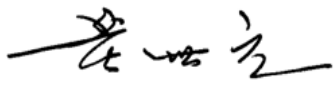




**Verification and certification report form for CDM project activities
(Version 01.0)**

Complete this form in accordance with the "Attachment: Instructions for filling out the verification and certification report form for CDM project activities" at the end of this form.

VERIFICATION AND CERTIFICATION REPORT

Title of the project activity	N2O Abatement Project of Capro Corporation
Reference number of the project activity	4665
Version number of the verification and certification report	Version 02
Completion date of the verification and certification report	17/07/2017
Monitoring period number and duration of this monitoring period	7th Monitoring period 01/11/2016 to 30/04/2017 (first and last days included)
Version number of monitoring report to which this report applies	Version 2.0
Crediting period of the project activity corresponding to this monitoring period	The crediting period is 09/06/2011 - 08/06/2021
Project participant(s)	Capro Corporation; Hyosung Ebara Engineering Co., Ltd.; and Hyosung Corporation
Host Party	Republic of Korea
Sectoral scope(s), selected methodology(ies), and where applicable, selected standardized baseline(s)	Sectoral scope: 5 : Chemical industries AM0028 Version 05 N2O destruction in the tail gas of Nitric Acid or Caprolactam Production Plants
Estimated GHG emission reductions or net anthropogenic GHG removals for this monitoring period in the registered PDD	170,908 tCO ₂ e
Certified GHG emission reductions or net anthropogenic GHG removals for this monitoring period	158,859 tCO ₂ e
Name of DOE	China Classification Society Certification Company (CCSC)
Name, position and signature of the approver of the verification and certification report	Mr. Huang Shiyuan, General Manager 

SECTION A. Executive summary

>>

Capro Corporation has commissioned China Classification Society Certification Company (hereafter referred to as "CCSC") to carry out the 7th periodic verification of N2O Abatement Project of Capro Corporation (hereafter referred to as "the Project", UNFCCC reference No.4665) covering the monitoring period from 01/11/2016 to 30/04/2017.

The verification is based on the currently valid documentation of the United Nations Framework Convention on Climate Change (UNFCCC).

The verification process includes three phases: 1) desk review of documents; 2) on-site inspection and follow-up interviews with the relevant personnel; 3) resolution of outstanding issues and the issuance of final verification report and opinion.

One Corrective Action Request (CAR) and one Clarification Request (CL) were raised in the verification process and successfully closed upon the project participant taken actions and submitted the revised monitoring report and supporting evidence. No Forward Action Request (FAR) was raised during this verification.

In summary, CCSC confirms that the Project is implemented as planned and described in the validated and registered project design documents. The monitoring plan is in accordance with the applied methodology and the monitoring system is in place and functional. The installed equipment for measuring parameters required for calculating emission reductions are calibrated appropriately. The Project is generating GHG emission reductions. The GHG emission reductions are calculated without material misstatements.

Based on the verified amount of emission reductions stated in the verification report, CCSC confirms the following statement, and requests the CDM-EB to issue the CERs:

Actual emission reduction for the monitoring period up to (and including) 31 December 2012	0 tCO ₂ e
Actual emission reduction for the monitoring period from (and including) 1 January 2013 onwards	158,859 tCO ₂ e
Total amount of GHG emission reductions or net GHG removals by sinks achieved in this monitoring period (01/11/2016 to 30/04/2017)	158,859 tCO ₂ e

A.1. Objective

CDM project Verification is the periodic independent review and ex-post determination by a DOE of the monitored reductions in GHG emissions during defined verification period. In carrying out its verification work, the DOE shall ensure that the project activity complies with the requirements of paragraph 62 of the CDM modalities and procedures. The verification shall:

- Ensure that the project activity has been implemented and operated as per the registered PDD or any approved revised PDD, and that all physical features (technology, project equipment, and monitoring and metering equipment) of the Project are in place;
- Ensure that the monitoring report and other supporting documents provided are complete in accordance with latest applicable version of the completeness checklist for requests for issuance of CERs and verifiable and in accordance with applicable CDM requirements;
- Ensure that actual monitoring systems and procedures comply with the monitoring systems and procedures described in the monitoring plan or any revised approved monitoring plan, and the approved methodology including applicable tool(s);

- Evaluate the data recorded and stored as per the monitoring methodology including applicable tool(s).

A.2. Scope

The verification scope covers the relevant documents (e.g. the registered PDD, the Monitoring Plan, the Monitoring Report, the emission reduction calculation spreadsheet, supporting documents available to the verifier and information collected through performing interviews and during the on-site assessment, EB's request and guidelines publicly available, relevant rules, including the host country legislation, etc.) to be independently reviewed, the Project geographical locations to be visited on-site, the Project local stakeholders to be interviewed with, and processes that are necessary to acquire objective evidence for the evaluation of the Project compliance to the CDM verification requirements.

The above verification activities are conducted according to the CDM requirements. In doing so, the principles of accuracy and completeness, relevance, reliability and credibility were followed.

The verification is not meant to provide any consulting service towards the PPs. However, stated requests for clarifications and/or corrective actions may provide input for improvement of the Project.

A.3. CDM Project Description

N₂O Abatement Project of Capro Corporation installed CRI N₂O abatement system, which is N₂O decomposition catalyst at the tail gas, developed by Capro Corporation; Hyosung Ebara Engineering Co., Ltd.; and Hyosung Corporation, located in Bugok-dong, Nam-gu, Ulsan, the south-eastern part of the Republic of Korea. The geographical coordinates of the Project are east longitude 129.3280° and north latitude 35.4958°.

The purpose of the Project is to reduce N₂O emissions of the tail gas emitted from Caprolactam production process in Capro Corporation by installing catalytic N₂O destruction system. The Project involves the installation of CRI N₂O abatement system. According to the PDD Version 8.1 /1/, the annual estimated emission reductions are 660,995tCO₂e. During this monitoring period (01/11/2016 to 30/04/2017), there have been no events or situations that occurred which may impact the applicability of the applied methodology. However, the Plant I was not operated during this monitoring period.

In summary, CCSC confirms that the project is implemented as planned and described in the registered project design documents. Installed equipment being essential for generating emission reduction run reliably and are calibrated appropriately. The monitoring system is in place and the project is generating GHG emission reductions. The GHG emission reductions are calculated without material misstatements, and the emission reductions verified totalize 158,859tons of CO₂e for the monitoring period.

SECTION B. Verification team, technical reviewer and approver

B.1. Verification team member

No.	Role	Type of resource	Last name	First name	Affiliation (e.g. name of central or other office of DOE or outsourced entity)	Involvement in			
						Desk review	On-site inspection	Interview(s)	Verification findings
1.	Team Leader	IR	LI	Xingtong	CCSC central office	√	√	√	√
2.	Team Member	EI	TAN	Wenbin	CCSC central office	√	√	√	√

Note: IR: Internal Resources,

EI: External Individuals

B.2. Technical reviewer and approver of the verification and certification report

No.	Role	Type of resource	Last name	First name	Affiliation (e.g. name of central or other office of DOE or outsourced entity)
1.	Technical reviewer	EI	SHEN	Meng	CCSC central office
2.	Technical reviewer	IR	ZHENG	Ling	CCSC central office
3.	Approver	IR	HUANG	Shiyuan	CCSC central office

SECTION C. Application of materiality

All the data and information has been checked during verification, thus the concept of materiality has not applied in the verification.

C.1. Consideration of materiality in planning the verification

No.	Risk that could lead to material errors, omissions or misstatements	Assessment of the risk		Response to the risk in the verification plan and/or sampling plan
		Risk level	Justification	
1	NA	NA	NA	NA

C.2. Consideration of materiality in conducting the verification

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NA

SECTION D. Means of verification**D.1. Desk review**

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After receiving the Monitoring Report Version 1.0 dated 08/05/2017, CCSC made it publicly available on the UNFCCC CDM dedicated website on 10/05/2017. (http://cdm.unfccc.int/Issuance/MonitoringReports/gotoIss?id=CCSC_DOE1494400312.89).

A desk review of the Monitoring Report Version 1.0 dated 08/05/2017 and supporting documents was conducted by the verification team. The aim of the desk review of the documentation was to verify the completeness of the data and the information presented, to carry out the compliance check of the MR with respect to the monitoring plan and the applied methodology. Particular attention was given to the frequency of measurements, the quality of the metering equipment including calibration requirements, and the quality assurance and quality control procedures. The evaluation of data management and the quality assurance and quality control system in the context of their influence on the generation and reporting of emission reductions was also conducted.

In addition to the monitoring documentation provided by the project participants, the DOE reviews:

- (a) The registered PDD, and the monitoring plan contained in the registered PDD /27/;
- (b) The validation report /28/;
- (c) Previous verification reports /29/;
- (d) The applied monitoring methodology /31/;
- (e) Relevant decisions, clarifications and guidance from the CMP and the CDM Executive Board /32/;
- (f) Other information and references relevant to the project activity's resulting emission reductions (e.g. IPCC reports, laboratory analysis or national regulations).

