				FM Approvals	3016050	15/07/2003	-
				CSA INTERNATIONAL	1431560	17/04/2003	-
F _{TE-2}	Ultrasonic Flow meter	D-FL 200 System	HEAD A: 1217013 HEAD B: 1217014 EVALUATION UNIT : 1216867 CASE OF EVALUATION : 1217003	MCERTS	Sira MC 060072/01	22/05/2007	-
C _{O2-2}	NDIR	ULTRAMAT 6	AO-751	TUV	Report Nr. 1290727	May 2009	-
				TUV	BB-EG1- KAR Gr02X	29/09/2003	EN 50016 EN 60079-14 Guidelines for explosion protection of GB Chemie(GRG 104)
				FM Approvals	3016050	15/07/2003	-
				CSA INTERNATIONAL	1431560	17/04/2003	-

Quality assurance of installation and calibration of AMS (:QAL2)

QAL 2 has been performed two times according to the Standard Reference Measurement Method (23/05/2011~27/05/2011 and 26/09/2011~29/09/2011) by AIR-TEC, which is the one of the organizations having an accredited quality assurance system on ISO/IEC 17025.

The results to the tests for QAL2 were summarized on the QAL 2 reports in the major items following:

- (a) Section of the location of measurement
- (b) Duly installation of the monitoring equipment
- (c) Correct choice of measurement range
- (d) Calibration of AMS using the standard-Reference-Method(SRM) as guidance
- (e) Calibration curve either as linear regression or as straight line from absolute zero to centre of a scatter-plot
- (f) Calibration of the standard deviation at the 95% confidence interval

Continuous quality Assurance through the local operator/manager (:QAL3)

QAL 3 has been implemented since the project start up. This includes:

- Permanent quality assurance during the plant operation by the operating staff
- Assurance of reliable and correct operation of the monitoring equipment
- Regular controls : zero point, span, drift, meet schedule of manufacturer maintenance intervals

Annual Surveillance test (AST)

Annual Surveillance test has been carried out in May of 2012 (14/05/2012~17/05/2012).

(g) Conservative calculation on tail gas flow

Measurement value by a flow meter at inlet of destruction facility (F_{TI}) and Measurement value by a flow meter at outlet of destruction facility (F_{TE}), both parameters shall be cross checked to ensure that no leak of N_2O is taking place, and in case of discrepancy, conservative calculation of emission reduction is provided. In order to achieve conservative approach, the measured inlet flow (F_{TI}) would be adjusted to the value (F_{TI}^*) by the below equation.

$$F_{TI}^* = \min \left[F_{TI} ; \left(\frac{F_{TE}}{1+VEF} - Q_{NG} \times \frac{Q_{NG \text{ combustion gas}}}{Q_{NG}} \right) \right]$$

Where:

F_{TI}^*	: Conservative volume flow at the inlet of destruction facility used for emission reduction calculation (Nm ³ /h)
F_{TI}	: Measurement value by a flow meter at inlet of destruction facility (Nm ³ /h)
F_{TE}	: Measurement value by a flow meter at outlet of destruction facility (Nm ³ /h)
Q_{NG}	: Natural gas input for re-heating the tail gas (Nm ³ /h)
$Q_{NG \text{ combustion gas}}$: Combustion gas of natural gas (Nm ³ /h)
VEF	: Volumetric Expansion Factor

For monitoring, the gas generated by combusting natural gas($Q_{NG \text{ combustion gas}}$) has been estimated on the supposition that air input according to the theoretical oxygen demand on the natural gas composition which information is provided by the natural gas supplier for Capro (Kyung Dong city gas CO., Ltd).

And for the conservative approach, any volume change from De-NOx and/or De-N₂O system will be considered by the Volumetric Expansion Factor (VEF). Before the first monitoring period, the Volumetric Expansion Factor (VEF) was determined as 0.001 which was provided by CRI, N₂O abatement catalysts supplier. This value of VEF is applied as a fixed official value.

(h) Training

The supplier of the NDIR system provided complete training to the monitoring engineers in charge of operation and maintenance of the monitoring system. The provider of the De-N₂O system, (Hyosung Ebara Engineering Co., Ltd.) initiated the operation technique for the system to the staff in the Technical department of Capro.

SECTION D. Data and parameters

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

Data/Parameter	GWP_{N_2O}
Unit	Not applicable
Description	Global warming potential of the nitrous oxide
Source of data	IPCC, The Second Assessment Report
Value(s) applied	310
Purpose of data	Baseline Emission / Project Emission Calculation
Additional comment	Not applicable

Data/Parameter	GWP_{CH_4}
Unit	Not applicable
Description	Global warming potential of the methane
Source of data	IPCC, The Second Assessment Report
Value(s) applied	21
Purpose of data	Project Emission Calculation
Additional comment	Not applicable

Data/Parameter	$P_{product, max}$
Unit	t Caprolactam /yr
Description	Design capacity of caprolactam production of the targeted line
Source of data	PDD
Value(s) applied	$P_{product1, max}$: 63,307 ton/yr (design capacity in Plant I) for 363 days $P_{product2, max}$: 64,965 ton/yr (design capacity in Plant II) for 355 days Each plant has an individual design capacity.
Purpose of data	Baseline Emission Calculation
Additional comment	Not applicable

Data/Parameter	$A_{OR, hist}$
Unit	tNH ₃ /day
Description	Maximum of historical ammonia flow rate of the ammonia oxidation reactor (AOR)
Source of data	PDD
Value(s) applied	$A_{OR, hist-1}$: 42.250tNH ₃ /d (total flow rate for AOR-a and AOR-b in Plant I) $A_{OR, hist-2}$: 44.557tNH ₃ /d (total flow rate for AOR-c and AOR-d in Plant II)
Purpose of data	Baseline Emission Calculation
Additional comment	Not applicable

Data/Parameter	$T_{g, hist}$
Unit	°C
Description	Historical operating temperature range of the ammonia oxidation reactor
Source of data	PDD

Value(s) applied	$T_{g,hist-a}$: 656.57– 731.66°C (for AOR-a in Plant I) $T_{g,hist-b}$: 662.08–743.92 °C (for AOR-b in Plant I) $T_{g,hist-c}$: 738.95– 774.85°C (for AOR-c in Plant II) $T_{g,hist-d}$: 734.53– 770.57°C (for AOR-d in Plant II)
Purpose of data	Baseline Emission Calculation
Additional comment	Not applicable

Data/Parameter	$P_{g,hist}$
Unit	<i>Pa gauge</i>
Description	Historical operating pressure range of the ammonia oxidation reactor
Source of data	PDD
Value(s) applied	$P_{g,hist_1}$: 43,320– 98,564 Pa gauge (for AOR-a and AOR-b in Plant I) $P_{g,hist_2}$: 79,317– 96,381 Pa gauge (for AOR-c and AOR-d in Plant II)
Purpose of data	Baseline Emission Calculation
Additional comment	Not applicable

Data/Parameter	$G_{sup,hist}$
Unit	Not applicable
Description	Historical supplier of the ammonia oxidation catalyst
Source of data	PDD
Value(s) applied	Name of the supplier: Johnson Matthey
Purpose of data	Baseline Emission Calculation
Additional comment	Not applicable

Data/Parameter	$G_{com,hist}$
Unit	%
Description	Historical composition of the ammonia oxidation catalyst
Source of data	PDD
Value(s) applied	Pt (90%): Rh (10%)
Purpose of data	Baseline Emission Calculation
Additional comment	Not applicable

Data/Parameter	$OXID_{HC}$
Unit	%
Description	Oxidation factor of natural gas, with two or more molecules of carbon
Source of data	PDD
Value(s) applied	100%
Purpose of data	Project Emission Calculation
Additional comment	Not applicable

Data/Parameter	EF_{CH4}
Unit	tCO ₂ /tCH ₄

Description	Emission factor of methane
Source of data	PDD
Value(s) applied	2.75(tCO ₂ /tCH ₄)
Purpose of data	Project Emission Calculation
Additional comment	Not applicable

Data/Parameter	ρ_{CH_4}
Unit	t/m ³
Description	Density of methane
Source of data	Tool to determine project emissions from flaring gases containing methane
Value(s) applied	0.000716 t/m ³ (0°C, 1atm)
Purpose of data	Project Emission Calculation
Additional comment	Not applicable

Data/Parameter	M_i
Unit	hour
Description	Length of measuring interval
Source of data	AMS
Value(s) applied	1 hour (to be measured continuously for 24 hours)
Purpose of data	Baseline Emission Calculation / Project Emission Calculation
Additional comment	Not applicable

