VERIFICATION REPORT

HYOSUNG EBARA ENGINEERING CO., LTD.

VERIFICATION OF THE

N2O ABATEMENT PROJECT OF CAPRO CORPORATION

REPORT NO.BVC/CHINA-VR/8434/2011

REVISION NO.02

BUREAU VERITAS CERTIFICATION

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VERIFICATION REPORT

Date of first issue:	Organizational unit:
28/04/2012	Bureau Veritas Certification Holding SAS
Client:	**Client ref.:**
Hyosung Ebara Engineering Co., Ltd.	Mr. Park, Jong-hoon

Summary:

Bureau Veritas Certification has conducted the 1st periodic verification of N2O Abatement Project of Capro Corporation, CDM Registration Reference Number 4665, owned by Capro Corporation; Hyosung Ebara Engineering Co., Ltd.; and Hyosung Corporation, which is located in Bugok-dong, Nam-gu, Ulsan, the south-eastern part of the Republic of Korea, and applying the methodology AM0028 Version 05, on the basis of UNFCCC criteria for the CDM, as well as criteria given to provide for consistent project operations, monitoring and reporting. UNFCCC criteria refer to Article 12 of the Kyoto Protocol, the CDM rules and modalities and the subsequent decisions by the CDM Executive Board, as well as the host country criteria.

The verification scope is defined as a periodic independent review and ex post determination by the Designated Operational Entity of the monitored reductions in GHG emissions during defined verification period, and consisted of the following three phases: i) desk review of the project design and the baseline and monitoring plan; ii) follow-up on-site visit and interviews with project stakeholders; iii) resolution of outstanding issues and the issuance of the final verification report and opinion. The overall verification, from Contract Review to Verification Report & Opinion, was conducted using Bureau Veritas Certification internal procedures.

The first output of the verification process is a list of Clarification, Corrective Actions Requests, Forward Actions Requests (CLs, CARs and FARs), presented in Appendix A.

In summary, Bureau Veritas Certification confirms that the project is implemented as planned and described in validated and registered project design documents. Installed equipments being essential for generating emission reductions 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 CER emission reductions verified totalize 144,751tons of CO_2e for the monitoring period.

Our opinion relates to the Projects' GHG emission and resulting GHG emission reductions reported and related to the valid and registered project baseline, monitoring plan and its associated documents.

Reporting period	09/06/2011 to 31/08/2011
Baseline emissions	162,628.267 t CO_2 equivalents
Project emissions	17,877.253 t CO_2 equivalents
Leakage emissions	0 t CO_2 equivalents
Emission Reductions	144,751 t CO_2 equivalents

Report No.:	Subject Group:
BVC-China/VR 8434/2011	CDM
Project title:	
N2O Abatement Project of Capro Corporation	
Work carried out by:	
Mr. (Ernesto) Tan Wenbin - Team leader Mr. (Jony) Li Qing - Specialist	
Internal Technical Review carried out by:	
Ms. (Coco) Geng Yan - Technical Reviewer Ms. An Baifang - Specialist	

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Indexing terms

Work approved by: Flavio Gomes

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Abbreviations

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_2e	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_2O Abatement System, also called destruction facility and De-N_2O Facility
N_2O	Nitrous Oxide
PDD	Project Design Document
PP	Project Participant
QAL	Quality Assurance Levels
RTO	Regenerative Thermal Oxidizer
UNFCCC	United Nations Framework Convention on Climate Change
VVM	Validation and Verification Manual

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1 INTRODUCTION

Hyosung Ebara Engineering Co., Ltd. has commissioned Bureau Veritas Certification to verify the emissions reductions of its CDM project N2O Abatement Project of Capro Corporation (hereafter called "**the Project**") owned by Capro Corporation; Hyosung Ebara Engineering Co., Ltd.; and Hyosung Corporation (hereinafter called "**the project owner**") located in Bugok-dong, Nam-gu, Ulsan, the south-eastern part of the Republic of Korea.

This report summarizes the findings of the verification of the Project, performed on the basis of UNFCCC criteria, as well as criteria given to provide for consistent project operations, monitoring and reporting.

1.1 Objective

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.

Based on the applicable requirements of paragraph 62 of the CDM modalities and procedures, this assessment shall:

(a) Ensure that the project activity has been implemented and operated as per the registered PDD and that all physical features (technology, project equipment, and monitoring and metering equipment) of the project are in place;

(b) 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;

(c) Ensure that actual monitoring systems and procedures comply with the monitoring systems and procedures described in the monitoring plan and the approved methodology;

(d) Evaluate the data recorded and stored as per the monitoring methodology.