D.2. On-site inspection

Duration of on-site inspection: 28/06/2017				
No.	Activity performed on-site	Site location	Date	Team member
1.	Management interview - Implementation & Operation - Monitoring System - Information flow - Management & Operation Procedure	project site	28/06/2017	Mr. LI Xingtong Mr. TAN Wenbin
2.	Site visit - Inspection of installations including N₂O abatement system (NAS) and monitoring system - Observation of monitoring practice (data generating system and storage system, data records) - Interviews with relevant personnel (operation procedure, training)	Project site	28/06/2017	
3.	Documents review - Implementation - Calibration - Quality Assurance of Automated measuring system - QA/QC procedures - Qualification & Training - Data records - Cross-check data - ER calculations	Project site	28/06/2017	
4.	Close meeting - Summary of findings - Follow-up actions	Project site	28/06/2017	

D.3. Interviews

No.	Interviewee			Date	Subject	Team member
	Last name	First name	Affiliation			
1.	CHOI	Cheong-Jeong	Capro Corporation	28/06/2017	Status of the CDM project implementation. Any changes of the CDM project;	Mr. LI Xingtong Mr. TAN Wenbin
2.	LEE	Myung-Jin	Capro Corporation		The Project on-site inspection – the evidences of construction, status and operation of key equipment, parameters monitoring and data processing activities, monitor equipment and calibration;	
3.	PARK	Byoung-Yong	Capro Corporation		Compliance of the project implementation with the registered project design document;	
4.	LEE	Hyun-Woo	Capro Corporation		Compliance with National Laws and Regulations.	
5.	PARK	Deok-Chan	Capro Corporation		Quality Management; organizational structure, responsibilities and competencies. Internal QA/QC Management procedures and document control (QA/QC)	
6.	KIM	Hi-Kwang	Capro Corporation		Environmental Impacts Preparation of Monitoring Report.	
7.	LEE	Dae-Heai	Capro Corporation		Compliance of the monitoring plan with the monitoring methodology;	
8.	JUNG	Taiwoo	Ecoeye Co., Ltd		Compliance of monitoring with the monitoring plan; Assessment of data and calculation of GHG emission reductions.	

D.4. Sampling approach

>>

N/A

D.5. Clarification requests, corrective action requests and forward action requests raised

Areas of verification findings	No. of CL	No. of CAR	No. of FAR
Compliance of the monitoring report with the monitoring report form	-	-	-
Compliance of the project implementation with the registered PDD	-	-	-
Post-registration changes	-	-	-
Compliance of the monitoring plan with the monitoring methodology including applicable tool and standardized baseline	-	-	-
Compliance of monitoring activities with the registered monitoring plan	-	-	-
Compliance with the calibration frequency requirements for measuring instruments	1	-	-
Assessment of data and calculation of emission reductions or net removals	-	1	-
Others (please specify)	-	-	-
Total	1	1	0

SECTION E. Verification findings**E.1. Compliance of the monitoring report with the monitoring report form**

Means of verification	Through cross-check and comparison, to confirm if the applied monitoring report form is valid and listed in UNFCCC website.
Findings	Through document review of the provided monitoring report (MR) /2/ and comparison with the latest MR template, the verification team confirm: • The MR /2/ used the latest form available at UNFCCC website. • The MR /2/ is complete and meets all requirements of Instructions for filling out the monitoring report form /35/ and “Clean development mechanism project standard” /33/. No CARs/CLs/FARs raised in this section.
Conclusion	According to Para. 382 of VVS Version 09.0 /32/, CCSC verification team confirms that the monitoring report /2/ was in compliance with relevant monitoring report form and instructions therein.

E.2. Remaining forward action requests from validation and/or previous verification

>>

There are no remaining forward action requests from validation and/or previous verification.

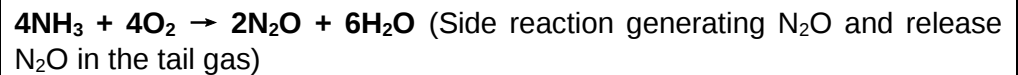
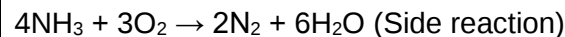
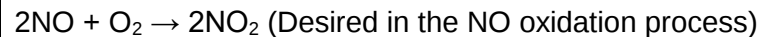
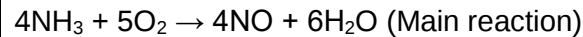
E.3. Compliance of the project implementation with the registered project design document

Means of verification	The verification team has performed an on-site inspection to assess: a) If all physical features (technology, project equipment, and monitoring and metering equipment) of the registered CDM are in place. The verification team has applied the GPS instruments to check the project location and geo-coordinates. b) If the PP has operated the project activity as per the PDD /27/.
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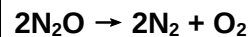
Findings

CCSC has performed an on-site visit and found that the Project has been put into operation in compliance with the registered PDD. The verification team has applied the GPS instruments to check the project location and geo-coordinates and can confirm that the project location and geo-coordinates are in conformity with the registered PDD. Through onsite inspection and interview against relevant personnel, the verification team can confirm that the PP has operated the project activity as per the registered PDD. During the site visit, no changes from the project activity as described in the registered PDD has been observed or identified.

Caprolactam is produced by cyclohexane, ammonia, and sulphur as its primary raw materials. The existing caprolactam plants for this proposed project activity employ Raschig process other than HPO process, which converts Ammonium Carbonate to Ammonium Nitrite through the reacting with Nitrogen Oxide, and Ammonium Nitrite converted to Hydroxylamine Disulfonate and thence to Hydroxylamine Sulfate. Within the Caprolactam production process, ammonia is oxidized in the four AORs to generate NO and NO₂. Nitrous oxide (N₂O) is generated as an undesired by-product through the side reaction of ammonia oxidation as follows:



N₂O is recognized as a potent greenhouse gas with a Global Warming Potential (GWP) of 298 compared to carbon dioxide (CO₂), i.e. GWP_{N₂O} = 298. De-N₂O system (NAS, N₂O abatement system) used in this project is to destruct the N₂O included in tail gas by catalyst without any reducing agent. Then greenhouse gas emission reductions are generated. The annual estimated emission reductions are 660,995tCO₂e.



The catalytic reactor designed by Hyosung Ebara Engineering Co., Ltd. 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". Liquefied natural gas (LNG, hereafter "natural gas") is used in this system as a fuel, not reducing agent, to supply the energy required for the de-N₂O catalytic reaction. The N₂O decomposing catalyst is provided by CRI, a wholly owned subsidiary of the Shell Group of Company, and it is designed and installed by Hyosung Ebara Engineering Co., Ltd.

The implementation history of the Project is shown in the following table:

Table 1 Implementation history

Date/time	Events
16/11/2010	Started Construction of N ₂ O abatement system /4/
20/04/2011	Commissioning started (Plant 1) /5/
27/04/2011	Commissioning started (Plant 2) /6/

	02/05/2011	Completed Construction of N ₂ O abatement system and the N ₂ O abatement system started normal operation /7/
	23/05/2011~27/05/2011	Field Test for Quality Assurance of installation and calibration of AMS (QAL2) /17/
	26/09/2011~29/09/2011	Additional Field Test for Quality Assurance of installation and calibration of AMS (QAL2) /17/
	14/05/2012~17/05/2012	Annual surveillance test (AST) for Quality Assurance of AMS /19/
	23/05/2013~25/05/2013	Taking Annual surveillance test (AST) for Quality Assurance of AMS for Plant 1 /19/
	22/05/2013~23/05/2013	Taking Annual surveillance test (AST) for Quality Assurance of AMS for Plant 2 /19/
	16/11/2013~29/05/2016	Plant 1 and Plant 2 Stopped operating /11//12/
	29/05/2016	Operation restart (Plant 2) /12/
	19/07/2016	The N ₂ O abatement system started normal operation (Plant 2) /12/
	25/07/2016~28/07/2016	Field Test for Quality Assurance of installation and calibration of AMS(QAL2) /20/
CCSC checked the documented evidences /4//5//6//7//11//12//17//19//20/ and can confirm the above implementation history is consistent with the documented evidence. Besides, the special events of the Plant I and Plant II included in the section B of the monitoring report are consistent with the information recorded in the EEU /8/. Plant 1 has not been operated after 5th monitoring period, and only the Plant 2 was operated during this monitoring period. No CARs/CLs/FARs raised in this section.		
Conclusion	According to Para. 385 of VVS Version 09.0 /32/, CCSC verification team confirms that: • The implementation status and equipments installation of the project activity are consistent with the PDD /27/; • The actual operation of the CDM project activity is as per the PDD /27/ by the PP; • Information (data and variables) provided in the monitoring report /2/ is in accordance with that stated in the PDD /27/.	

E.4. Post-registration changes

E.4.1. Temporary deviations from the registered monitoring plan, monitoring methodology or standardized baseline

>>

As per the conclusion in section E.5 and E.6, there are no temporary deviations from registered monitoring plan or applied methodology.

E.4.2. Corrections

>>

As per the conclusion in section E.3, there are no correction for the Project.

E.4.3. Changes to the start date of the crediting period

>>

There is no change to the start date of the crediting period for the Project.

E.4.4. Inclusion of a monitoring plan to a registered project activity

>>

The verification team has checked the registered PDD /27/ to confirm the inclusion of a monitoring plan to the Project.

E.4.5. Permanent changes from registered monitoring plan, monitoring methodology or standardized baseline

>>

As per the conclusion in section E.5 and E.6, no permanent change from registered monitoring plan or monitoring methodology occurred in the Project.

E.4.6. Changes to the project design of a registered project activity

>>

As per the conclusion in section E.3, no permanent change from registered monitoring plan or monitoring methodology occurred in the Project.