Data/Parameter	Reg_{NOx}
Unit	tNO _x /Nm ³
Description	National regulation on NO _x emissions
Source of data	The "Clean Air Conservation Act", one of the National environmental legislation, Ministry of Environment
Value(s) applied	4.10714×10 ⁻⁷ tNO _x /Nm ³ (as a NO ₂ concentration)
Purpose of data	Not applicable
Additional comment	Not applicable

D.2. Data and parameters monitored

Data / Parameter:	$F_{Ti,i}$		
Unit:	Nm ³ /hr		
Description:	Volume flow rate at the inlet of the destruction facility		
Measured/ Calculated / Default:	Measured		
Source of data:	Flow meter with normalizing functions		
Value(s) of monitored parameter:	For this period, the average values of F_{Ti}		
		Plant I ($F_{Ti,1}$)	Plant II($F_{Ti,2}$)
	F_{Ti} (Nm ³ /hr) average	40,698	39,079
Monitoring equipment:		Plant I ($F_{Ti,1}$)	Plant II($F_{Ti,2}$)
	Type	Ultrasonic flow meter	Ultrasonic flow meter
	Accuracy class	< 2%	< 2%
	Serial No.	<ul style="list-style-type: none"> • HEAD A: 1217007 • HEAD B: 1217008 • Evaluation Unit :1216861 • Case of Evaluation : 1216999 	<ul style="list-style-type: none"> • HEAD A: 1217011 • HEAD B: 1217012 • Evaluation Unit :1216866 • Case of Evaluation : 1217002
	Calibration frequency	Every day by Auto calibration manner	Every day by Auto calibration manner
	Date of last calibration	08/06/2012	08/06/2012
	Validity	Yes	Yes
Measuring/ Reading/ Recording frequency:	<ul style="list-style-type: none"> •Measuring period : Continuously •Recording frequency : Hourly 		
Calculation method (if applicable):	Not applicable		
QA/QC procedures:	QAL 1, 2,3 and AST for AMS		
Purpose of data:	Baseline Emission Calculation		
Additional comment:	Not applicable		

Data / Parameter:	$F_{TE,i}$		
Unit:	Nm ³ /hr		
Description:	Volume flow rate at the exit of the destruction facility		
Measured/ Calculated / Default:	Measured		
Source of data:	Flow meter with normalizing functions		
Value(s) of monitored parameter:	For this period, the average values of F_{TE}		
		Plant I ($F_{TE,1}$)	Plant II ($F_{TE,2}$)
	F_{TE} as Nm ³ /hr in average	43,747	45,596

Monitoring equipment:		Plant I ($F_{TE,1}$)	Plant II ($F_{TE,2}$)
	Type	Ultrasonic flow meter	Ultrasonic flow meter
	Accuracy class	< 2%	< 2%
	Serial No.	•HEAD A: 1217009 •HEAD B: 1217010 • Evaluation Unit : 1216862 • Case of Evaluation : 1217001	•HEAD A: 1217013 •HEAD B: 1217014 • Evaluation Unit : 1216867 • Case of Evaluation : 1217003
	Calibration frequency	Every day by Auto calibration manner	Every day by Auto calibration manner
	Date of last calibration	08/06/2012	08/06/2012
	Validity	Yes	Yes
Measuring/ Reading/ Recording frequency:	•Measuring period : Continuously •Recording frequency : Hourly		
Calculation method (if applicable):	Not applicable		
QA/QC procedures:	QAL 1, 2,3 and AST for AMS		
Purpose of data:	Project Emission Calculation		
Additional comment:	Not applicable		

Data / Parameter:	$CI_{N2O,i}$		
Unit:	tN ₂ O/Nm ³		
Description:	N ₂ O concentration at destruction facility inlet		
Measured/ Calculated / Default:	Measured		
Source of data:	Non-dispersion infrared absorption analyzer (NDIR)		
Value(s) of monitored parameter:	For this period, the average values of CI_{N2O}		
		Plant I (CI_{N2O-1})	Plant II (CI_{N2O-2})
	$CI_{N2O,i}$ as tN ₂ O/Nm ³	4.261 × 10 ⁻⁶	3.566 × 10 ⁻⁶

Monitoring equipment:		Plant I (CI_{N2O-1})	Plant II (CI_{N2O-2})
	Type	NDIR	NDIR
	Accuracy class (repeatability)	>95%	>95%
	Serial No.	AO-748	AO-749
	Calibration frequency	Every 2weeks	Every 2weeks
	Date of last calibration	31/05/2012	31/05/2012
	Validity	Yes	Yes
Measuring/ Reading/ Recording frequency:	•Measuring period : Continuously •Recording frequency : Hourly		
Calculation method (if applicable):	Not applicable		
QA/QC procedures:	QAL 1, 2,3 and AST for AMS		
Purpose of data:	Baseline Emission Calculation		
Additional comment:	Not applicable		

Data / Parameter:	$CO_{N2O,i}$		
Unit:	tN ₂ O/Nm ³		
Description:	N ₂ O concentration at destruction facility outlet		
Measured/ Calculated / Default:	Measured		
Source of data:	Non-dispersion infrared absorption analyzer (NDIR)		
Value(s) of monitored parameter:	For this period, the average values of CO_{N2O}		
		Plant I(CO_{N2O-1})	Plant II(CO_{N2O-2})
	$CO_{N2O,i}$ as tN ₂ O/Nm ³	5.294×10^{-7}	3.472×10^{-7}
Monitoring equipment:		Plant I(CO_{N2O-1})	Plant II(CO_{N2O-2})
	Type	NDIR	NDIR
	Accuracy class (repeatability)	>95%	>95%
	Serial No.	AO-750	AO-751
	Calibration frequency	Every 2weeks	Every 2weeks
	Date of last calibration	31/05/2012	31/05/2012
	Validity	Yes	Yes
Measuring/ Reading/ Recording frequency:	•Measuring period : Continuously •Recording frequency : Hourly		
Calculation method (if applicable):	Not applicable		
QA/QC procedures:	QAL 1, 2,3 and AST for AMS		
Purpose of data:	Project Emission Calculation		
Additional comment:	Not applicable		

Data / Parameter:	$P_{product,y}$			
Unit:	t Caprolactam/yr			
Description:	Plant output of caprolactam			
Measured/ Calculated / Default:	Measured			
Source of data:	The value measured by Mass flow meter			
Value(s) of monitored parameter:			Plant I ($P_{product-1}$)	Plant II($P_{product-2}$)
	$P_{product, period,}$ (ton/period)	Period 1	13764.22	14415.80
		Period 2	17035.04	20618.53
		Period 3	24260.29	28071.06
	$P_{product, y}$ (ton/yr)		55059.55	63105.39