1.2 Scope

The verification scope is defined as an independent and objective review of the project design document, the project's baseline study and monitoring plan and other relevant documents. The information in these documents is reviewed against Kyoto Protocol requirements, UNFCCC rules and associated interpretations.

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 monitoring towards reductions in the GHG emissions.

1.3 GHG Project Description

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 NO_2. Nitrous oxide (N_2O) is generated as an undesired by-product through the side reaction of ammonia oxidation as follows:

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

$2NO + O_2 \rightarrow 2NO_2$ (Desired in the NO oxidation process)

$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$ (Side reaction)

$4NH_3 + 4O_2 \rightarrow 2N_2O + 6H_2O$ (Side reaction generating N_2O and release N_2O in the tail gas)

N_2O is recognized as a potent greenhouse gas with a Global Warming Potential (GWP) of 310 compared to carbon dioxide (CO_2), i.e. GWP_{N2O} = 30. De-N_2O system (NAS, N_2O abatement system) used in this project is to destruct the N_2O included in tail gas by catalyst without any reducing agent. Then greenhouse gas emission reductions are generated. The annual estimated emission reductions are 660,995tCO_2e.

$2N_2O \rightarrow 2N_2 + O_2$

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 N_2O, and this N_2O 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-N_2O catalytic reaction. The N_2O 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 Project has been registered on 09/06/2011 (UNFCCC ref. No. 4665) under approved CDM methodology AM0028 Version 05 *Catalytic N2O destruction in the tail gas of Nitric Acid Plants or Caprolactam Production* /5/. The Project has chosen the renewable crediting period in the registered PDD, the first renewable crediting period is from 09/06/2011 - 08/06/2021.

Project title:	N2O Abatement Project of Capro Corporation
UNFCCC ref number:	4665
Registration Date:	09/06/2011, with the registered PDD version 8.1 dated 24/05/2011
Crediting Period:	09/06/2011 - 08/06/2021

Monitoring Period:	09/06/2011 to 31/08/2011
Project Participants:	Republic of Korea (Host Party): Capro Corporation; Hyosung Ebara Engineering Co., Ltd.; and Hyosung Corporation
Methodologies used	AM0028 Version 05 - *Catalytic N2O destruction in the tail gas of Nitric Acid Plants or Caprolactam Production*
Location of the Project:	in Bugok-dong, Nam-gu, Ulsan, the south-eastern part of the Republic of Korea
Geo coordinates:	Longitude: 129.3280E, Latitude: 35.4958N
UNFCCC link:	http://cdm.unfccc.int/Projects/DB/TUEV-SUED1302245900.58/view

1.4 Verification Team and Internal Technical Reviewer

The verification team and internal technical reviewer consist of the following personnel:

FUNCTION	NAME	CODE HOLDER	TASK PERFORMED*
Team Leader	Mr. (Ernesto) Tan Wenbin	☐**Yes** ☒ **No**	☒**DR** ☒**SV** ☒**RI**
Team Member	N/A	☐**Yes** ☐ **No**	☐**DR** ☐**SV** ☐**RI**
Technical Specialist	Mr. (Jony) Li Qing	☒**Yes** ☐ **No**	☒**DR** ☒**SV** ☐**RI**
Internal Technical Reviewer (ITR)	Ms. (Coco) Geng Yan	☐**Yes** ☒ **No**	☒**DR** ☐**SV** ☐**RI**
Specialist supporting ITR	Ms. An Baifang	☒**Yes** ☐ **No**	☒**DR** ☐**SV** ☐**RI**

*DR = Document Review; SV = Site Visit; RI = Report issuance

2 METHODOLOGY

The overall verification, from Contract Review to Verification Report & Opinion, was conducted using Bureau Veritas Certification internal procedures.

In order to ensure transparency, a verification protocol was customized for the Project, according to the version 01.2 of the Clean Development Mechanism Validation and Verification Manual /6/, issued by CDM Executive Board at its 55th meeting on 30/07/2010. The protocol shows, in a transparent manner, criteria (requirements), means of verification and the results from verifying the identified criteria. The verification protocol serves the following purposes:

- It organizes, details and clarifies the requirements a CDM project is expected to meet;
- It ensures a transparent verification process where the verifier will document how a particular requirement has been verified and the result of the verification.

The completed verification protocol is enclosed in Appendix A to this report.