E.4.7. Types of changes specific to afforestation and reforestation project activities

>>

N/A

E.5. Compliance of monitoring plan with the monitoring methodology including applicable tool and standardized baseline

Means of verification	The monitoring plan of the Project has been assessed against the monitoring methodology AM0028 Version 05 /31/.
Findings	Through review of the registered monitoring plan against the monitoring methodology AM0028 Version 05 /31/, the verification team confirmed that the monitoring plan in the PDD /27/ is in accordance with the applied monitoring methodology AM0028 Version 05 /31/. The on-site assessment further demonstrated there are no monitoring aspects of the Project that are not specified in the methodology AM0028 Version 05 /31/. No CARs/CLs/FARs raised in this section.
Conclusion	CCSC verification team confirms that the monitoring plan in the PDD is in accordance with the applied methodology, i.e. AM0028 Version 05 /31/. Therefore, the Project is also in compliance with Para. 388 of VVS Version 09.0 /32/.

E.6. Compliance of monitoring activities with the registered monitoring plan

E.6.1. Data and parameters fixed ex ante or at renewal of crediting period

Means of verification	The data and parameters fixed ex-ante reported in the MR /2/ have been checked against the PDD /27/ and the applied methodology /31/ by the verification team.																				
Findings	The data and parameters fixed ex-ante include the following parameters: <table border="1"> <tr> <td>GWP_{N_2O} and GWP_{CH_4}</td><td>global warming potentials of N_2O and CH_4</td></tr> <tr> <td>$P_{product, max}$</td><td>Design capacity of caprolactam production</td></tr> <tr> <td colspan="2">historical production data of AORs:</td></tr> <tr> <td>$A_{OR, hist}$</td><td>maximum ammonia flow rate</td></tr> <tr> <td>$T_{g, hist}$ and $P_{g, hist}$</td><td>operating temperature and pressure range</td></tr> <tr> <td>$G_{sup, hist}$ and $G_{com, hist}$</td><td>ammonia oxidation catalyst supplier and composition</td></tr> <tr> <td>$OXID_{HC}$</td><td>Oxidation factor of natural gas with two or more molecules of carbon</td></tr> <tr> <td>EF_{CH_4} and ρ_{CH_4}</td><td>methane emission factor and density</td></tr> <tr> <td>M_i</td><td>length of measuring interval</td></tr> <tr> <td>Reg_{NOx}</td><td>national regulation on NO_x emissions</td></tr> </table> CCSC compared the values included in the section D.1 of the monitoring report to those values included in the section B6.2 of the registered PDD and can confirm that the values of these parameters included in the monitoring report are the same as those in the registered PDD, except for the GWP_{N_2O} and GWP_{CH_4}. The values of the GWP_{N_2O} and GWP_{CH_4} are updated as per the EB 69 Report, Annex 3 for the 2nd commitment period, since this monitoring period started after 01/01/2013. The verification team can confirm that this is reasonable. No CARs/CLs/FARs raised in this section.	GWP_{N_2O} and GWP_{CH_4}	global warming potentials of N_2O and CH_4	$P_{product, max}$	Design capacity of caprolactam production	historical production data of AORs:		$A_{OR, hist}$	maximum ammonia flow rate	$T_{g, hist}$ and $P_{g, hist}$	operating temperature and pressure range	$G_{sup, hist}$ and $G_{com, hist}$	ammonia oxidation catalyst supplier and composition	$OXID_{HC}$	Oxidation factor of natural gas with two or more molecules of carbon	EF_{CH_4} and ρ_{CH_4}	methane emission factor and density	M_i	length of measuring interval	Reg_{NOx}	national regulation on NO_x emissions
GWP_{N_2O} and GWP_{CH_4}	global warming potentials of N_2O and CH_4																				
$P_{product, max}$	Design capacity of caprolactam production																				
historical production data of AORs:																					
$A_{OR, hist}$	maximum ammonia flow rate																				
$T_{g, hist}$ and $P_{g, hist}$	operating temperature and pressure range																				
$G_{sup, hist}$ and $G_{com, hist}$	ammonia oxidation catalyst supplier and composition																				
$OXID_{HC}$	Oxidation factor of natural gas with two or more molecules of carbon																				
EF_{CH_4} and ρ_{CH_4}	methane emission factor and density																				
M_i	length of measuring interval																				
Reg_{NOx}	national regulation on NO_x emissions																				

Conclusion	In conclusion, according to Para. 392 and 393 of VVS (Version 09.0) /32/ and based on the verification team's local and sectorial knowledge, CCSC confirms that: The data and parameters fixed ex-ante have been correctly listed. Parameters fixed ex-ante for required parameters have been verified by checking the information flow and in compliance with the monitoring plan of the PDD.
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E.6.2. Data and parameters monitored

Means of verification	According to Para. 390 of VVS Version 09.0 /32/, CCSC has performed the following activities to determine whether the monitoring of parameters related to the GHG emission reductions has been implemented in accordance with the registered monitoring plan. (a) Through the on-site inspection of the monitoring system, interview with the operation staff, document review including relevant records, procedures and technical specifications, the verification team has assessed the implementation of the registered monitoring plan followed by the PP; (b) The parameters stated in the registered monitoring plan have been checked by means above; (c) The verification team has checked the installation of the monitoring equipments by onsite inspection against the registered PDD; (d) The Data records stored in the EEU and HDD /8/, Supplier information on catalyst delivery confirmation document /9/, Production Log /12/, and AMS records /13/ were checked by the verification team to confirm the monitoring results; (e) Based on the interview with the top management and operation staff and the review of the CDM Monitoring & Management Manual /25/, the verification team has assessed the quality assurance and quality control procedures applied by the PP. No sampling plan was involved in the project activity.
Findings	Monitoring has been carried out in accordance with the monitoring plan contained in the registered PDD. [Management and Operation] The PP has operated the Project as per the registered PDD. The monitoring organization has been set up and all monitoring staffs have been trained /26/. The monitoring parameters are measured by the PP as per the approved frequency included in the registered PDD. CDM Monitoring & Management Manual and CDM monitoring internal training records /25//26/ have been provided and verified by CCSC. CCSC also checked the emergency procedures contained in the CDM Monitoring & Management Manual /25/ and is able to confirm that it complies with the registered PDD. [Metering System] Monitoring points are shown in the following Figure 1 and Figure 2. The monitoring equipments were installed as per the following diagram, where the monitoring parameters are indicated. CCSC has onsite checked the monitoring equipments and reviewed the Diagram of production process included in the registered PDD and is able to confirm the information of monitoring points provided in the monitoring report is valid. CCSC also

onsite checked the tag No. of the monitoring equipments, which are included in the monitoring report, and can confirm that they are consistent with those in the registered PDD, except for the tag No. of the monitoring parameters of the N_2O concentration and CH_4 concentration at destruction facility outlet (CO_{N_2O-1} , CO_{CH_4-1} , CO_{N_2O-2} , and CO_{CH_4-2}). These four tag numbers are changed for distinguishing each other. All the monitoring equipment have been properly installed, maintained, calibrated and recorded according to relevant standard.

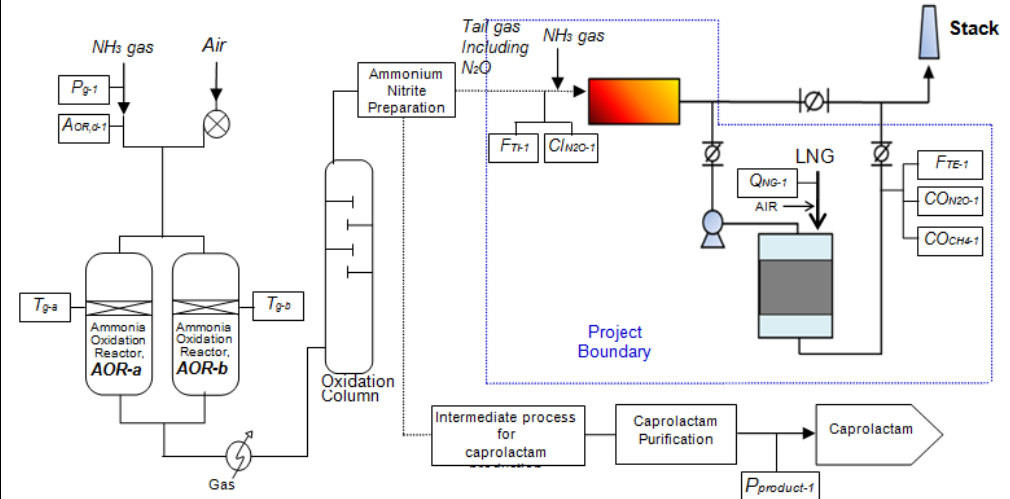


Figure 1 Monitoring points of Plant 1

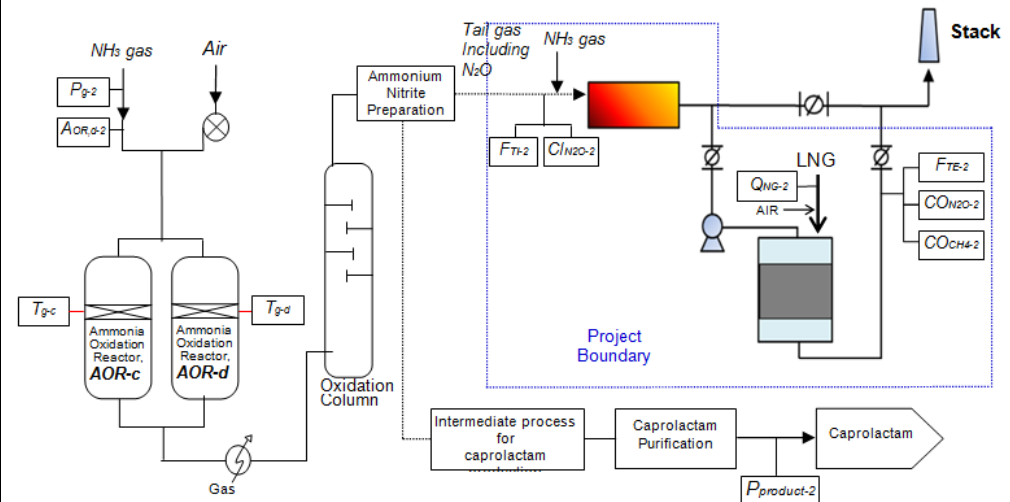


Figure 2 Monitoring points of Plant 2

The metering equipments are listed in the following table:

Table 2 metering equipments

Monitoring parameters	Metering equipments
$A_{OR,d-1}$ and $A_{OR,d-2}$	Differential pressure transmitter with normalizing functions
P_{g-1} and P_{g-2}	Pa gauge
T_{g-a} , T_{g-b} , T_{g-c} and T_{g-d}	Thermocouples
F_{TI-1} and F_{TI-2}	Ultrasonic flow meters with normalizing functions

F_{TE-1} and F_{TE-2}	Ultrasonic flow meters with normalizing functions
Cl_{N2O-1} and Cl_{N2O-2}	Non-dispersion infrared absorption analyzer (NDIR)
CO_{N2O-1} and CO_{N2O-2}	Non-dispersion infrared absorption analyzer (NDIR)
Q_{NG-1} and Q_{NG-2}	Flow meter with normalizing functions
CO_{CH4-1} and CO_{CH4-2}	Non-dispersion infrared absorption analyzer (NDIR), same as CO_{N2O-1} and CO_{N2O-2}
$P_{product-1}$ and $P_{product-2}$	Mass flow meters

Note: the subscripts 1 and 2 refer to the Plant I and Plant II respectively, while the subscripts a, b, c, and d refer to the four AORs.

The data of the AOR operating parameters (A_{OR} , T_g , P_g) and the productivity of caprolactam ($P_{product}$) are logged and stored by the existed DCS (Distributed Control System) which has been independently operated for Plant I and II before the implementation of this project.

Besides, the data of 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), i.e. N_2O emission at the two monitoring points of the inlet and outlet of N_2O destruction facility, 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. Q_{NG} is measured by Flow meter separately installed from AMS and CO_{CH4} 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. CCSC randomly onsite checked some data stored in the DCS system and the EEU and/or DCU system comparing to the documented data records provided by the PP to verify and no discrepancy between the provided data records and onsite stored data was found.

CCSC checked the Data records stored in the EEU and HDD /8/ and can confirm that the information of the DCU, EEU, External Hard Disk Drive (HDD) provided in the Table C.1 of the monitoring report is valid. The new PC for back-up is in-place 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.

[Quality Assurance of Automated measuring system]

The latest European Norm EN 14181:2004 which is required to be used as the basis for selecting and operating the automated measuring system (AMS) under methodology AM0028 Version 05, stipulates three levels of Quality Assurance Levels (QAL), and one Annual Surveillance Test (AST) /16//17//18//19//20/.

QAL1 is a quality test procedure, which shall be conducted before the installation of the measurement equipments in the plants. The test was performed by the manufacturer of the AMS. The monitoring report shows the records of QAL1 of the AMS equipments in the Table C.2 (a) Information of the quality assurance of tested AMS located in Plant I and Table C.2 (b) Information of the quality assurance of tested AMS located in Plant II. The verification team checked the QAL 1 records of the AMS monitoring equipments /16/ is able to confirm that the information provided in the Table C.2 (a) and Table C.2 (b) in the monitoring report is consistent with the documented evidence /16/, the evaluation has been carried out by the manufacturer before installation of AMS, and the evaluation is deemed to be acceptable.

QAL2 is a procedure to calibrate the AMS and determine the variability of the measured values obtained by it, so as to demonstrate the suitability of the AMS for its application, following its installation. The latest QAL2 test was performed from 25/07/2016 to 28/07/2016 by AIR-TEC /17/. CCSC checked the QAL2 test reports /17/ and can confirm that the reports conclude that the AMS complies with QAL2 requirements within EN 14181. 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

QAL3 is a procedure to maintain and demonstrate the results obtained during normal operations of an AMS, by checking that the zero and span characteristics are consistent with those determined during QAL1. QAL 3 has been implemented since the project start up, which includes:

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

The verification team checked the zero/span test records /18/ and is able to confirm that the QAL3 test complies with the requirements within EN 14181 and the results were without significant deviation.

The **AST** is a procedure which is used to evaluate whether the measured values obtained from the AMS still meet the required uncertainty criteria – as demonstrated in the previous QAL2 test. It also determines whether the calibration function obtained during the previous QAL2 test is still valid. Since the QAL2 has been performed less than one year before the end of this monitoring period, the AST has not been carried out yet. CCSC can confirm that this comply with the requirements within EN 14181.

According to the registered monitoring plan, the parameters required by the

monitoring plan and the way CCSC has verified the information flow including the values in the monitoring reports are described below:

Parameters required to be monitored by AMS ($F_{Ti,i}$, $Cl_{N2O,i}$, $F_{TE,i}$ and $CO_{N2O,i}$) /13/

The Parameters required to be monitored by AMS include the following parameters:

$F_{Ti,i}$ (F_{Ti-1} and F_{Ti-2}) Volume flow rate at the inlet of the destruction facility

$F_{TE,i}$ (F_{TE-1} and F_{TE-2}) Volume flow rate at the exit of the destruction facility

$Cl_{N2O,i}$ (Cl_{N2O-1} and Cl_{N2O-2}) N_2O concentration at destruction facility inlet

$CO_{N2O,i}$ (CO_{N2O-1} and CO_{N2O-2}) N_2O concentration at destruction facility outlet

Raw measurement data of volume flow rate parameters are measured using Ultrasonic flow meters with normalizing functions, while raw measurement data of N_2O concentration parameters is measured using Non-dispersion infrared absorption analyzers (NDIR). DCUs record the raw measurement data, and transmit those to EEU. The hourly recording frequency is more frequently than the requirements in the registered PDD.

The parameter F_{Ti} is determined conservatively as per the procedure described in the monitoring report. 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

The verification team has checked the Emission Reductions Calculation Spreadsheet and can confirm that the calculation of the $Q_{NG \text{ combustion gas}}$ is correct and this conservative approach is correctly applied to determine the F_{Ti} . VEF was determined as 0.001. This value of VEF is applied as a fixed official value. CCSC checked the documented evidence /10/ and can confirm the determination of the VEF complies with the registered PDD.

Parameters recorded by DCS ($P_{\text{product},y}$, $T_{g,d}$, $P_{g,d}$, $A_{OR,d}$) /12/

$P_{\text{product},y}$ ($P_{\text{product-1}}$ and $P_{\text{product-2}}$) Plant output of caprolactam

$T_{g,d}$ (T_{g-a} , T_{g-b} , T_{g-c} and T_{g-d}) Actual daily (d) operating temperature

of the ammonia oxidation reactor

$P_{g,d}$ (P_{g-1} and P_{g-2}) Actual operating pressure of the ammonia oxidation reactor on day d

$A_{OR,d}$ ($A_{OR,d-1}$ and $A_{OR,d-2}$) Actual ammonia flow rate to the ammonia oxidation reactor (AOR)

Raw measurement data of plant output of caprolactam is measured using mass flow meter, raw measurement data of operating temperature of the AORs is measured using thermocouple, raw measurement data of operating pressure of the AORs is measured using pressure gauge, while raw measurement data of ammonia flow rate to the AORs is measured using differential pressure transmitter with normalizing functions. DCSs record the raw measurement data, and transmit those to DCUs. The hourly recording frequency is more frequently than the requirement in the registered PDD. Cross-check of amount of the produced caprolactam ($P_{product,y}$) is performed on the basis of stock change data and weighbridge data. CCSC checked the data of stock change and weighbridge, and can confirm that the crosscheck process of the $P_{product,y}$ is reasonable and valid, and no error was found between the reported values and the stock change/weighbridge data.

CCSC has checked the information flows for generating, aggregating and reporting the monitoring parameters, raw data for AMS parameters and DCS parameters and the data monitoring procedures including the monitoring frequency and data transference of the these parameters through the onsite checking the monitoring system, interactions with the management representatives and operators of the PP and document review, and can confirm that they are in compliance with the requirements included in the methodology AM0028 Version 05. CCSC has verified and cross-checked the reported values by comparing randomly sampled values from the data records provided by the PP to the values onsite stored in the EEU to check whether there is error in the data transfer, and CCSC can confirm that there are no errors in the data transfer.

Parameters related to ammonia oxidation catalyst (G_{sup} , G_{com})

G_{sup} Supplier of the ammonia oxidation catalyst, and

G_{com} Composition of the ammonia oxidation catalyst

CCSC can confirm that the data of G_{sup} and G_{com} sourced from the Supplier information on catalyst delivery confirmation document /9/ is realistic.