Monitoring equipment:	<p>The measuring instrument for $P_{product,-1}$ which is indicated in the registered PDD was replaced on 6th February 2012.</p> <p>The information of the measuring instrument for $P_{product-1}$ in plant I, and $P_{product-2}$ in plant II is as follows:</p> <table border="1"> <thead> <tr> <th rowspan="2"></th><th colspan="2">Plant I ($P_{product-1}$)</th><th rowspan="2">Plant II ($P_{product,-2}$)</th></tr> <tr> <th>Before replacement</th><th>After replacement</th></tr> </thead> <tbody> <tr> <td>Type</td><td>Mass flow meter</td><td>Mass flow meter</td><td>Mass flow meter</td></tr> <tr> <td>Accuracy class</td><td>Within $\pm 0.1\%$</td><td>Within $\pm 0.1\%$</td><td>Within $\pm 0.15\%$</td></tr> <tr> <td>Serial No.</td><td>6T 681125</td><td>F1013202000</td><td>28 529138</td></tr> <tr> <td>Calibration frequency</td><td>Every 2years</td><td>Every 2years</td><td>Every 2years</td></tr> <tr> <td>Date of last calibration</td><td>07/10/2010</td><td>20/01/2012</td><td>07/10/2010</td></tr> <tr> <td>Validity</td><td>Yes</td><td>Yes</td><td>Yes</td></tr> </tbody> </table>				Plant I ($P_{product-1}$)		Plant II ($P_{product,-2}$)	Before replacement	After replacement	Type	Mass flow meter	Mass flow meter	Mass flow meter	Accuracy class	Within $\pm 0.1\%$	Within $\pm 0.1\%$	Within $\pm 0.15\%$	Serial No.	6T 681125	F1013202000	28 529138	Calibration frequency	Every 2years	Every 2years	Every 2years	Date of last calibration	07/10/2010	20/01/2012	07/10/2010	Validity	Yes	Yes	Yes
	Plant I ($P_{product-1}$)		Plant II ($P_{product,-2}$)																														
	Before replacement	After replacement																															
Type	Mass flow meter	Mass flow meter	Mass flow meter																														
Accuracy class	Within $\pm 0.1\%$	Within $\pm 0.1\%$	Within $\pm 0.15\%$																														
Serial No.	6T 681125	F1013202000	28 529138																														
Calibration frequency	Every 2years	Every 2years	Every 2years																														
Date of last calibration	07/10/2010	20/01/2012	07/10/2010																														
Validity	Yes	Yes	Yes																														
Measuring/ Reading/ Recording frequency:	<ul style="list-style-type: none"> •Measuring period : Continuously •Recording frequency : Hourly 																																
Calculation method (if applicable):	Not applicable																																
QA/QC procedures:	Cross-check of amount of the produced caprolactam is performed on the basis of stock change data and weighbridge data.																																
Purpose of data:	Baseline emission Calculation																																
Additional comment:	Not applicable																																
Data / Parameter:	$T_{g,d}$																																
Unit:	°C																																
Description:	Actual daily (d) operating temperature of the ammonia oxidation reactor																																
Measured/ Calculated / Default:	Measured																																
Source of data:	Thermocouple																																
Value(s) of monitored parameter:	<p>Average daily temperature (°C) of AOR in this period</p> <table border="1"> <thead> <tr> <th colspan="2">Plant I</th><th colspan="2">Plant II</th></tr> <tr> <th>$T_{g,a}$ (°C)</th><th>$T_{g,b}$ (°C)</th><th>$T_{g,c}$ (°C)</th><th>$T_{g,d}$ (°C)</th></tr> </thead> <tbody> <tr> <td>702.11</td><td>732.15</td><td>758.25</td><td>750.03</td></tr> </tbody> </table> <p>The measuring instrument for T_{g-b} which is indicated in the registered PDD was replaced on October 2011. Even though the model number and Maker of the new measuring equipment are different from past one described in PDD, the type and the accuracy class of the equipment are the same.</p>			Plant I		Plant II		$T_{g,a}$ (°C)	$T_{g,b}$ (°C)	$T_{g,c}$ (°C)	$T_{g,d}$ (°C)	702.11	732.15	758.25	750.03																		
Plant I		Plant II																															
$T_{g,a}$ (°C)	$T_{g,b}$ (°C)	$T_{g,c}$ (°C)	$T_{g,d}$ (°C)																														
702.11	732.15	758.25	750.03																														

Monitoring equipment:	<table border="1"> <tr> <th>Plant I</th> <th colspan="2">T_{g-a}</th> <th colspan="2">T_{g-b}</th> </tr> <tr> <td>Type</td> <td colspan="2">Thermocouple K</td> <td colspan="2">Thermocouple K</td> </tr> <tr> <td rowspan="3">Accuracy class (Maximum error)</td> <td>300°C</td> <td>+0.00°C</td> <td>300°C</td> <td>+0.00°C</td> </tr> <tr> <td>500°C</td> <td>+0.35°C</td> <td>500°C</td> <td>+0.35°C</td> </tr> <tr> <td>700°C</td> <td>+0.98°C</td> <td>700°C</td> <td>+0.98°C</td> </tr> <tr> <td>Serial No.</td> <td colspan="2">2170447</td> <td colspan="2">2170445</td> </tr> <tr> <td>Calibration frequency</td> <td colspan="2">Every 2 years</td> <td colspan="2">Every 2 years</td> </tr> <tr> <td>Date of last calibration</td> <td colspan="2">13/05/2011</td> <td colspan="2">17/10/2011</td> </tr> <tr> <td>Validity</td> <td colspan="2">Yes</td> <td colspan="2">Yes</td> </tr> </table>					Plant I	T_{g-a}		T_{g-b}		Type	Thermocouple K		Thermocouple K		Accuracy class (Maximum error)	300°C	+0.00°C	300°C	+0.00°C	500°C	+0.35°C	500°C	+0.35°C	700°C	+0.98°C	700°C	+0.98°C	Serial No.	2170447		2170445		Calibration frequency	Every 2 years		Every 2 years		Date of last calibration	13/05/2011		17/10/2011		Validity	Yes		Yes	
	Plant I	T_{g-a}		T_{g-b}																																												
	Type	Thermocouple K		Thermocouple K																																												
	Accuracy class (Maximum error)	300°C	+0.00°C	300°C	+0.00°C																																											
		500°C	+0.35°C	500°C	+0.35°C																																											
		700°C	+0.98°C	700°C	+0.98°C																																											
	Serial No.	2170447		2170445																																												
	Calibration frequency	Every 2 years		Every 2 years																																												
	Date of last calibration	13/05/2011		17/10/2011																																												
	Validity	Yes		Yes																																												
	<table border="1"> <tr> <th>Plant II</th> <th colspan="2">T_{g-c}</th> <th colspan="2">T_{g-d}</th> </tr> <tr> <td>Type</td> <td colspan="2">Thermocouple K</td> <td colspan="2">Thermocouple K</td> </tr> <tr> <td rowspan="3">Accuracy class (Maximum error)</td> <td>300°C</td> <td>-0.7°C</td> <td>300°C</td> <td>-0.7°C</td> </tr> <tr> <td>500°C</td> <td>-0.1°C</td> <td>500°C</td> <td>-0.1°C</td> </tr> <tr> <td>700°C</td> <td>-0.7°C</td> <td>700°C</td> <td>-0.7°C</td> </tr> <tr> <td>Serial No.</td> <td colspan="2">24001</td> <td colspan="2">24002</td> </tr> <tr> <td>Calibration frequency</td> <td colspan="2">Every 2 years</td> <td colspan="2">Every 2 years</td> </tr> <tr> <td>Date of last calibration</td> <td colspan="2">23/05/2011</td> <td colspan="2">23/05/2011</td> </tr> <tr> <td>Validity</td> <td colspan="2">Yes</td> <td colspan="2">Yes</td> </tr> </table>					Plant II	T_{g-c}		T_{g-d}		Type	Thermocouple K		Thermocouple K		Accuracy class (Maximum error)	300°C	-0.7°C	300°C	-0.7°C	500°C	-0.1°C	500°C	-0.1°C	700°C	-0.7°C	700°C	-0.7°C	Serial No.	24001		24002		Calibration frequency	Every 2 years		Every 2 years		Date of last calibration	23/05/2011		23/05/2011		Validity	Yes		Yes	
	Plant II	T_{g-c}		T_{g-d}																																												
	Type	Thermocouple K		Thermocouple K																																												
	Accuracy class (Maximum error)	300°C	-0.7°C	300°C	-0.7°C																																											
		500°C	-0.1°C	500°C	-0.1°C																																											
		700°C	-0.7°C	700°C	-0.7°C																																											
	Serial No.	24001		24002																																												
	Calibration frequency	Every 2 years		Every 2 years																																												
	Date of last calibration	23/05/2011		23/05/2011																																												
	Validity	Yes		Yes																																												
Measuring/ Reading/ Recording frequency:	•Measuring period : Continuously •Recording frequency : Hourly																																															
Calculation method (if applicable):	Not applicable																																															
QA/QC procedures:	Every two years, the measuring instrument is calibrated by the authorized organization providing the calibration service on the basis of the national standard. Otherwise, the measuring instrument is replaced with new instrument calibrated according to the national standard.																																															
Purpose of data:	Baseline emission Calculation																																															
Additional comment:	Not applicable																																															
Data / Parameter:	$P_{g,d}$																																															
Unit:	Pa gauge																																															
Description:	Actual operating pressure of the ammonia oxidation reactor on day d																																															
Measured/ Calculated / Default:	Measured																																															
Source of data:	Pressure gauge																																															
Value(s) of monitored parameter:	Average daily Pressure (Pa/day) of AOR in this period																																															
		Plant I (P_{g-1})		Plant II (P_{g-2})																																												
	$P_{g,d}$ (Pa/day)	88,231		88,746																																												