2.1 Review of Documents

The verification of the project documentation provided by the project participant is based upon both quantitative and qualitative information on emission reductions. Quantitative information comprises the reported numbers in the Monitoring Report Version 3.0 dated 25/09/2012 /4/ submitted to the DOE. Qualitative information comprises information on internal management controls, calculation procedures, procedures for transfer of data, frequency of emissions reports, and review and internal audit of calculations.

The Monitoring Report Version 1.1 /3/ submitted by the project participant was also web hosted on the UNFCCC-CDM web site on 10/01/2012 and thus, was available in the public domain.

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

(a) The registered PDD, including the monitoring plan and the corresponding validation report; /1//2/

(b) The applied monitoring methodology; /5/

(c) Relevant decisions, clarifications and guidance from the CMP and the CDM Executive Board;

2.2 Follow-up Interviews

On 02/02/2012, Bureau Veritas Certification performed an on-site visit and interviews with project stakeholders to confirm selected information and to resolve issues identified in the document review. Representatives of Capro Corporation; Hyosung Ebara Engineering Co., Ltd.; and Hyosung Corporation were interviewed (see References). The main topics of the interviews are summarized in Table 1.

Table 1 Interview topics

Interviewed organization	Interview topics
Capro Corporation; Hyosung Ebara Engineering Co., Ltd.; and Hyosung Corporation	➢ Project Design and implementation ➢ Technical equipment, calibration and operation ➢ Monitoring Plan and management procedures ➢ Monitoring data ➢ Data uncertainty and residual risks (QA/QC) ➢ GHG Calculation ➢ Environmental Impacts ➢ Compliance with National Laws and Regulations ➢ Monitoring Plan ➢ Monitored data and Monitoring Report ➢ GHG Calculation

2.3 Resolution of Clarification, Corrective and Forward Action Requests

The objective of this phase of the verification is to raise the requests for corrective actions and clarification and any other outstanding issues that needed to be clarified for Bureau Veritas Certification positive conclusion on the GHG emission reduction calculation.

Findings established during the verification can either be seen as a non-fulfilment of criteria ensuring the proper implementation of a project or where a risk to deliver high quality emission reductions is identified.

Corrective Action Requests (CARs) are issued, where:

(a) Non-conformities with the monitoring plan or methodology are found in monitoring and reporting, or if the evidence provided to prove conformity is insufficient;

(b) Mistakes have been made in applying assumptions, data or calculations of emission reductions which will impair the estimate of emission reductions;

(c) Issues identified in a FAR during verification to be verified during verification have not been resolved by the project participants.

Forward Action Requests (FARs) are issued, for actions if the monitoring and reporting require attention and/or adjustment for the next verification period.

Bureau Veritas Certification may also use the term Clarification Requests (CLs), if information is insufficient or not clear enough to determine whether the applicable CDM requirements have been met.

To guarantee the transparency of the verification process, the concerns raised are documented in more detail in the verification protocol in Appendix A.

2.4 Internal Technical Review

The verification report underwent an Internal Technical Review (ITR) before requesting issuance of CERs for the project activity.

The ITR is an independent process performed to examine thoroughly that the process of verification has been carried out in conformance with the requirements of the verification scheme as well as internal Bureau Veritas Certification procedures.

The Team Leader provides a copy of the verification report to the reviewer, including any necessary verification documentation. The reviewer reviews the submitted documentation for conformance with the verification scheme. This will be a comprehensive review of all documentation generated during the verification process.

When performing an Internal Technical Review, the reviewer ensures that:

> The verification activity has been performed by the team by exercising utmost diligence and complete adherence to the CDM rules and requirements.
>
> The review encompasses all aspects related to the project which includes project design, baseline, additionality, monitoring plans and emission reduction calculations, internal quality assurance systems of the project participant as well as the project activity, review of the stakeholder comments and responses, closure of CARs, CLs and FARs during the verification exercise, review of sample documents.

The reviewer compiles clarification questions for the Team Leader and Verification Team and discusses these matters with Team Leader.

After the agreement of the responses on the 'Clarification Request' from the Team Leader as well as the PP(s) the finalized verification report is accepted for further processing such as uploading on the UNFCCC webpage.

3 VERIFICATION CONCLUSIONS

In the following sections, the conclusions of the verification are stated.

The findings from the desk review of the original monitoring documents and the findings from interviews during the follow up visit are described in the Verification Protocol in Appendix A.

The Clarification, Corrective and Forward Action Requests are stated, where applicable, in the following sections and are further documented in the Verification Protocol in Appendix A. The verification of the Project resulted in 6 Corrective Action Requests and 1 Clarification Request.

The CARs, CLs and FARs were closed based on adequate responses from the Project

Participant(s) which meet the applicable requirements. They have been reassessed before their formal acceptance and closure.