Parameters related to natural gas ($Type_{HC}$, CF_{CH_4} , $Q_{NG,y}$, ρ_{NG} , CO_{CH_4})

$Type_{HC}$ (Type of hydrocarbon / Natural gas) and **CF_{CH_4}** (Methane content of hydrocarbon, natural gas) are sourced from natural gas supplier KyungDong city gas CO., Ltd. **$Q_{NG,y}$** (Natural gas input for re-heating the tail gas) is measured using flow meter with normalizing functions, and the hourly recording frequency is more frequently than the requirement in the registered PDD. **ρ_{NG}** (Density of the natural gas) is sourced from monthly report provided by the fuel supplier. **CO_{CH_4}** (Methane concentration at destruction facility outlet) is measured using non-dispersion infrared absorption analyzer with dual-channel as a gas path and the hourly recording frequency is more frequently than the requirement in the registered PDD.

Calculated parameters ($Q_{CH_4,d}$, $Q_{HC,y}$, ρ_{HC} , EF_{NG} , EF_{HC} , SE_{N_2O})

$Q_{CH_4,d}$

Methane part of the natural gas used

It is calculated with the following formula:

$$Q_{CH_4,y} = Q_{NG,y} \times CF_{CH_4}$$

 $Q_{HC,y}$

The hydrocarbon with two or more molecules of carbon in natural gas

It is calculated with the following formula:

$$Q_{HC,y} = Q_{NG,y} \times (1 - CF_{CH_4})$$

 ρ_{HC}

Density of the hydrocarbon with two or more molecules of carbon in natural gas

It is calculated with the following formula:

$$\rho_{HC} = (\rho_{NG} - \rho_{CH_4} \times CF_{CH_4}) / (1 - CF_{CH_4})$$

 EF_{NG}

Emission factor of the natural gas

It is calculated with the following formula:

$$EF_{NG} = COEF_{NG} \times NCV_{NG} / \rho_{NG} \times 44/12$$

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/Nm³]For this project, NCV_{NG} is offered by KOGAS. ρ_{NG} Density of the natural gas[t/Nm³]

For this project, based on data source by natural gas supplier.

 EF_{HC}

Emission factor of the hydrocarbon with two or more molecular of carbon, which is existed as a contents of the natural gas

It is calculated with the following formula:

$$EF_{HC} = (EF_{NG} \times \rho_{NG} - EF_{CH_4} \times \rho_{CH_4} \times CF_{CH_4}) / (1 - CF_{CH_4}) / \rho_{HC}$$

Where

 EF_{NG} : CO₂ emission factor of NG[tCO₂/tNG] ρ_{NG} : Density of natural gas (tNG/m³) EF_{CH_4} : CO₂ emission factor of CH₄(tCO₂/tCH₄). ρ_{CH_4} : Density of methane (tCH₄/ m³).

	CF_{CH_4} : Methane fraction in the natural gas SE_{N2O} N2O emission rate per ton of caprolactam It is calculated with the following formula: $SE_{N2O,period} = QI_{N2O,period} / P_{product,period} \times 1000$ Where, $QI_{N2O,y}$ means Quantity of N₂O emissions at the inlet of the destruction facility (t N₂O) OXID_{CH4} Oxidation factor of CH₄ in natural gas for re-heating tail gas It is calculated with the following formula: $OXID_{CH4} = \left\{ Q_{CH4} - \left(\sum_i^n F_{TE,i} \times CO_{CH4,i} \times 10^{-6} \right) \right\} / Q_{CH4} \times 100$ Regarding the above formulae, both the subscripts d (day) and y means the period. CCSC can confirm that the above formulae are correct and calculation of these parameters is valid. Reg_{NOx} (National regulation on NO_x emissions) and RSE_{N2O,y} (regulatory limit of N₂O emissions per unit of outlet of caprolactam) According to the “Clean Air Conservation Act”, one of the National environmental legislation, Ministry of Environment, the permitted values of NO_x emissions is 4.10714E⁻⁷ tNO_x/Nm³ (as a NO₂ concentration). According to the National legislation in Republic of Korea, there is no regulatory limit of N₂O emissions per unit of outlet of caprolactam (RSE_{N2O,y}). CCSC has verified the information flow provided in the monitoring report /2/ through onsite check and document review, i.e. interactions with the management representatives and operators of the PP, checking the nitric acid production line, checking the monitoring system, checking the monitoring management and organization, reviewing the CDM monitoring & management manual /25/, training records /26/ and all the data records /8/ and can confirm that the information flow of all the monitoring parameters complies with the monitoring plan and the methodology AM0028 Version 05. No CARs/CLs/FARs raised in this section.
Conclusion	Corresponding to the paragraph 392 and 393 of VVS Version 09.0 /32/, CCSC verification team confirms that: - The monitoring has been carried out in accordance with the monitoring plan contained in the PDD /27/. - All parameters required by the monitoring plan have been sufficiently monitored and correctly listed. The monitored data for required parameters have been verified by checking the whole information flow.

E.6.3. Implementation of sampling plan

Means of verification	No sampling plan has been applied in the project.
Findings	N/A
Conclusion	N/A

E.7. Compliance with the calibration frequency requirements for measuring instruments

Means of verification	The monitoring equipments should be calibrated periodically according to relevant national standards. The verification team has verified the calibration reports against the monitoring plan and relevant national or local standards.
Findings	All the monitoring equipments were calibrated in accordance with the requirements included in the monitoring plan. The calibration information is listed in the following Table 3. CCSC has on-site checked the monitoring equipments which are not auto calibrated and verified the calibration records /21/ issued by the calibration organizations and the accreditation certificates /23/ of the calibration organizations. Each calibration was conducted within the accreditation period of the calibration organizations. CCSC can confirm that all the monitoring equipments are within suitable accuracy level and consistent with the registered PDD. The calibration frequency complies with the requirements of the Monitoring Plan. However, the verification team found that the accuracy class of the thermocouples with serial No. "2879576" and "2879575" is different from the calibration records. Thus, a CL was raised: CL-1: the accuracy class of the thermocouples with serial No. "2879576" and "2879575" is different from the calibration records. The PP has revised the accuracy class of the thermocouples as per the calibration records. The verification team has checked the revised monitoring report and can confirm that the revised accuracy class of the thermocouples is consistent with the calibration records. The CL-1 was closed.
Conclusion	Corresponding to the paragraph 400 of VVS Version 09.0 /32/, CCSC verification team confirms that: • The calibration is conducted at the frequency as specified by the methodology /31/ and the monitoring plan contained in the PDD /27/.

Table 3 Calibration information of the monitoring equipments¹

Monitoring equipment type	Tag number	Monitoring parameter	Serial number	Accuracy class	Calibration frequency	Last calibration date	Validity period
Ultrasonic flow meters with normalizing functions	2FI-1521	F _{TI-2}	• HEAD A: 1217011 • HEAD B: 1217012 • Evaluation Unit :1216866 • Case of Evaluation : 1217002	< 2%	Every day by Auto calibration manner	30/04/2017	01/11/2016 to 30/04/2017
Ultrasonic flow meters with normalizing functions	2FI-1522	F _{TE-2}	•HEAD A: 1217013 •HEAD B: 1217014 • Evaluation Unit : 1216867 • Case of Evaluation : 1217003	< 2%	Every day by Auto calibration manner	30/04/2017	01/11/2016 to 30/04/2017
Non-dispersion infrared absorption analyzer (NDIR)	2AI-1521	Cl _{N2O-2}	AO-749	>95% (repeatability)	Every 2 weeks	21/04/2017	01/11/2016 to 30/04/2017
Non-dispersion infrared absorption analyzer (NDIR)	2AI-1522(a) 2AI-1522(b)	CO _{N2O-2} and CO _{CH4-2}	AO-751	>95% (repeatability)	Every 2 weeks	21/04/2017	01/11/2016 to 30/04/2017
Mass flow meters	2FI-7705	P _{product-2}	28 529138	± 0.15%	Every 2 years	02/05/2016 27/04/2017	02/05/2016 to 26/04/2019
Differential pressure transmitter with normalizing functions	2FIC-1201	AOR,d-2 ²	1210 80055040029 (before 27/04/2017)	± 0.1%	Every 2 years	19/05/2016	19/05/2016 to 18/05/2018
			1210 80055040028 (after 27/04/2017)	± 0.1%	Every 2 years	26/04/2017	26/04/2017 to 25/04/2019
Gauge pressure (Pa gauge)	2PI-1205	P _{g-2} ³	1211 80055040031 (before 27/04/2017)	± 0.1%	Every 2 years	19/05/2016	19/05/2016 to 18/05/2018

¹ Since the Plant 1 was not operated during this monitoring period, the information of the monitoring equipments of the Plant 1 is not included in the monitoring report and the calibration records of the monitoring equipments of the Plant 1 are not provided by the PP. This is reasonable.

² This equipment has been replaced on 27/04/2017. The verification team has checked the replacement record and can confirm the replacement did not impact the monitoring activity. The accuracy class of the instrument before and after the replacement complies with the requirement of the registered PDD.

³ This equipment has been replaced on 27/04/2017. The verification team has checked the replacement record and can confirm the replacement did not impact the monitoring activity. The accuracy class of the instrument before and after the replacement complies with the requirement of the registered PDD.