Monitoring equipment:	<table border="1"> <tr> <th></th><th>Plant I (P_{g-1})</th><th>Plant II (P_{g-2})</th></tr> <tr> <td>Type</td><td>Gauge Pressure</td><td>Gauge Pressure</td></tr> <tr> <td>Accuracy class</td><td>Within $\pm 0.1\%$</td><td>Within $\pm 0.1\%$</td></tr> <tr> <td>Serial No.</td><td>10530360183</td><td>10530360212</td></tr> <tr> <td>Calibration frequency</td><td>Every 2 years</td><td>Every 2 years</td></tr> <tr> <td>Date of last calibration</td><td>06/01/2012</td><td>09/03/2012</td></tr> <tr> <td>Validity</td><td>Yes</td><td>Yes</td></tr> </table>		Plant I (P_{g-1})	Plant II (P_{g-2})	Type	Gauge Pressure	Gauge Pressure	Accuracy class	Within $\pm 0.1\%$	Within $\pm 0.1\%$	Serial No.	10530360183	10530360212	Calibration frequency	Every 2 years	Every 2 years	Date of last calibration	06/01/2012	09/03/2012	Validity	Yes	Yes
	Plant I (P_{g-1})	Plant II (P_{g-2})																				
Type	Gauge Pressure	Gauge Pressure																				
Accuracy class	Within $\pm 0.1\%$	Within $\pm 0.1\%$																				
Serial No.	10530360183	10530360212																				
Calibration frequency	Every 2 years	Every 2 years																				
Date of last calibration	06/01/2012	09/03/2012																				
Validity	Yes	Yes																				
Measuring/ Reading/ Recording frequency:	•Measuring period : Continuously •Recording frequency : Hourly																					
Calculation method (if applicable):	Not applicable																					
QA/QC procedures:	Every two years, the measuring instrument is calibrated by the authorized organization providing the calibration service on the basis of the national standard. Otherwise, the measuring instrument is replaced with new instrument calibrated according to the national standard.																					
Purpose of data:	Baseline emission Calculation																					
Additional comment:	Not applicable																					

Data / Parameter:	$A_{OR,d}$						
Unit:	tNH ₃ /day						
Description:	Actual ammonia flow rate to the ammonia oxidation reactor (AOR)						
Measured/ Calculated / Default:	Measured						
Source of data:	Differential pressure transmitter with normalizing functions						
Value(s) of monitored parameter:	Average ammonia flow rate a day (tNH ₃ /day) of AOR in this period <table border="1"> <tr> <th></th><th>Plant I ($A_{OR,d-1}$)</th><th>Plant II ($A_{OR,d-2}$)</th></tr> <tr> <td>$A_{OR,d}$ (tNH₃/day)</td><td>38.67</td><td>42.30</td></tr> </table>		Plant I ($A_{OR,d-1}$)	Plant II ($A_{OR,d-2}$)	$A_{OR,d}$ (tNH ₃ /day)	38.67	42.30
	Plant I ($A_{OR,d-1}$)	Plant II ($A_{OR,d-2}$)					
$A_{OR,d}$ (tNH ₃ /day)	38.67	42.30					

Monitoring equipment:	<table border="1"> <tr> <th></th><th>Plant I ($A_{OR,d-1}$)</th><th>Plant II ($A_{OR,d-2}$)</th></tr> <tr> <td>Type</td><td>Differential Pressure</td><td>Differential Pressure</td></tr> <tr> <td>Accuracy class</td><td>Within $\pm 0.1\%$</td><td>Within $\pm 0.1\%$</td></tr> <tr> <td>Serial No.</td><td>10530360038</td><td>10530360080</td></tr> <tr> <td>Calibration frequency</td><td>Every 2 years</td><td>Every 2 years</td></tr> <tr> <td>Date of last calibration</td><td>06/01/2012</td><td>09/03/2012</td></tr> <tr> <td>Validity</td><td>Yes</td><td>Yes</td></tr> </table>		Plant I ($A_{OR,d-1}$)	Plant II ($A_{OR,d-2}$)	Type	Differential Pressure	Differential Pressure	Accuracy class	Within $\pm 0.1\%$	Within $\pm 0.1\%$	Serial No.	10530360038	10530360080	Calibration frequency	Every 2 years	Every 2 years	Date of last calibration	06/01/2012	09/03/2012	Validity	Yes	Yes
	Plant I ($A_{OR,d-1}$)	Plant II ($A_{OR,d-2}$)																				
Type	Differential Pressure	Differential Pressure																				
Accuracy class	Within $\pm 0.1\%$	Within $\pm 0.1\%$																				
Serial No.	10530360038	10530360080																				
Calibration frequency	Every 2 years	Every 2 years																				
Date of last calibration	06/01/2012	09/03/2012																				
Validity	Yes	Yes																				
Measuring/ Reading/ Recording frequency:	•Measuring period : Continuously •Recording frequency : Hourly																					
Calculation method (if applicable):	Since this parameter is measured																					
QA/QC procedures:	Every two years, the measuring instrument is calibrated by the authorized organization providing the calibration service on the basis of the national standard. Otherwise, the measuring instrument is replaced with new instrument calibrated according to the national standard.																					
Purpose of data:	Baseline emission Calculation																					
Additional comment:	Not applicable																					

Data / Parameter:	G_{sup}
Unit:	Not applicable
Description:	Supplier of the ammonia oxidation catalyst
Measured/ Calculated / Default:	Not applicable
Source of data:	Supplier information on catalyst delivery confirmation document
Value(s) of monitored parameter:	Johnson Matthey
Monitoring equipment:	Not applicable
Measuring/ Reading/ Recording frequency:	Recording frequency : Date of changing catalyst
Calculation method (if applicable):	Not applicable
QA/QC procedures:	Not applicable
Purpose of data:	Baseline emission Calculation
Additional comment:	Not applicable

Data / Parameter:	G_{com}
Unit:	%
Description:	Composition of the ammonia oxidation catalyst
Measured/ Calculated / Default:	Not applicable
Source of data:	Supplier information on catalyst delivery confirmation document
Value(s) of monitored parameter:	Pt (90)% : Rh(10)%
Monitoring equipment:	Not applicable
Measuring/ Reading/ Recording frequency:	Recording frequency : Date of changing catalyst
Calculation method (if applicable):	Not applicable
QA/QC procedures:	Not applicable
Purpose of data:	Baseline emission Calculation
Additional comment:	Not applicable

Data / Parameter:	$Type_{HC}$
Unit:	Not applicable
Description:	Type of hydrocarbon / Natural gas
Measured/ Calculated / Default:	Not applicable
Source of data:	Natural gas supplier : KyungDong city gas CO., Ltd. This company is one of the city gas companies in the Republic of Korea. The most of natural gas supplied by KyungDong city gas CO., Ltd. is provided from Korea Gas Corporation (hereafter, KOGAS), which imports natural gas from around the world and supplies it to power generation plants, gas-utility companies and city gas companies throughout the country.
Value(s) of monitored parameter:	Natural Gas
Monitoring equipment:	Not applicable

Measuring/ Reading/ Recording frequency:	Monthly
Calculation method (if applicable):	Not applicable
QA/QC procedures:	Not applicable
Purpose of data:	Project emission Calculation
Additional comment:	Not applicable

Data / Parameter:	CF_{CH_4}																								
Unit:	-																								
Description:	Methane content of hydrocarbon, natural gas																								
Measured/ Calculated / Default:	Not applicable																								
Source of data:	Information provided by the natural gas supplier																								
Value(s) of monitored parameter:	<p>The same kinds of natural gas are supplied to the Plant I and Plant II.</p> <table border="1"> <tr> <th>Date</th> <th colspan="6">2012</th> <th>Period</th> </tr> <tr> <td></td> <td>Jan</td> <td>Feb</td> <td>March</td> <td>April</td> <td>May</td> <td>June</td> <td>3</td> </tr> <tr> <td>CF_{CH_4}</td> <td>0.9142</td> <td>0.9147</td> <td>0.9166</td> <td>0.9161</td> <td>0.9142</td> <td>0.9146</td> <td>0.9151</td> </tr> </table>	Date	2012						Period		Jan	Feb	March	April	May	June	3	CF_{CH_4}	0.9142	0.9147	0.9166	0.9161	0.9142	0.9146	0.9151
Date	2012						Period																		
	Jan	Feb	March	April	May	June	3																		
CF_{CH_4}	0.9142	0.9147	0.9166	0.9161	0.9142	0.9146	0.9151																		
Monitoring equipment:	Not applicable																								
Measuring/ Reading/ Recording frequency:	Recording frequency : Monthly																								
Calculation method (if applicable):	Not applicable																								
QA/QC procedures:	Not applicable																								
Purpose of data:	Project emission Calculation																								
Additional comment:	Not applicable																								