The number between brackets at the end of each section corresponds to the VVM paragraph.

3.1 Remaining issues from previous validation and verification (190)

All CARs and CLs raised were successfully closed during the validation stage and this is the first periodic verification, no remaining issues and no FARs were left.

3.2 Project implementation in accordance with the registered project design document (198)

Bureau Veritas Certification has performed an on-site visit and found that the Project has been put into operation in compliance with the registered PDD. No notification or approval of changes has been requested for the Project. During the site visit, no changes from the project activity as described in the registered PDD have been observed or identified. Hence there is no need to request for notification or approval of changes.

During the process of the ammonia oxidation in AOR of the caprolactam production, N_2O is generated as an undesired by-product through the side reaction of Ammonia oxidation:

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

$2NO + O_2 \rightarrow 2NO_2$ (Desired in the NO oxidation process)

$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$ (Side reaction)

$4NH_3 + 4O_2 \rightarrow 2N_2O + 6H_2O$ (Side reaction generating N_2O and release N_2O in the tail gas)

De-N_2O system (NAS, N_2O abatement system) used in this project is to destruct the N_2O included in tail gas by catalyst without any reducing agent. 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 N_2O, and this N_2O 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-N_2O catalytic reaction. The N_2O 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 2:

Table 2 Implementation history

Date/time	Events
16/11/2010	Started Construction of N_2O abatement system /8/
23/03/2011	Conducted trial run after loading N_2O decomposition catalyst /9/
15/04/2011	Installed Measuring instruments including AMS /10/
20/04/2011	Commissioning started (Plant 1) /11/
27/04/2011	Commissioning started (Plant 2) /12/
02/05/2011	Completed Construction of N_2O abatement system and the N_2O abatement system started normal operation /13/
23/05/2011 ~27/05/2011	Field Test for Quality Assurance of installation and calibration of AMS (QAL2) /24/
26/09/2011 ~29/09/2011	Additional Field Test for Quality Assurance of installation and calibration of AMS (QAL2) /24/

Bureau Veritas Certification checked the documented evidence /8/ /9/ /10/ /11/ /12/ /13/ /24/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 /14/.

Information provided in the monitoring report is in accordance with that stated in the registered PDD. Further analysis of monitored parameters as reported in the monitoring report compared to those estimated in the PDD is developed in section 3.5 of this report.

✌ Corresponding to the paragraph 198 of VVM version 01.2, Bureau Veritas Certification can confirm that:

- The implementation of the Project is consistent with the registered PDD.
- The Project is operated as per the registered PDD by the PP.
- Information provided in the MR is in accordance with that stated in the registered PDD.

3.3 Compliance of the monitoring plan with the monitoring methodology (203)

✌ Corresponding to the paragraph 203 of VVM version 01.2, Bureau Veritas Certification has verified the validated monitoring plan, including the data and parameters required to be

monitored, measurement procedures, monitoring frequency and QC/QA procedures as described in the registered PDD, and is able to confirm that the monitoring plan is in accordance with the approved methodology applied by the Project.

3.4 Compliance of monitoring with the monitoring plan (206)

Monitoring has been carried out in accordance with the monitoring plan contained in the registered PDD /1/.

[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 /29//30/. 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 have been provided and verified by Bureau Veritas Certification. Bureau Veritas Certification also checked the emergency procedures contained in the CDM Monitoring & Management Manual /29/ 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. Bureau Veritas Certification 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. Bureau Veritas Certification 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_{N2O-1}, CO_{CH4-1},CO_{N2O-2}, and CO_{CH4-2}). These four tag numbers are changed for distinguishing each other. All the monitoring equipments have been properly installed, maintained, calibrated and recorded according to relevant standard.