Monitoring equipment type	Tag number	Monitoring parameter	Serial number	Accuracy class	Calibration frequency	Last calibration date	Validity period
			1211 80055040030 (after 27/04/2017)	± 0.1%	Every 2 years	26/04/2017	26/04/2017 to 25/04/2019
Thermocouples	2TI-1204	Tg-c ⁴	4232653 (before 26/04/2017)	Maximum error 300°C: +1.17°C 500°C: +1.28°C 700°C: +1.14°C	Every 2 years	05/04/2016	05/04/2016 to 04/04/2018
			2879576 (after 26/04/2017)	Maximum error 300°C: +1.27°C 500°C: +1.74°C 700°C: +2.05°C	Every 2 years	26/04/2017	26/04/2017 to 25/04/2019
	2TI-1206	Tg-d ⁵	4232654 (before 26/04/2017)	Maximum error 300°C: +1.17°C 500°C: +1.28°C 700°C: +1.14°C	Every 2 years	05/04/2016	05/04/2016 to 04/04/2018
			2879575 (after 26/04/2017)	Maximum error 300°C: +1.27°C 500°C: +1.74°C 700°C: +2.05°C	Every 2 years	26/04/2017	26/04/2017 to 25/04/2019
Flow meter with normalizing functions	2FI-1523	Q _{NG-2}	02319623	±0.90%	Every 2 years	26/10/2016	26/10/2016 to 25/10/2019

⁴ This equipment has been replaced on 26/04/2017. The verification team has checked the replacement record and can confirm the replacement did not impact the monitoring activity. The accuracy class of the instrument before and after the replacement complies with the requirement of the registered PDD.

⁵ This equipment has been replaced on 26/04/2017. The verification team has checked the replacement record and can confirm the replacement did not impact the monitoring activity. The accuracy class of the instrument before and after the replacement complies with the requirement of the registered PDD.

E.8. Assessment of data and calculation of emission reductions or net removals**E.8.1. Calculation of baseline GHG emissions or baseline net GHG removals by sinks**

Means of verification	According to the Para.402 of VVS Version 09.0 /32/, the verification team has performed the following activities to assess the data and calculations of GHG emission reductions achieved by the Project as per the methodology /31/: (a) Through desk review and on-site inspection on the monthly electricity reports and electricity invoice, to verify that a complete set of data for the specified monitoring period is available. (b) Information provided in the monitoring report /2/ has been cross-checked with other sources /8//9//10//11//12//13/. (c) Review the calculations of baseline GHG emissions have been carried out in accordance with the formulae and methods described in the PDD /27/, and the methodology /31/; (d) Review emission factors, IPCC default values, GWPs and other reference values as per the PDD /27/.
Findings	The verification team has checked the daily average of the production ($P_{product,y}$) of caprolactam during this monitoring period and can confirm that the daily average of the production ($P_{product,y}$) did not exceed the design capacity ($P_{product,max}$) for both nitric acid plants. Since $P_{product,y} < P_{product,max}$, baseline emissions ($BE$) for the period can be calculated as follows for this period: $BE_{period} = BE_{period, within permit range} + BE_{period, out of permit range}$ When the daily average of the operating conditions were within the permitted range, the baseline emissions during these days are recalculated as follows according to the methodology AM0028 Version 05 and the registered PDD: $BE_{period, within permit range} = \left(\sum_i^n F_{TI,i} \times CI_{N2O,i} \times M_i \right) \times GWP_{N2O}$ Where M_i Length of Measuring Interval (hr), (1hr) GWP_{N2O} Global warming potential of the N_2O, (298: default value). n Number of intervals during this period $F_{TI,i}$ Volume flow rate at the inlet of the DF during interval (Nm³/hr)

$CI_{N_2O,i}$ N_2O concentration in the tail gas of the DF inlet during interval (tN_2O/ Nm^3)

When the daily average of the operating conditions were out of the permitted range, the baseline emissions during these days are recalculated as follows,

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

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

Where

$BE_{daily, out of permit range}$ The daily daseline emission for the respective day in which AOR operation conditions were outside of "permitted range (tonCO₂/day)

$P_{product, day}$ 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 (kgN₂O/ton caprolactam)

Emission factor of N_2O (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. $RSE_{N_2O,y}$). See the section E.1 of the monitoring report. There is no applicable $RSE_{N_2O,y}$ in the host country. CCSC can conclude that it is reasonable to use the $EF_{N_2O,IPCC}$ as the EF_{N_2O} since it is the lowest value among the options, and this recalculation procedure complies with the methodology AM0028 Version 05 and the monitoring plan.

The PP monitored the operating conditions parameters including the operating temperature and pressure, and the baseline emissions during the days when the daily average of the operating conditions were out of the permitted range, are recalculated with the daily output of caprolactam $P_{product, day}$ multiply the default IPCC value $EF_{N_2O,IPCC}$. The verification team has checked the data records /8//12/ and can confirm the results included in the monitoring report are consistent with the data records /8//12/.

CCSC has checked the records of all the monitoring parameters, and can confirm that the monitored values of the parameters included in the emission reductions calculation spreadsheet /3/ and the monitoring report version 2.0 /2/ are consistent with the documented evidences. CCSC has checked the calculation of the baseline emissions included in the emission reductions calculation spreadsheet, and can confirm that the calculation of the baseline emissions is correct and reasonable, and the $BE_{period} = 180,257tCO_2e$.

No CARs/CLs/FARs raised in this section.

Conclusion	Corresponding to the paragraph 403 of VVS Version 09.0 /32/, CCSC verification team confirms that: • A complete set of data for the monitoring period is available. • Information on the baseline GHG emission calculation provided in the monitoring report /2/ has been cross-checked with other sources. • Calculations of baseline emissions have been carried out in accordance with the formulae and methods described in the monitoring plan and the applied methodology document. • There are no assumptions applied. • Appropriate emission factor of the power grid has been correctly applied.
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E.8.2. Calculation of project GHG emissions or actual net GHG removals by sinks

Means of verification	The verification team has reviewed the project emission calculation as per the PDD /27/ and the applied methodology /31/.
Findings	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 $PE_{period} = PE_{ND,period} + PE_{HC,period} = PE_{ND,period} + HCE_{C,period} + HCE_{NC,period} =$ $\left(\sum_i^n F_{TE,i} \times CO_{N_2O,i} \times M_i \right) \times GWP_{N_2O}$ $+ [(\rho_{HC} \times Q_{HC,y} \times EF_{HC} \times OXID_{HC}/100) + (\rho_{CH_4} \times Q_{CH_4,y} \times EF_{CH_4} \times OXID_{CH_4}/100)]$ $+ [\rho_{CH_4} \times Q_{CH_4,y} \times GWP_{CH_4} \times (1-OXID_{CH_4}/100)]$ <i>PE_{period}</i> : Project emissions (tCO₂e) <i>PE_{ND}</i> : Project emissions from N₂O not destroyed (tCO₂e) <i>HCE_{C,y}</i> : Converted hydrocarbons emissions (tCO₂e) <i>HCE_{NC}</i> : Methane emissions (tCO₂e) <i>n</i> : Number of intervals during the year (period⁻¹) <i>M_i</i> : Length of Measuring Interval (hr), (1hr : set value at instrument for this project) <i>F_{TE,i}</i> : Volume flow rate at the exit of the DF during interval

	i (Nm³/hr) $CO_{N_2O,i}$: N₂O concentration in the tail gas of the DF exit during interval i (tN₂O/ m³) GWP_{CH_4} : Global warming potential of CH₄, 25 (default value) GWP_{N_2O} : Global warming potential of the nitrous oxide, 298 (default value) ρ_{CH_4} : Density of methane (tCH₄/m³) , 0.000716 ρ_{HC} : Density of HC (tHC/m³) EF_{CH_4} : CO₂ emission factor of CH₄ (tCO₂e/tCH₄), 2.75 EF_{HC} : CO₂ emission factor of HC with two or more carbon molecule in natural gas (tCO₂e/tHC) $Q_{CH_4,y}$: Methane used in period (Nm³/period) $Q_{HC,y}$: HC with two or more carbon molecule in natural gas used in period (Nm³/period) $OXID_{CH_4}$: Oxidation factor of methane (%) $OXID_{HC}$: Oxidation factor of HC(%), 100% (Fixed value) CCSC has checked the records of the monitoring parameters and can confirm that the monitored values of the parameters included in the emission reductions calculation spreadsheet /3/ and the monitoring report version 2.0 /2/ are consistent with the documented evidences. CCSC has checked the calculation of the project emissions included in the emission reductions calculation spreadsheet, and can confirm that the calculation of the project emissions is correct and reasonable, and the $PE_{period} = 21,398tCO_2e$. CAR-1: The data of natural gas used to calculate the emission reductions in the emissions calculation spreadsheet shall be revised according to the evidence. The verification team has checked the revised the data used to calculate the emission reductions in the spreadsheet and can confirm that the revised data is fully consistent with the evidence /8//13/ and the recalculation is correct. The CAR-1 was closed.
Conclusion	Corresponding to the paragraph 403 of VVS Version 09.0 /32/, CCSC verification team confirms that: • A complete set of data for the monitoring period is available. • Information on the project GHG emission calculation provided in the monitoring report /2/ has been cross-checked with other sources.