Data / Parameter:	$Q_{NG,y}$																					
Unit:	Nm ³																					
Description:	Natural gas input for re-heating the tail gas																					
Measured/ Calculated / Default:	Measured																					
Source of data:	Flow meter with normalizing functions																					
Value(s) of monitored parameter:	<p>Average daily value of Q_{NG} (Nm³/day) in this period</p> <table border="1"> <tr> <th></th> <th>Plant I ($Q_{NG,1}$)</th> <th>Plant II($Q_{NG,2}$)</th> </tr> <tr> <td>Q_{NG} (Nm³/day)</td> <td>625.70</td> <td>837.28</td> </tr> </table>		Plant I ($Q_{NG,1}$)	Plant II($Q_{NG,2}$)	Q_{NG} (Nm ³ /day)	625.70	837.28															
	Plant I ($Q_{NG,1}$)	Plant II($Q_{NG,2}$)																				
Q_{NG} (Nm ³ /day)	625.70	837.28																				
Monitoring equipment:	<table border="1"> <tr> <th></th> <th>Plant I ($Q_{NG,1}$)</th> <th>Plant II($Q_{NG,2}$)</th> </tr> <tr> <td>Type</td> <td>Orifice</td> <td>Orifice</td> </tr> <tr> <td>Accuracy class</td> <td>±0.90%</td> <td>±0.90%</td> </tr> <tr> <td>Serial No.</td> <td>02319622</td> <td>02319623</td> </tr> <tr> <td>Calibration frequency</td> <td>Every 2 years</td> <td>Every 2 years</td> </tr> <tr> <td>Date of last calibration</td> <td>08/03/2012</td> <td>08/03/2012</td> </tr> <tr> <td>Validity</td> <td>Yes</td> <td>Yes</td> </tr> </table>		Plant I ($Q_{NG,1}$)	Plant II($Q_{NG,2}$)	Type	Orifice	Orifice	Accuracy class	±0.90%	±0.90%	Serial No.	02319622	02319623	Calibration frequency	Every 2 years	Every 2 years	Date of last calibration	08/03/2012	08/03/2012	Validity	Yes	Yes
	Plant I ($Q_{NG,1}$)	Plant II($Q_{NG,2}$)																				
Type	Orifice	Orifice																				
Accuracy class	±0.90%	±0.90%																				
Serial No.	02319622	02319623																				
Calibration frequency	Every 2 years	Every 2 years																				
Date of last calibration	08/03/2012	08/03/2012																				
Validity	Yes	Yes																				
Measuring/ Reading/ Recording frequency:	•Measuring period : Continuously •Recording frequency : Hourly																					

Calculation method (if applicable):	Not applicable		
QA/QC procedures:	Every two years, the measuring instrument is calibrated by the authorized organization providing the calibration service on the basis of the national standard. Otherwise, the measuring instrument is replaced with new instrument calibrated according to the national standard.		
Purpose of data:	Project emission Calculation		
Additional comment:	Not applicable		

Data / Parameter:	$Q_{CH_4,y}$		
Unit:	Nm ³ /yr		
Description:	Methane part of the natural gas used.		
Measured/ Calculated / Default:	Calculated		
Source of data:	Information provided by the natural gas supplier		
Value(s) of monitored parameter:	Average values of daily used ($Q_{CH_4,d}$) in this period		
		Plant I	Plant II
	$Q_{CH_4,d}$ (Nm ³ /day)	557.38	759.62
Monitoring equipment:	Not applicable		
Measuring/ Reading/ Recording frequency:	Not applicable		
Calculation method (if applicable):	$Q_{CH_4,y} = Q_{NG,y} \times CF_{CH_4}$		
QA/QC procedures:	Not applicable		
Purpose of data:	Project emission Calculation		
Additional comment:	Not applicable		

Data / Parameter:	$Q_{HC,y}$		
Unit:	Nm ³ / yr		
Description:	The hydrocarbon with two or more molecules of carbon in natural gas		
Measured/ Calculated / Default:	Calculated		
Source of data:	Information provided by the natural gas supplier		
Value(s) of monitored parameter:	Average values of daily used ($Q_{HC,d}$) for this period		
		Plant I	Plant II
	$Q_{HC,d}$ (Nm ³ /day)	51.70	70.46
Monitoring equipment:	Not applicable		
Measuring/ Reading/ Recording frequency:	Not applicable		
Calculation method (if applicable):	$Q_{HC,y} = Q_{NG,y} \times (1 - CF_{CH_4})$		
QA/QC procedures:	Not applicable		
Purpose of data:	Project emission Calculation		
Additional comment:	Not applicable		

Data / Parameter:	ρ_{NG}		
Unit:	t/Nm ³		

Description:	Density of the natural gas																															
Measured/ Calculated / Default:	Not applicable																															
Source of data:	Monthly report provided by the fuel supplier																															
Value(s) of monitored parameter:	<table><tr><td>Date</td><td colspan="6">2012</td><td>Period</td></tr><tr><td></td><td>Jan</td><td>Feb</td><td>March</td><td>April</td><td>May</td><td>June</td><td>3</td></tr><tr><td>ρ_{NG}</td><td>0.0007959</td><td>0.0007959</td><td>0.0007962</td><td>0.0007970</td><td>0.0007972</td><td>0.0007970</td><td>0.0007965</td></tr></table>								Date	2012						Period		Jan	Feb	March	April	May	June	3	ρ_{NG}	0.0007959	0.0007959	0.0007962	0.0007970	0.0007972	0.0007970	0.0007965
Date	2012						Period																									
	Jan	Feb	March	April	May	June	3																									
ρ_{NG}	0.0007959	0.0007959	0.0007962	0.0007970	0.0007972	0.0007970	0.0007965																									
Monitoring equipment:	Not applicable																															
Measuring/ Reading/ Recording frequency:	Recording frequency : Monthly																															
Calculation method (if applicable):	Not applicable																															
QA/QC procedures:	Not applicable																															
Purpose of data:	Project emission Calculation																															
Additional comment:	Not applicable																															

Data / Parameter:	ρ_{HC}																															
Unit:	t/m ³																															
Description:	Density of the hydrocarbon with two or more molecules of carbon in natural gas																															
Measured/ Calculated / Default:	Calculated																															
Source of data:	Information provided by the natural gas supplier																															
Value(s) of monitored parameter:	<table><tr><td>Date</td><td colspan="6">2012</td><td>Period</td></tr><tr><td></td><td>Jan</td><td>Feb</td><td>March</td><td>April</td><td>May</td><td>June</td><td>3</td></tr><tr><td>ρ_{HC}</td><td>0.001647</td><td>0.001653</td><td>0.001678</td><td>0.001681</td><td>0.001662</td><td>0.001664</td><td>0.001664</td></tr></table>								Date	2012						Period		Jan	Feb	March	April	May	June	3	ρ_{HC}	0.001647	0.001653	0.001678	0.001681	0.001662	0.001664	0.001664
Date	2012						Period																									
	Jan	Feb	March	April	May	June	3																									
ρ_{HC}	0.001647	0.001653	0.001678	0.001681	0.001662	0.001664	0.001664																									
Monitoring equipment:	Not applicable																															
Measuring/ Reading/ Recording frequency:	Not applicable																															
Calculation method (if applicable):	$\rho_{HC} = (\rho_{NG} - \rho_{CH_4} \times CF_{CH_4}) / (1 - CF_{CH_4})$																															
QA/QC procedures:	Not applicable																															
Purpose of data:	Project emission Calculation																															
Additional comment:	Not applicable																															

Data / Parameter:	EF_{NG}																															
Unit:	tCO ₂ /tNG																															
Description:	Emission factor of the natural gas																															
Measured/ Calculated / Default:	Calculated																															
Source of data:	Information provided by the natural gas supplier																															
Value(s) of monitored parameter:	<table><tr><td>Date</td><td colspan="6">2012</td><td>Period</td></tr><tr><td></td><td>Jan</td><td>Feb</td><td>March</td><td>April</td><td>May</td><td>June</td><td>3</td></tr><tr><td>EF_{NG}</td><td>2.7725</td><td>2.7729</td><td>2.7714</td><td>2.7663</td><td>2.7686</td><td>2.7690</td><td>2.7701</td></tr></table>								Date	2012						Period		Jan	Feb	March	April	May	June	3	EF_{NG}	2.7725	2.7729	2.7714	2.7663	2.7686	2.7690	2.7701
Date	2012						Period																									
	Jan	Feb	March	April	May	June	3																									
EF_{NG}	2.7725	2.7729	2.7714	2.7663	2.7686	2.7690	2.7701																									
Monitoring equipment:	Not applicable																															