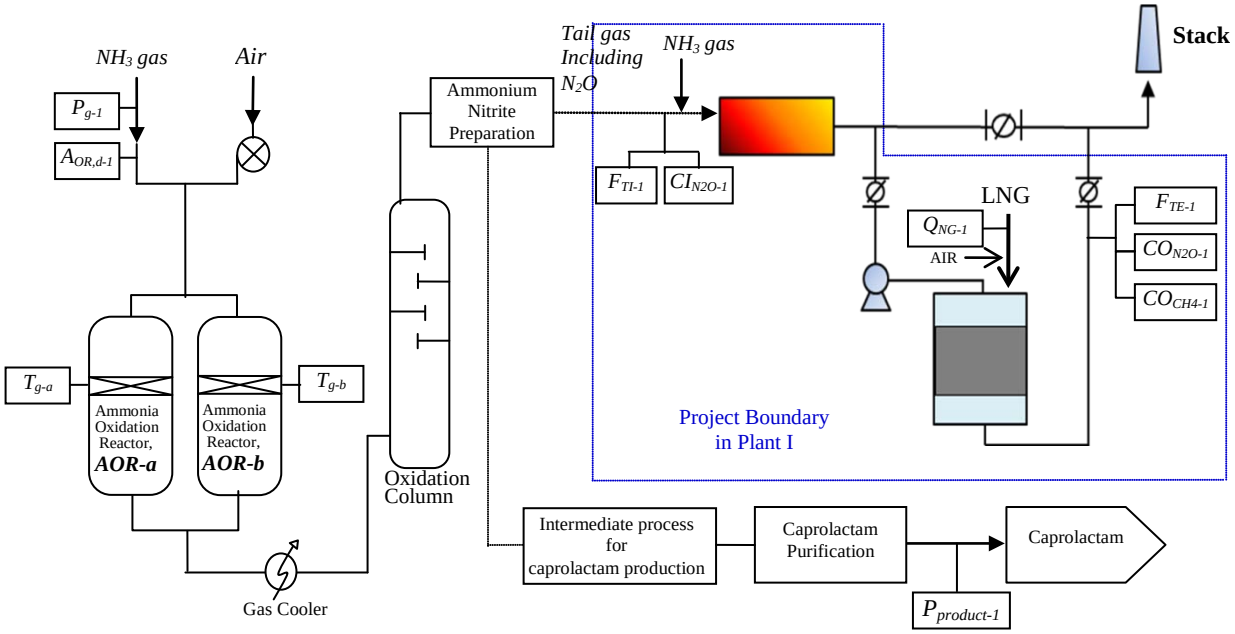

Figure 1 Monitoring points of Plant 1

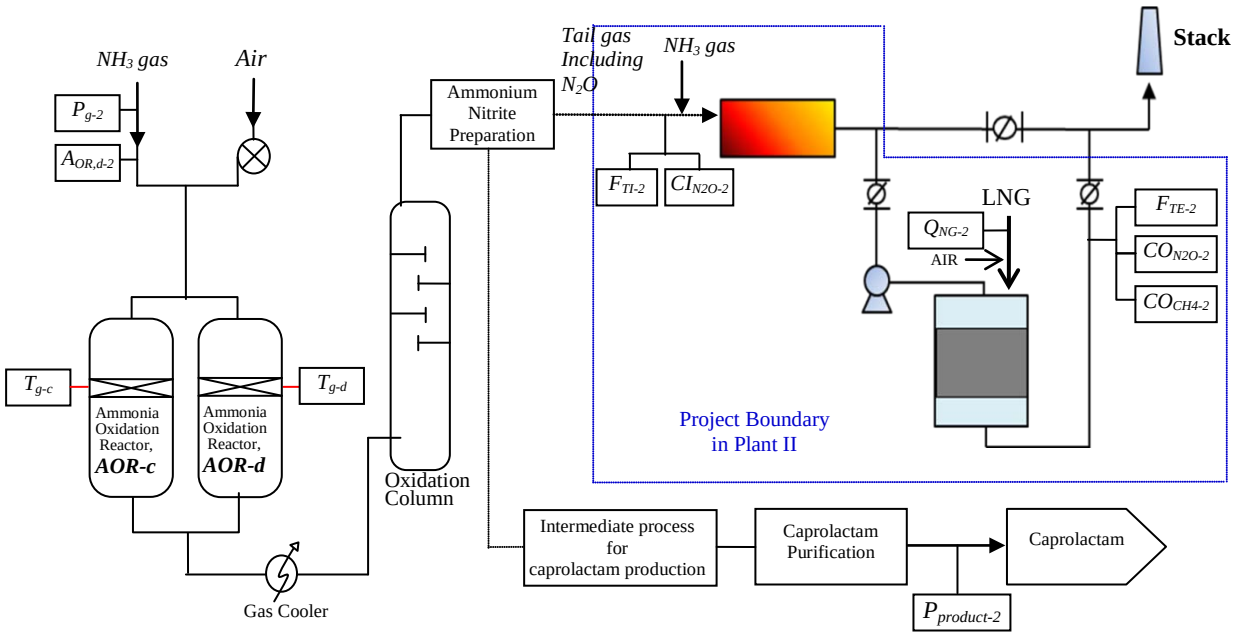

Figure 2 Monitoring points of Plant 2

The metering equipments are listed in the following Table 3

Table 3 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
CI_{N2O-1} and CI_{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. Bureau Veritas Certification randomly checked some DCS data and the EEU and/or DCU data and no discrepancy was found.