	Calculations of project emissions have been carried out in accordance with the formulae and methods described in the monitoring plan and the applied methodology document.
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E.8.3. Calculation of leakage GHG emissions

Means of verification	The verification team has reviewed the leakage calculation as per the PDD /27/ and the applied methodology /31/.
Findings	As per the registered PDD, heat exchange is conducted in De-N₂O system, and the installation of the N₂O destruction facility does not result in significant additional energy consumption at the caprolactam production plant, and therefore no leakage is expected at this project, and the LE_{period} = 0. No CARs/CLs/FARs raised in this section.
Conclusion	Corresponding to the paragraph 403 of VVS Version 09.0 /32/, CCSC verification team confirms that: - A complete set of data for the monitoring period is available. - Information on the leakage GHG emission calculation provided in the monitoring report /2/ has been cross-checked with other sources. - Calculations of leakage have been carried out in accordance with the formulae and methods described in the monitoring plan and the applied methodology document.

E.8.4. Summary of calculation of GHG emission reductions or net anthropogenic GHG removals by sinks

Means of verification	The verification team has reviewed the calculation of GHG emission reductions in the final MR /2/ and the ER spreadsheet /3/ as per the PDD /27/ and the applied methodology /31/.
Findings	The emission reductions during the monitoring period from 01/11/2016 to 30/04/2017 are calculated as: $ER_{period} = BE_{period} - PE_{period} - LE_{period}$ $= 180,257 - 21,398 - 0$ $= 158,859 \text{ tCO}_2\text{e}$ The emission reductions are recalculated for the periods when special events happened. CCSC has checked the information and data records /8//11//12//13/ during these periods and can confirm that the information provided in the monitoring report and the emission reductions are consistent with the data records /8//11//12//13/. The verification team can conclude the recalculation method is conservative, since the emission reductions are not claimed during the periods of the events of NAS and the periods when the NAS and product facility stopped operation for conservative purpose and the emission reductions were recalculated accordingly. No CARs/CLs/FARs raised in this section.
Conclusion	Corresponding to the paragraph 403 of VVS Version 09.0 /32/, CCSC verification team confirms that: A complete set of data for the monitoring period is available.

	- Information provided in the monitoring report /2/ has been cross-checked with other sources; - Calculations of baseline emissions, and project activity emissions and leakage, as appropriate, been carried out in accordance with the formulae and methods described in the monitoring plan and the applied methodology document. - There are no assumptions in emission reductions calculation. - Appropriate emission factor of the power grid has been correctly applied.
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E.8.5. Comparison of actual GHG emission reductions or net anthropogenic GHG removals by sinks with estimates in registered PDD

Means of verification	The comparison of actual GHG emission reductions with estimates in PDD /27/ has been checked and re-calculated by the verification team.
Findings	Based on the above assessment, the emission reduction during the monitoring period (01/11/2016 to 30/04/2017) is verified as 158,859 tCO₂e. According to the PDD, the annual emission reductions were estimated as 660,995 tCO₂e, while the ex-ante estimated ERs of the Plant II is 340,856tCO₂e and annual operating days of Plant II is 355 days. Plant I has not been operated after 5th monitoring period and the actual operating days of Plant II are 178 days. Therefore the value of estimated emission reductions during this monitoring period /27/ calculated as 170,908 tCO₂e (340,856 tCO₂e * 178 days/365 days), the verified emission reductions are lower than the estimated value in the monitoring period. No CARs/CLs/FARs raised in this section.
Conclusion	Corresponding to the paragraph 256 of CDM Project Standard Version 09.0 /32/, the verification team can confirm that: - A comparison of actual GHG emission reductions or net anthropogenic GHG removal of the project activity achieved during this monitoring period with the estimates in the PDD /27/ has been provided in the Monitoring Report /2/. - The verification team confirms that the calculation of the comparison is correct.

E.8.6. Remarks on difference from estimated value in registered PDD

Means of verification	The verified emission reductions are less than the estimated value in the monitoring period. Thus, no remarks need to be provided in the MR /2/.
Findings	The verified emission reductions are less than the estimated value in the monitoring period. Thus, no remarks need to be provided in the MR /2/. No CARs/CLs/FARs raised in this section.
Conclusion	The actual GHG emission reductions are lower than the estimates in the PDD /27/.

E.8.7. Actual GHG emission reductions or net anthropogenic GHG removals by sinks during the first commitment period and the period from 1 January 2013 onwards

Means of verification	The verification team has reviewed the monitoring report with the meter
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	reading records, electricity transaction notes to assess whether the GHG emission reductions or removals has been correctly calculated based on a pro-rata approach.
Findings	The current monitoring period starts after 31/12/2012. Thus, for this monitoring period, the emission reductions are 0 tCO₂e during the first commitment period; and the emission reductions are 158,859tCO₂e from 01/01/2013 onwards. No CARs/CLs/FARs raised in this section.
Conclusion	According to Para.254 of CDM Project Standard Version 09.0 /32/, CCSC verification team confirms that the project participants has calculated GHG emission reductions or removals based on a pro-rata approach in the following manner: The amount of emission reductions or removals achieved in the monitoring period for each GHG has be allocated proportionally to the duration of the period up to 31 December 2012 and the period from 1 January 2013 onwards before multiplying with the GWPs for the respective periods.

SECTION F. Internal quality control

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CCSC has taken the following quality control measures within the verification team and of the verification process according to relevant CCSC's internal procedures:

- The application review of the verification was conducted and concluded that CCSC has the accredited scope and competence to verify the Project with impartiality as well;
- The verification team was selected with due considerations given in terms of the competence and impartiality;
- The verification team carried out the verification work and compiled a verification report strictly following CCSC's Procedures for Implementation of Verification.

The verification report submitted by the verification team was subjected to a technical review and decision-making process, the technical reviewers and decision-makers are qualified and independent from the verification team. If any issue is raised during technical review and/or decision-making the same is to be discussed between the issue-raiser and the team leader as well as the PP. All issues must be satisfactorily addressed before the submission of the report for final approval. The persons who conducted the technical review and decision-making for the Project are shown in section B.2 this report and their Certificates of Competence can be found in Appendix 2 of this report.

The report approved by the authorized official of CCSC as the final report together with relevant documents are submitted to CDM EB through the UNFCCC dedicated web-platform for request for issuance (only if an unconditioned positive verification/certification opinion is concluded).

SECTION G. Verification opinion

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The verification team assigned by the China Classification Society Certification Company (CCSC) concludes that the CDM Project "N2O Abatement Project of Capro Corporation" in P.R. China, as described in the monitoring plan contained in the PDD /27/ (Version 8.1, 24/05/2011), and Monitoring Report (Version 2.0, 03/07/2017) /2/, meets all relevant requirements of the UNFCCC for CDM project activities including article 12 of the Kyoto Protocol, the modalities and procedures for CDM (Marrakesh Accords) and the subsequent decisions by the COP/MOP and CDM Executive Board. The verification is conducted in line with the VVS /32/ requirements.

The verification was executed by taking the following methods and in the following steps so far:

- Publication of the MR on the UNFCCC website (on 10/05/2017)
- Desk review of Monitoring Report Version 1.0 dated 08/05/2017 and related documents
- On-site inspection and interviews (on 28/06/2017)
- Raise corrective action requests (CARs) and clarification requests (CLs)
- Desk review of revised MR (Version 2.0, 03/07/2017) /2/ and responses to CARs/CLs/FARs
- Issue of this version of the verification report

The Project is implemented according to selected monitoring methodology AM0028 Version 05 /31/ and the monitoring plan contained in the PDD /27/. The monitoring equipment was installed, calibrated and maintained in a proper manner. The monitoring system is in place and the Project is generating GHG emission reductions as a CDM project.

CCSC therefore issues the positive verification opinion expressed in the Certification statement in SECTION H.

SECTION H. Certification statement

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CCSC has carried out the 7th periodic verification of the Project “N2O Abatement Project of Capro Corporation” (UNFCCC reference No.4665). This verification covers the period from 01/11/2016 to 30/04/2017 (first and last days included).

In the course of the verification 1 Corrective Action Request (CAR) and 1 Clarification Request (CL) were raised and successfully closed. The verification is based on the Monitoring Report Version 1.0 dated 08/05/2017 /1/, the revised Monitoring Report Version 2.0 dated 03/07/2017 /2/, the PDD /27/ and the validation report and validation opinion for the changes from the PDD, ER Spreadsheet /28/, and supporting documents available to CCSC.

As the result of the 7th periodic verification, CCSC confirms that:

- The project activity has been implemented and operated as per the PDD /27/ and that all physical features (technology, project equipment, and monitoring and metering equipment) of the project are in place;
- The monitoring report /2/ and other supporting documents provided are complete in accordance with the latest applicable version of the completeness checklist for requests for issuance of CERs and in accordance with applicable CDM requirements;
- The actual monitoring systems and procedures are in place and functional, and comply with the monitoring systems and procedures described in the monitoring plan;
- The monitoring plan is in accordance with the applied methodology, i.e., AM0028 Version 05 /31/;
- The installed equipment for measuring parameters required for calculating emission reductions are calibrated appropriately.
- The GHG emission reductions are calculated without material omission, errors, misstatements and in a conservative and appropriate manner.