Measuring/ Reading/ Recording frequency:	Not applicable
Calculation method (if applicable):	$EF_{NG} = COEF_{NG} \times NCV_{NG}/\rho_{NG} \times 44/12$ Where $COEF_{NG}$: Carbon Emission factor of natural gas [tC/TJ] 15.3[tC/TJ] is applied to this project as Ex-ante value by IPCC DEFAULT VALUES OF CARBON CONTENT of “Natural Gas” in TABLE 1.3 (2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2, Energy) NCV_{NG} : Net calorific value of the natural gas [TJ/Nm ³] For this project, NCV_{NG} is offered by KOGAS. ρ_{NG} : Density of the natural gas[t/Nm ³] For this project, based on data source by natural gas supplier.
QA/QC procedures:	Not applicable
Purpose of data:	Project emission Calculation
Additional comment:	Not applicable

Data / Parameter:	EF_{HC}																						
Unit:	tCO ₂ /tHC																						
Description:	Emission factor of the hydrocarbon with two or more molecular of carbon, which is existed as a contents of the natural gas																						
Measured/ Calculated / Default:	Calculated																						
Source of data:	Calculated based on the followings: Methane content offered by the fuel supplier ; The density of the natural gas provided by the fuel supplier ; Estimated emission factor of the natural gas, and Specified methane density																						
Value(s) of monitored parameter:	<table><tr><th rowspan="2">Date</th><th colspan="6">2012</th><th rowspan="2">Period 3</th></tr><tr><th>Jan</th><th>Feb</th><th>March</th><th>April</th><th>May</th><th>June</th></tr><tr><td>EF_{HC}</td><td>2.8765</td><td>2.8795</td><td>2.8719</td><td>2.8419</td><td>2.8539</td><td>2.8568</td><td>2.8634</td></tr></table>	Date	2012						Period 3	Jan	Feb	March	April	May	June	EF_{HC}	2.8765	2.8795	2.8719	2.8419	2.8539	2.8568	2.8634
Date	2012						Period 3																
	Jan	Feb	March	April	May	June																	
EF_{HC}	2.8765	2.8795	2.8719	2.8419	2.8539	2.8568	2.8634																
Monitoring equipment:	Not applicable																						
Measuring/ Reading/ Recording frequency:	Not applicable																						
Calculation method (if applicable):	$EF_{HC} = (EF_{NG} \times \rho_{NG} - EF_{CH_4} \times \rho_{CH_4} \times CF_{CH_4}) / (1 - CF_{CH_4}) / \rho_{HC}$ Where EF_{NG} : CO ₂ emission factor of NG[tCO ₂ /tNG ρ_{NG} : Density of natural gas (tNG/m ³) EF_{CH_4} : CO ₂ emission factor of CH ₄ (tCO ₂ /tCH ₄). ρ_{CH_4} : Density of methane (tCH ₄ / m ³). CF_{CH_4} : Methane fraction in the natural gas																						
QA/QC procedures:	Not applicable																						
Purpose of data:	Project emission Calculation																						
Additional comment:	Not applicable																						

Data / Parameter:	SE_{N_2O}
Unit:	kgN ₂ O/tCaprolactam
Description:	N ₂ O emission rate per ton of caprolactam
Measured/ Calculated / Default:	Calculated

Source of data:	Baseline and Monitoring Methodology (AM0028 ver05)		
Value(s) of monitored parameter:	The yearly monitored SE_{N_2O} for 1 st crediting year including period 3.		
		Plant I	Plant II
	$SE_{N_2O,y}(\text{kgN}_2\text{O/t Caprolactam})$	26.53 in period 3, 24.91 in the 1 st crediting year	18.81 in period 3, 17.56 in the 1 st crediting year
Monitoring equipment:	Not applicable		
Measuring/ Reading/ Recording frequency:	Not applicable		
Calculation method (if applicable):	$SE_{N_2O,y} = Q_{IN_2O,y} / P_{product,y} \times 1000$ Where, $Q_{IN_2O,y}$ means the monitored quantity of N_2O emissions at the inlet of the destruction facility (t N_2O), and $P_{product,y}$ is the actual output of caprolactam for one year.		
QA/QC procedures:	Not applicable		
Purpose of data:	Baseline emission Calculation		
Additional comment:	Not applicable		

Data / Parameter:	$OXID_{CH_4}$		
Unit:	%		
Description:	Oxidation factor of CH_4 in natural gas for re-heating tail gas		
Measured/ Calculated / Default:	Calculated		
Source of data:	Not applicable		
Value(s) of monitored parameter:	Average value in this period		
		Plant I	Plant II
	$OXID_{CH_4}$	94.17	98.20
Monitoring equipment:	Not applicable		
Measuring/ Reading/ Recording frequency:	Not applicable		
Calculation method (if applicable):	$OXID_{CH_4} = \{ Q_{CH_4} - (\sum_i^n F_{TE,i} \times CO_{CH_4,i} \times 10^{-6}) \} / Q_{CH_4} \times 100$		
QA/QC procedures:	Not applicable		
Purpose of data:	Project emission Calculation		
Additional comment:	Not applicable		

Data / Parameter:	CO_{CH_4}		
Unit:	ppm (v)		
Description:	Methane concentration at destruction facility outlet.		
Measured/ Calculated / Default:	Measured		
Source of data:	Non-dispersion infrared absorption analyzer with dual-channel as a gas path		
Value(s) of monitored parameter:	Average value in this period		
		Plant I	Plant II
	CO_{CH_4}	30.61	12.59

Monitoring equipment:		Plant I (CO _{CH4-1})	Plant II(CO _{CH4-2})
	Type	NDIR	NDIR
	Accuracy class	>95%	>95%
	Serial No.	AO-750	AO-751
	Calibration frequency	Every 2weeks	Every 2weeks
	Date of last calibration	31/05/2012	31/05/2012
	Validity	Yes	Yes
	Model	ULTRAMAT 6	ULTRAMAT 6
Measuring/ Reading/ Recording frequency:	•Measuring period : Continuously •Recording frequency : Hourly		
Calculation method (if applicable):	Not applicable		
QA/QC procedures:	Every two years required by the registered PDD, the measuring instrument is calibrated by the authorized organization providing the calibration service on the basis of the national standard. Otherwise, the measuring instrument is replaced with new instrument calibrated according to the national standard.		
Purpose of data:	Project emission Calculation		
Additional comment:	Not applicable		
Data / Parameter:	Reg_{NOx}		
Unit:	tNOx/Nm ³		
Description:	National regulation on NOx emissions		
Measured/ Calculated / Default:	Not applicable		
Source of data:	The “Clean Air Conservation Act”, one of the National environmental legislation, Ministry of Environment		
Value(s) of monitored parameter:	4.10714 x 10 ⁻⁷ tNOx/Nm ³ (as a NO ₂ concentration)		
Monitoring equipment:	Not applicable		
Measuring/ Reading/ Recording frequency:	Recording frequency : Date of Regulation		
Calculation method (if applicable):	Not applicable		
QA/QC procedures:	Not applicable		
Purpose of data:	Baseline emission Calculation		
Additional comment:	Not applicable		
Data / Parameter:	RSE_{N2O,y}		
Unit:	tN ₂ O/tCaprolactam		
Description:	Regulatory limit of N ₂ O emissions per unit of outlet of caprolactam (tN ₂ O/t caprolactam)		
Measured/ Calculated / Default:	Not required by national legislation in Republic of Korea.		
Source of data:	National legislation in Republic of Korea. (That may be mostly like environmental regulation.)		

Value(s) of monitored parameter:	Not applicable
Monitoring equipment:	Not applicable
Measuring/ Reading/ Recording frequency:	Recording frequency : Date of Regulation
Calculation method (if applicable):	Not applicable
QA/QC procedures:	Not applicable
Purpose of data:	Baseline emission Calculation
Additional comment:	Not applicable

D.3. Implementation of sampling plan

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Not applicable

SECTION E. Calculation of emission reductions or GHG removals by sinks**E.1. Calculation of baseline emissions or baseline net GHG removals by sinks**

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In the case of a nitric acid plant or a caprolactam plant using the Raschig process, baseline emissions are limited to the design capacity of the existing nitric acid or caprolactam production plant. If the actual production of caprolactam (P_{product}) exceeds the design capacity ($P_{\text{product,max}}$), the emissions related to the production above $P_{\text{product,max}}$ will not be claimed for the baseline scenario. Therefore P_{product} of each plant should be monitored.