Bureau Veritas Certification checked the Test report of the D-EMS 2000 System dated 07/2011 /28/ 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) /21/.

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. Bureau Vertias Certification checked the QAL 1 records of the AMS monitoring equipments /23/ 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 /26/, 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 QAL2 test was performed twice, from 23/05/2011 to 27/05/2011 and from 26/09/2011 to 29/09/2011 by AIR-TEC /24/. Bureau Veritas Certification checked the QAL2 test reports /24/ 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 Bureau Vertias Certification checked the zero/span test records /25/ 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 for annual surveillance tests on the system to ensure that its performance remains as previously determined. Since there were only 84 days have passed since the crediting period was started of this monitoring period, annual surveillance test has not been carried out yet. Bureau Veritas Certification can accept this procedure, and does not doubt the validity of the conformity of the AMS with the EN14181:2004.

[Calibration] /26//27/

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 4.

Table 4 Calibration information of the monitoring equipments

Monitoring equipment type	Tag number	Serial number	Accuracy class	Parameter	Calibration frequency	Last calibration date	Validity
Differential pressure transmitter with normalizing functions	FIC-1201	10530360038	± 0.1%	$A_{OR,d-1}$	Every 2 years	11/01/2010	Yes
	2FIC-1201	10530360080	± 0.1%	$A_{OR,d-2}$	Every 2 years	11/03/2010	Yes
Gauge pressure (Pa gauge)	PI-1205	10530360183	± 0.1%	P_{g-1}	Every 2 years	11/01/2010	Yes
	2PI-1205	10530360212	± 0.1%	P_{g-2}	Every 2 years	11/03/2010	Yes
Thermocouples	TI-1204	2170447	Maximum error 300°C: +0.00°C 500°C: +0.35°C 700°C: +0.98°C	T_{g-a}	Every 2years	13/05/2011	Yes
	TI-1206	09002677	± 0.75°C	T_{g-b}	Every 2years	13/05/2011	Yes
	2TI-1204	24001	Maximum error 300°C: -0.7°C 500°C: -0.1°C 700°C: -0.7°C	T_{g-c}	Every 2years	23/05/2011	Yes
	2TI-1206	24002	Maximum error 300°C: -0.7°C 500°C: -0.1°C 700°C: -0.7°C	T_{g-d}	Every 2years	23/05/2011	Yes
Ultrasonic flow meters with	FI-1521	• HEAD A: 1217007 • HEAD B: 1217008	< 2%	F_{TI-1}	Every day by Auto calibration manner	31/08/2011	Yes

Monitoring equipment type	Tag number	Serial number	Accuracy class	Parameter	Calibration frequency	Last calibration date	Validity
normalizing functions		• Evaluation Unit :1216861 • Case of Evaluation : 1216999					
	2FI-1521	• HEAD A: 1217011 • HEAD B: 1217012 • Evaluation Unit :1216866 • Case of Evaluation : 1217002	< 2%	F_{TI-2}	Every day by Auto calibration manner	31/08/2011	Yes
Ultrasonic flow meters with normalizing functions	FI-1522	•HEAD A: 1217009 •HEAD B: 1217010 • Evaluation Unit : 1216862 • Case of Evaluation : 1217001	< 2%	F_{TE-1}	Every day by Auto calibration manner	31/08/2011	Yes
	2FI-1522	•HEAD A: 1217013 •HEAD B: 1217014 • Evaluation Unit	< 2%	F_{TE-2}	Every day by Auto calibration manner	31/08/2011	Yes

Monitoring equipment type	Tag number	Serial number	Accuracy class	Parameter	Calibration frequency	Last calibration date	Validity
		: 1216867 • Case of Evaluation : 1217003					
Non-dispersion infrared absorption analyzer (NDIR)	AI-1521	AO-748	>95% (repeatability)	CI_{N2O-1}	Every 2 weeks	25/08/2011	Yes
	2AI-1521	AO-749	>95% (repeatability)	CI_{N2O-2}	Every 2 weeks	25/08/2011	Yes
Non-dispersion infrared absorption analyzer (NDIR)	AI-1522(a) AI-1522(b)	AO-750	>95% (repeatability)	CO_{N2O-1} and CO_{CH4-1}	Every 2 weeks	25/08/2011	Yes
	2AI-1522(a) 2AI-1522(b)	AO-751	>95% (repeatability)	CO_{N2O-2} and CO_{CH4-2}	Every 2 weeks	25/08/2011	Yes
Flow meter with normalizing functions	FI-1523	02319622	±0.90%	Q_{NG-1}	Every 2 years	12/03/2010	Yes
	2FI-1523	02319623	±0.90%	Q_{NG-2}	Every 2 years	12/03/2010	Yes
Mass flow meters	FR-7705	6T 681125	± 0.10%	$P_{product-1}$	Every 2 years	07/10/2010	Yes
	2FI-7705	28 529138	± 0.15%	$P_{product-2}$	Every 2 years	07/10/2010	Yes