CCSC hereby certifies that the Project has achieved emission reductions as follows:

Actual emission reduction for the monitoring period up to (and including) 31 December 2012	0 tCO ₂ e
Actual emission reduction for the monitoring period from (and including) 1 January 2013	158,859 tCO ₂ e

Total amount of GHG emission reductions or net GHG removals by sinks achieved in this monitoring period (01/11/2016 to 30/04/2017)	158,859 tCO ₂ e
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For and on behalf of CCSC

Authorized Signature

Name: Huang Shiyuan

Date: 17/07/2017

Appendix 1. Abbreviations

Abbreviations	Full texts
AMS	Automated Measuring System
AOR	ammonia oxidation reactor
AST	Annual Surveillance Test
CAR	Corrective Action Request
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CL	Clarification Request
CO ₂	Carbon Dioxide
CO ₂ e	Carbon Dioxide Equivalent
DAS	Data Acquisition System
DCS	Distributed Control System
DCU	Data Communication Units
DOE	Designated Operational Entity
EEU	Electronic Evaluation Unit
FAR	Forward Action Request
GHG	Green House Gas(es)
HDD	Hard Disk Drive
HNO ₃	Nitric Acid
LNG	Liquefied Natural Gas
MoV	Means of Verification
MP	Monitoring Plan
MR	Monitoring Report
NAS	N ₂ O Abatement System, also called destruction facility and De-N ₂ O Facility
N ₂ O	Nitrous Oxide
PDD	Project Design Document
PP	Project Participant
PS	Project Standard
QAL	Quality Assurance Levels
RTO	Regenerative Thermal Oxidizer
UNFCCC	United Nations Framework Convention on Climate Change
VVS	Validation and Verification Standard

Appendix 2. Competence of team members and technical reviewers



Appendix 9

CERTIFICATE OF COMPETENCE

Date of issue: 16/10/2016

Mr. Li Xingtong

Has been qualified in accordance with *CDM Personnel Competence Requirements and Professional Competence Evaluation Instructions* (CDMI0301) as

- CDM validator for Technical Area(s): TA1.1/TA1.2/TA3.1/TA9.2/TA13.1
- CDM verifier for Technical Area(s): TA1.1/TA1.2/TA3.1/TA9.2/TA13.1
- ☐ Technical expert for Technical Area(s): _____

Huang ShiYuan
CCSC General Manager



Appendix 9

CERTIFICATE OF COMPETENCE

Date of issue: 16/10/2016

Mr. Tan Wenbin

Has been qualified in accordance with *CDM Personnel Competence Requirements and Professional Competence Evaluation Instructions* (CDMI0301) as

- CDM validator for Technical Area(s): TA1.2/TA5.2/TA8.1/TA10.1
- CDM verifier for Technical Area(s): TA1.2/TA5.2/TA8.1/TA10.1
- ☐ Technical expert for Technical Area(s): _____

Huang ShiYuan
CCSC General Manager



Appendix 9

CERTIFICATE OF COMPETENCE

Date of issue: 16/10/2016

Mr. Shen Meng

Has been qualified in accordance with *CDM Personnel Competence Requirements and Professional Competence Evaluation Instructions* (CDMI0301) as

- CDM validator for Technical Area(s): TA1.1/TA1.2/TA5.2/TA13.1
- CDM verifier for Technical Area(s): TA1.1/TA1.2/TA5.2/TA13.1
- ☐ Technical expert for Technical Area(s): _____

Huang ShiYuan
CCSC General Manager



Appendix 9

CERTIFICATE OF COMPETENCE

Date of issue: 16/10/2016

Ms. Zheng Ling

Has been qualified in accordance with *CDM Personnel Competence Requirements and Professional Competence Evaluation Instructions* (CDMI0301) as

- CDM validator for Technical Area(s): TA1.2
- ☐ CDM verifier for Technical Area(s): _____
- Technical expert for Technical Area(s): TA13.1

Huang ShiYuan
CCSC General Manager

Documents reviewed or referenced

No	Author	Title	References to the document	Provider
1.	Hyosung Corporation	Monitoring Report Version 1.0	Dated 08/05/2017	PP
2.	Hyosung Corporation	Final monitoring report Version 2.0	Dated 03/07/2017	PP
3.	Hyosung Corporation	Emission reductions calculation spreadsheet Version 2.0	Dated 03/07/2017	PP
4.	/	Record of construction start	Dated 16/11/2010	PP
5.	/	Record of commissioning start of Plant 1	Dated 20/04/2011	PP
6.	/	Record of commissioning start of Plant 2	Dated 27/04/2011	PP
7.	/	Record of completing construction of N2O abatement system	Dated 02/05/2011	PP
8.	Capro Corporation	Data records stored in the EEU and HDD	/	PP
9.	/	Supplier information on catalyst delivery confirmation document	/	PP
10.	/	Statement on the Volumetric Expansion Factor (VEF) by CRI Catalyst Company	Dated 05/2011	PP
11.	Capro Corporation	Process shutdown log	/	PP
12.	Capro Corporation	Production Log	/	PP
13.	Capro Corporation	AMS records	/	PP
14.	/	European Norm EN 14181:2004 Stationary source emissions - Quality assurance of automated measuring systems	/	PP
15.	/	Air quality - Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty (ISO 14956:2002)	/	PP
16.	/	QAL 1 records of the AMS monitoring equipments	/	PP
17.	/	Reports of QAL2 tests conducted from 23/05/2011 to 27/05/2011 and from	/	PP

		26/09/2011 to 29/09/2011 for the AMS installed for the Plant 1 and Plant 2, issued by AIRTEC		
18.	/	QLA3 zero/span test records	/	PP
19.	/	Reports of Annual surveillance tests (AST) conducted for Quality Assurance of AMS	/	PP
20.	/	Reports of QAL2 tests conducted from 25/07/2016 to 28/07/2016 for the AMS, issued by AIRTEC	/	PP
21.	/	Calibration records of the monitoring equipments	/	PP
22.	/	Replacement records of the monitoring equipments	/	PP
23.	/	Accreditation certificates of the calibration organizations	/	PP
24.	/	Test report of the D-EMS 2000 System	Dated 07/2011	PP
25.	Capro Corporation	CDM Monitoring & Management Manual	/	PP
26.	Capro Corporation	CDM and Monitoring Internal Training Records	/	PP
27.	/	Registered PDD Version 8.1	Dated 24/05/2011	PP
28.	TUV-SUD	Validation report Version 4.1	Dated 01/06/2011	PP
29.	/	Previous monitoring reports	/	PP
30.	Verification DOE	Previous verification reports	/	PP
31.	UNFCCC CDM-EB	Methodology AM0028 Version 05	Dated 12/02/2010	Others
32.	UNFCCC CDM-EB	Validation and verification standard Version 09.0	Dated 20/02/2015	Others
33.	UNFCCC CDM-EB	Project standard Version 09.0	Dated 20/02/2015	Others
34.	UNFCCC CDM-EB	Project cycle procedure Version 09.0	Dated 20/02/2015	Others
35.	UNFCCC CDM-EB	Monitoring report form Version 05.1	/	Others

Appendix 3. Clarification requests, corrective action requests and forward action requests

Table 1. Remaining FAR from validation and/or previous verification

FAR ID	N/A	Section no.	N/A	Date :	N/A
Description of FAR					
N/A					
Project participant response				Date :	N/A
N/A					
Documentation provided by project participant					
N/A					
DOE assessment				Date:	N/A
N/A					

Table 2. CL from this verification

Table 2: CE from this verification													
CL ID	CL-1	Section no.	E.7	Date : 29/06/2017									
Description of CL													
The accuracy class of the thermocouples with serial No. “2879576” and “2879575” is different from the calibration records.													
Project participant response				Date : 03/07/2017									
The accuracy class of the thermocouples with serial No. “2879576” and “2879575” has been revised as per the calibration records. Revised accuracy class to:													
<table><tr><td colspan="2">Maximum error</td></tr><tr><td>300°C:</td><td>+1.27°C</td></tr><tr><td>500°C:</td><td>+1.74°C</td></tr><tr><td>700°C:</td><td>+2.05°C</td></tr></table>						Maximum error		300°C:	+1.27°C	500°C:	+1.74°C	700°C:	+2.05°C
Maximum error													
300°C:	+1.27°C												
500°C:	+1.74°C												
700°C:	+2.05°C												
Documentation provided by project participant													
Revised monitoring report													
DOE assessment				Date: 06/07/2017									
The verification team has checked the revised monitoring report and can confirm that the revised accuracy class of the thermocouples is consistent with the calibration records, and the accuracy class of the thermocouples comply with the requirements in the registered PDD.													

Table 3. CAR from this verification

CAR ID	CAR-1	Section no.	E.8	Date:	29/06/2017
Description of CAR					

The data of natural gas sourced from the fuel supplier, including the CF_{CH_4} (Methane content of hydrocarbon, natural gas), ρ_{NG} (Density of the natural gas), ρ_{HC} (Density of the hydrocarbon with two or more molecules of carbon in natural gas), used to calculate the emission reductions in the emissions calculation spreadsheet shall be revised according to the evidence.	
Project participant response	Date: 03/07/2017
The data used to calculate the emission reductions in the emissions calculation spreadsheet is revised as per the evidence and the emission reductions have been recalculated according to the evidence. Emission reductions before recalculation: 158,858tCO₂e Emission reductions after recalculation: 158,859tCO₂e	
Documentation provided by project participant	
Revised monitoring report and emission reductions calculation spreadsheet.	
DOE assessment	Date: 06/07/2017
The verification team has checked the revised the data used to calculate the emission reductions in the spreadsheet and can confirm that the revised data is fully consistent with the evidence /8//13/ and the recalculation is correct. The CAR-1 was closed.	

Table 4. FAR from this verification

FAR ID	N/A	Section No.	N/A	Date : N/A
Description of FAR				
N/A				
Project participant response				Date : N/A
N/A				
Documentation provided by project participant				
N/A				
DOE assessment				Date : N/A
N/A				

Document information

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Business		Function:
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