Table E1-1. Caprolactam Productions for 1st crediting year including period 3

The actual production for 1 st year	Each period (ton/period)	Period	Duration	Days	Plant I	Plant II
		1	09/06/2011 – 31/08/2011	84	13764.22	14415.80
		2	01/09/2011 – 31/12/2011	122	17035.04	20618.53
		3	01/01/2012 – 08/06/2012	160	24260.29	28071.06
	P_{product} (ton/yr)	Total	09/06/2011 – 08/06/2012	366	55059.55	63105.39
Design Capacity in PDD , $P_{\text{product,max}}$ (ton/yr)					63,307	64,965

As a result, it can be said that actual production of caprolactam (P_{product}) did not exceed the design capacity ($P_{\text{product,max}}$). Therefore on the condition of $P_{\text{product,y}} < P_{\text{product,max}}$, baseline emissions (BE) for the period are given by following equation :

$$BE_{\text{period, within permit range}} = \left(\sum_i^n F_{TI,i} \times CI_{N_2O,i} \times M_i \right) \times GWP_{N_2O}$$

Where

M_i	Length of Measuring Interval (hr), (1hr : set value at instrument for this project)
GWP_{N_2O}	Global warming potential of the N_2O , (310: default value).
n	Number of intervals during this period
$F_{TI,i}$	Volume flow rate at the inlet of the DF during interval (Nm^3/hr)
$CI_{N_2O,i}$	N_2O concentration in the tail gas of the DF inlet during interval (tN_2O / Nm^3)

However, if the actual average daily operating temperature and/or pressure in the ammonia oxidation reactor (T_g and P_g) are outside the bounds of the “permitted range” of AOR operation conditions ($T_{g,hist}$ and/or $P_{g,hist}$), the calculation of baseline emission is the integration of the daily baseline emission ($BE_{\text{daily, out of permit range}}$) for the respective day. The daily baseline emission is calculated for the respective time period as follows:

$$BE_{\text{daily, out of permit range}} = P_{\text{product, day}} \times EF_{N_2O} \times GWP_{N_2O} / 1000$$

$$BE_{\text{period, out of permit range}} = \sum BE_{\text{daily, out of permit range}}$$

Where

$BE_{\text{daily, out of permit range}}$: The daily baseline emission for the respective day in which AOR operation conditions were outside of “permitted range”(tonCO ₂ /day)
$P_{\text{product, day}}$: The daily output of caprolactam for the respective day in which AOR operation conditions were outside of permitted range (ton caprolactam/day)
EF_{N_2O}	: N_2O Emission factor to the process of caprolactam production (kgN ₂ O/ton caprolactam)

Emission factor of N₂O (EF_{N_2O}) is the lowest value among (a) $EF_{N_2O,IPCC}$, (b) $SE_{N_2O,y}$ and (c) any related value as a result of legal regulation (e.g. $RSE_{N_2O,y}$). In Republic of Korea, there is no mandatory regulation for N₂O emission. Therefore, actually EF_{N_2O} is the lower value between (a) $EF_{N_2O,IPCC}$ and (b) $SE_{N_2O,y}$.

$EF_{N_2O,IPCC}$ means Conservative IPCC default value of the latest IPCC GHG Inventory Guidelines accepted by the IPCC for the equivalent N₂O emission process. At this time, $EF_{N_2O,IPCC}$ is 5.4kgN₂O/tonne of caprolactam.

$SE_{N_2O,y}$ is the specific N₂O emission per unit of output of caprolactam defined as :

$$SE_{N_2O,y} = QI_{N_2O,y} / P_{product,y} \times 1000$$

Where, $QI_{N_2O,y}$ means Quantity of N₂O emissions at the inlet of the destruction facility in year y, given by :

$$QI_{N_2O,y} = \sum_i^n F_{TI,i} \times CI_{N_2O,i} \times M_i$$

Also,

$$QI_{N_2O,y} = \sum QI_{N_2O,period,y}$$

The both of $SE_{N_2O,y}$ values for plants are calculated as higher than $EF_{N_2O,IPCC}$ (24.91 for plant 1 and 17.56 for plant 2), and thus the values of EF_{N_2O} are decided as 5.4kgN₂O/tonne of caprolactam in order to calculate $BE_{period, out of permit range}$.

Table E1-2. $SE_{N_2O,y}$ for 1st crediting year including period 3

	Parameters	Values				Unit
		Period 1	Period 2	Period 3	Year total	
Plant I	$QI_{N_2O-Plant1}$	302.84	425.30	643.56	1371.70	ton N ₂ O/period
	$P_{product-Plant1}$	13764.22	17035.04	24260.29	55059.55	ton Caprolactam/yr
	$SE_{N_2O-Plant1}$				24.91	kgN ₂ O/tCaprolactam
Plant II	$QI_{N_2O-Plant2}$	221.82	358.25	527.97	1108.04	ton N ₂ O/period
	$P_{product-Plant2}$	14415.80	20618.53	28071.06	63105.39	ton Caprolactam/yr
	$SE_{N_2O-Plant2}$				17.56	kgN ₂ O/tCaprolactam

On condition of that the actual daily ammonia flow rate exceeds the (upper) limit on maximum historical daily permitted ammonia flow rate, the baseline N₂O emissions for this operating day are capped at conservative IPCC default values. Where, the upper limit on ammonia flow should be determined based on “the historical operating data on maximum daily average ammonia flow”.

Consequently, $P_{product,y} < P_{product,max}$, baseline emissions (BE) for the period can be calculated as follows for this period.

$$BE_{period} = BE_{period, within permit range} + BE_{period, out of permit range}$$

(a) Baseline emission of Plant 1

In Case of AOR operation conditions within “permitted range”

In order to calculate the hourly BE (BE_{hr-1}), the hourly integrated measured values of $F_{TI,i-1}$ and $CI_{N_2O,-1}$ except the data to the day in which AOR was operated outside of permit range, are input. These hourly BE (BE_{hr-1}) are aggregated to the daily BE (BE_{day}), and total BE on this period for plant I ($BE_{period-1}$), 199503.02 tonCO₂/period. BE calculated on hourly input data is explained in detail on the emission reductions calculation spreadsheet.

In case of AOR operation conditions outside of “permitted range”

There are none of days when the conditions of AOR deviated from permitted range for this period. So, the

baseline emission in which AOR operation conditions were outside of permitted range for period 3 ($BE_{period, out}$ of permit range) is zero.

(b) Baseline emission of Plant II

In Case of AOR operation conditions within "permitted range"

Hourly BE (BE_{hr-2}) calculated on hourly integrated measured values of $F_{T\ i-2}$ and $CI_{N2O, i-2}$ are aggregated to the daily BE (BE_{day-2}), and total BE on the period ($BE_{period-2}$) are estimate as sum of BE_{day-2} . The total BE on the period 3 for Plant 2 ($BE_{period-2}$) is 163671.85 tonCO₂/period. BE calculated on hourly input data is explained in detail on the emission reductions calculation spreadsheet.

In case of AOR operation conditions outside of "permitted range".

There are none of days when the conditions of AOR deviated from permitted range for this period. So, the baseline emission in which AOR operation conditions were outside of permitted range for period 3 ($BE_{period, out}$ of permit range) is zero.

(c) The total BE of Period 3

Eventually, Total BE in this period is 363174.88 tonCO₂ /period as shown below table.