Bureau Veritas Certification has on-site checked the monitoring equipments which are not auto calibrated and verified the calibration records /26/ issued by the calibration organizations and the accreditation certificates /27/ of the calibration organizations. Each calibration was conducted within the accreditation period of the calibration organizations. Bureau Veritas Certification 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.

[Parameters and information flow]

Parameters monitored:

The parameters required by the monitoring plan and the way Bureau Veritas Certification has verified the information flow including the values in the monitoring reports are described below:

Parameters required to be monitored by AMS ($F_{TI,i}$, $CI_{N2O,i}$, $F_{TE,i}$ and $CO_{N2O,i}$; $F_{TI,i}$, $CI_{N2O,i}$, $F_{TE,i}$ and $CO_{N2O,i}$) /19/

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
$CI_{N2O,i}$	**(CI_{N2O-1} and CI_{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 is 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.

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

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)
$Q_{NG\ combustion\ gas}$	Combustion gas of natural gas (Nm^3/h)
VEF	Volumetric Expansion Factor

Bureau Veritas has checked the Emission Reductions Calculation Spreadsheet and can confirm that the calculation of the $Q_{NG\ combustion\ gas}$ 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. Bureau Veritas Certification checked the documented evidence /16/ and can confirm the determination of the VEF complies with the registered PDD.

Parameters recorded by DCS ($P_{product,y}$, $T_{g,d}$, $P_{g,d}$, $A_{OR,d}$) /18//20/

$P_{product,y}$ ($P_{product-1}$ and $P_{product-2}$)	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. Bureau Veritas Certification randomly selected and checked some 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.

Bureau Veritas Certification 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. Bureau Veritas Certification has verified and cross-checked the reported values by comparing randomly sampled values from the spreadsheets to the values stored in the EEU. No errors were found 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

Bureau Veritas Certification can confirm that the data of G_{sup} and G_{com} sourced from the Supplier information on catalyst delivery confirmation document /15/ is realistic.

Parameters related to natural gas ($Type_{HC}$, CF_{CH4}, $Q_{NG,y}$, ρ_{NG}, CO_{CH4})

$Type_{HC}$ (Type of hydrocarbon / Natural gas) and CF_{CH4} (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_{CH4} (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 ($Q_{CH4,d}$, $Q_{HC,y}$, ρ_{HC}, EF_{NG}, EF_{HC}, SE_{N2O})

$Q_{CH4,d}$ Methane part of the natural gas used

It is calculated with the following formula:

$$Q_{CH4,y} = Q_{NG,y} \times CF_{CH4}$$

$Q_{HC,y}$ The hydrocarbon with two or more molecules of carbon in natural gas

It is calculated with the following formula:

$$Q_{HC,y} = Q_{NG,y} \times (1 - CF_{CH4})$$

ρ_{HC} Density of the hydrocarbon with two or more molecules of carbon in natural

gas

It is calculated with the following formula:

$$\rho_{HC} = (\rho_{NG}-\rho_{CH4} \times CF_{CH4}) / (1-CF_{CH4})$$

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/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.

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:

$$EF_{HC} = (EF_{NG} \times \rho_{NG} - EF_{CH4} \times \rho_{CH4} \times CF_{CH4}) / (1-CF_{CH4}) / \rho_{HC}$$

Where

EF_{NG} : CO_2 emission factor of NG[tCO_2/tNG
ρ_{NG} : Density of natural gas (tNG/m^3)
EF_{CH4} : CO_2 emission factor of CH_4(tCO_2/tCH_4).
ρ_{CH4} : Density of methane (tCH_4/ m^3).
CF_{CH4} : 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 N_2O emissions at the inlet of the destruction facility (t N_2O)

$OXID_{CH4}$ Oxidation factor of CH4 in natural gas for re-heating tail gas

It is calculated with the following formula:

$$OXID_{CH4}=\{ Q_{CH4} -(\sum_{i}^{n} F_{TE,i} \times CO_{CH4,i} \times 10^{-6})\} / Q_{CH4} \times 100$$

Regarding the above formulae, both the subscripts d (day) and y means the period. Bureau Veritas Certification 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 N_2O 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/Nm^3 (as a NO_2 concentration). According to the National legislation in Republic of Korea, there is no regulatory limit of N_2O emissions per unit of outlet of caprolactam **($RSE_{N2O,y}$).**

Bureau Veritas Certification has verified the information flow provided in the monitoring report /4/ 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 /29/, training records /30/ and all the data records /14/ and can confirm that the information flow of all the monitoring parameters complies with the monitoring plan and the methodology AM0028 Version 05.