Table E1-3. Summary of BE for period 3

		BE _{period-3} (ton CO ₂ /period)	
		BE _{period-3} in Plant I	BE _{period-3} in Plant II
BE_{period} on AOR condition	within "permitted range"	199503.04	163671.84
	Outside "permitted range"	0	0
BE_{period} total	BE _{period} for each plant	199503.04	163671.84
	BE _{period-total}	363174.88	

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

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The emission due to the project activity are composed of (a) the emissions of not destroyed N₂O, (b) on-site emissions due to the hydrocarbons (; Natural Gas) use as input to the N₂O destruction facility, and (c) the emissions from the operation of the destruction facility. Hydrocarbons can be used as reducing agent and/or re-heating the tail gas to enhance the catalytic N₂O reduction efficiency. In this project, natural gas is used for re-heating the tail gas to enhance the catalytic N₂O reduction efficiency.

$$\begin{aligned}
 PE_{period} = & \left(\sum_i^n F_{TE,i} \times CO_{N2O,i} \times M_i \right) \times GWP_{N2O} \\
 & + [(\rho_{HC} \times Q_{HC,y} \times EF_{HC} \times OXID_{HC}/100) + (\rho_{CH4} \times Q_{CH4,y} \times EF_{CH4} \times OXID_{CH4}/100)] \\
 & + [\rho_{CH4} \times Q_{CH4,y} \times GWP_{CH4} \times (1-OXID_{CH4}/100)]
 \end{aligned}$$

n : Number of intervals during the year (period⁻¹)

M_i : Length of Measuring Interval (hr), (1hr : set value at instrument for this project)

$F_{TE,i}$: Volume flow rate at the exit of the DF during interval i (Nm³/hr)

$CO_{N2O,i}$: N₂O concentration in the tail gas of the DF exit during interval i (tN₂O/ m³)

GWP_{CH4} : Global warming potential of CH₄, 21 (: default value)

GWP_{N2O} : Global warming potential of the nitrous oxide, 310 (: default value)

ρ_{CH4} : Density of methane (tCH₄/m³), 0.000716

ρ_{HC} : Density of HC (tHC/m³)

EF_{CH_4}	: CO ₂ emission factor of CH ₄ (tCO ₂ e/tCH ₄), 2.75
EF_{HC}	: CO ₂ emission factor of HC with two or more carbon molecule in natural gas (tCO ₂ e/tHC)
$Q_{CH_4,y}$: Methane used in period (Nm ³ /period)
$Q_{HC,y}$: HC with two or more carbon molecule in natural gas used in period (Nm ³ /period)
$OXID_{CH_4}$: Oxidation factor of methane (%)
$OXID_{HC}$: Oxidation factor of HC(%), 100% (Fixed value)

Hourly calculated PE (PE_{hr}) are aggregated into the daily PE(PE_{day}), and total PE on the period (PE_{period}) are estimated as sum of PE_{day} . ER calculation sheet for each plant which daily measured and calculated results were integrated into is in detail on the mission reductions calculation spreadsheet.

(a) Project emission of Plant 1

In order to calculate the hourly PE (PE_{hr-1}) for Plant I, the hourly integrated measured values of $F_{TE,i-1}$ and $CO_{N_2O,i-1}$ are input. These hourly PE (PE_{hr-1}) are aggregated to the daily PE(PE_{day-1}). The total PE on the period3 for plant I ($PE_{period-1}$) is 27010.19 tonCO₂/period . PE on this period for plant I calculated on hourly input data is explained in detail on the emission reductions calculation spreadsheet.

(b) Project emission of Plant II

The hourly integrated measured values of $F_{TE,i-2}$ and $CO_{N_2O,i-2}$ are input for calculating hourly PE for Plant II(PE_{hr-2}), and then these hourly PE (PE_{hr-2}) are aggregated to the daily PE(PE_{day-2}). The total PE on this period for plant II ($PE_{period-2}$) is 18928.69 tonCO₂/period. PE on the period3 for plant II calculated on hourly input data is explained in detail on the emission reductions calculation spreadsheet.

(c) The total PE of Period 3

Total PE in this period is 26,361.62 ton CO₂ as shown below table.

Table E2. Summary of PE for period 3

	Plant I	Plant II
PE for each Plant (ton CO ₂ /period)	27010.19	18928.69
PE for Period total, $PE_{period-3}$ (ton CO ₂ /period)	45938.88	

E.3. Calculation of leakage

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The installation of the N₂O destruction facility doesn't result in significant additional energy consumption at the caprolactam production plant. In conclusion, no leakage is expected at this project as per the registered PDD. The emission by leakage is accounted as zero ($LE_y = 0$)

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

The emission reduction ER_{period} by the project activity during a given year y is the difference between the baseline emissions (BE_{period}) and project emissions (PE_{period}), as follows:

$$ER_{period} = BE_{period} - PE_{period} - LE_{period}$$

Therefore ER_{period} can be estimated upon the values of BE_{period} , PE_{period} and LE_{period} those are calculated as mentioned above.

Table E.4. Summary of calculation of emission reductions

Item	Baseline emissions or baseline net GHG removals by sinks (t CO ₂ e)	Project emissions or actual net GHG removals by sinks (t CO ₂ e)	Leakage (t CO ₂ e)	Emission reductions or net anthropogenic GHG removals by sinks (t CO ₂ e)
Plant I	199503.04	27010.19	0	172492.85
Plant II	163671.84	18928.69	0	144743.15
Period Total	363174.88	45938.88	0	317236.00

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

Below table is to show comparison of actual values of the emission reductions achieved during the monitoring period with the estimations in the registered CDM-PDD.

Table E5-1. Comparison Ex-ante values with Actual values in ER

Item	Values estimated in ex-ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO ₂ e)	289,751	317,236

Up here, the “values estimated in ex-ante calculation of registered PDD” are calculated as follows.

$$ER_{\text{ex-ante, period}} = \frac{ER_{\text{ex-ante,y}}}{365 \text{ days}} \times D_{\text{actual, period}}$$

Where,

$ER_{\text{ex-ante, period}}$: Ex-ante calculated ER values for the period, tonCO₂e/period

$ER_{\text{ex-ante,y}}$: Ex-ante calculated ER values for one year in registered PDD, tonCO₂e/yr (660,995 ton/yr)

$D_{\text{actual, period}}$: The number of days for this period, days (160 days for Period 3)

As a conclusion, The actual value is bigger than the ex-ante calculated value of the registered CDM-PDD.

For information, the total ER values during 1st Crediting year are accumulated.

Table E5-2. The Summary of the actual ER values during 1st Crediting year

Item	Values estimated in ex-ante calculation of registered PDD	Actual values achieved during 1 st Crediting year	
Emission reductions for one year (t CO ₂ e/ yr)	660,995	Period 1	144,751
		Period 2	216,537
		Period 3	317,236
		1 st crediting year	678,524

Depending on the yearly based comparison, actual ER value is 2.65% (= (678,524 - 660,995) / 660,995) higher than that of ex-ante value on PDD.

Up here, the data related period 1 and 2 are already submitted and certified excel sheets, which can be down loaded from UNFCCC website.

Period	File name
1	ER calculation sheet_Capro_ref.4665-1 for review.xls
2	ER calculation sheet_Capro_ref.4665-2.xls

The data for period and calculated results are in detail on calculation spreadsheet for this period (period 3)

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

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It is considered that the difference from estimated ER value in registered PDD is because the actual BE is higher than the ex-ante number. When ex-ante calculating the baseline emissions, the designed values including the $F_{Ti,i}$, the volume flow rate at the inlet, and the $Cl_{N2O,i}$, N_2O concentration in the tail gas at the inlet, were used in the PDD to calculate the baseline emissions. The designed values of $F_{Ti,i}$ and $Cl_{N2O,i}$ were estimated before this project started operation, while it is reasonable that the actual values of $F_{Ti,i}$ and $Cl_{N2O,i}$ during the operation of this project fluctuate around the ex-ante estimation, either lower or higher than the designed values. The actual value of ER is 2.65% larger than ex-ante value as about 17,529 tonCO₂eq./yr during the whole year from 09/06/2011 to 08/06/2012, and the actual emission reductions during the 1st and 2nd periods are even lower than the ex-ante values. See the following table.

Table E 6. Comparison Ex-ante values with Actual values in BE, PE and ER

Items	Periods	Ex-ante values tonCO ₂ eq./yr	Actual Values tonCO ₂ eq./yr	Comparison
BE	period 1	169,700	162,628.267	-
	period 2	246,470	242,899.40	-
	period 3	323,239	363,174.88	-
	total	739,409	768,702	-
PE	period 1	17,997	17,877.253	-
	period 2	26,138	26,361.62	-
	period 3	34,279	45,938.88	-
	total	78,414	90,178	-
ER	period 1	151,704	144,751	↓ 4.58%
	period 2	220,332	216,537	↓ 1.72%
	period 3	288,960	317,236	↑ 9.78%
	total	660,995	678,524	↑ 2.65%

E.7. Actual emission reductions or net anthropogenic GHG removals by sinks during the first commitment period and the period from 1 January 2013 onwards

Item	Actual values achieved up to 31 December 2012	Actual values achieved from 1 January 2013 onwards
Emission reductions or GHG removals by sinks (t CO ₂ e)	317,236	Not applicable

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Document information

<i>Version</i>	<i>Date</i>	<i>Description</i>
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 anthropogenic GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01	28 May 2010	EB 54, Annex 34. Initial adoption.
Decision Class: Regulatory		
Document Type: Form		
Business Function: issuance		
Keywords: monitoring report, performance monitoring		