Parameters determined at registration:

There are values of the parameters contained in the section D.1, including the following parameters:

GWP_{N2O} and GWP_{CH4}	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_{CH4} and ρ_{CH4}	methane emission factor and density
M_i	length of measuring interval
Reg_{NOx}	national regulation on NO_X emissions

Bureau Veritas Certification compared the values included in the section D.1 of the monitoring report to those values included in the section 6.2 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.

✌ Corresponding to the paragraph 206 of VVM version 01.2, Bureau Veritas Certification can confirm that:

- The monitoring has been carried out in accordance with the monitoring plan contained in the registered PDD.
- All parameters stated in the monitoring plan of the registered PDD have been sufficiently monitored and correctly listed. The monitored data for required parameters have been verified and found complete and consistent by checking the whole procedure for information aggregation.

3.5 Assessment of data and calculation of greenhouse gas emission reductions (209)

A complete set of data for the specified monitoring period to calculate the emission reductions is available. The data pertaining to the above parameters are maintained in the identified records. All the data are in compliance with that stated in the Monitoring Report version 3.0 /4/. Values regarding errors readings (e.g. downtime, malfunction or special events), and extreme values were eliminated to recalculate the emission reductions.

Appropriate methods and formulae for calculating baseline emissions, project emissions and leakage have been followed. The assumptions, emission factors and default values that were applied in the calculations have been justified and found to be valid.

[Baseline emissions]

Based on the production of caprolactam during this first monitoring period, the daily average of the production ($P_{product,y}$) did not exceed the design capacity ($P_{product,max}$) for both nitric acid plants. Therefore on the assumption $P_{product,y} < P_{product,max}$, baseline emissions (*BE*) for this period are given by following equation according to the methodology AM0028 Version 05 and the registered PDD:

$$BE_{period} = \left(\sum_{i}^{n} F_{TI,i} \times CI_{N2O,i} \times M_i \right) \times GWP_{N2O}$$

Where

M_i	Length of Measuring Interval (hr), (1hr)
GWP_{N2O}	Global warming potential of the N_2O, (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)
$CI_{N2O,i}$	N_2O concentration in the tail gas of the DF inlet during interval (tN_2O/ Nm^3)

The PP monitored the operating conditions parameters including the operating temperature and pressure, and the baseline emissions during the day when the daily average of the operating conditions were out of the permitted range, i.e., on 04/07/0211 when *the actual operating temperatures of the AORs of Plant II were out of permitted rage*, are recalculated with the default IPCC value, i.e.,

$$BE_{daily,\ out\ of\ permit\ range} = P_{product,\ day} \times EF_{N2O} \times GWP_{N2O} / 1000$$

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 (tonCO_2/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_{N2O}	N_2O Emission factor to the process of caprolactam production (kgN2O/ton caprolactam)

Emission factor of N_2O (EF_{N2O}) is the lowest value among (a) $EF_{N2O,IPCC}$, (b) $SE_{N2O,y}$ and (c) any related value as a result of legal regulation(e.g. $RSE_{N2O,y}$). See the section E.1 of the monitoring report. Bureau Veritas Certification can conclude that it is reasonable to use the $EF_{N2O,IPCC}$ as the EF_{N2O} since it is the lowest value among the three options, and this recalculation procedure complies with the methodology AM0028 Version 05 and the monitoring plan.

Bureau Veritas Certification 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 /31/ and the monitoring report version 3.0 /4/ are consistent with the documented evidences. Bureau Veritas Certification 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} = 162,628.267tCO_2e.

[Project emissions]

The emission due to the project activity are composed of (a) the emissions of not destroyed N_2O, (b) on-site emissions due to the hydrocarbons (Natural Gas) use as input to the N_2O 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 N_2O reduction efficiency. In this project, natural gas is used for re-heating the tail gas to enhance the catalytic N2O reduction efficiency

$PE_{period} = PE_{ND,period} + PE_{HC,period} = PE_{ND,period} + HCE_{NC,period} + HCE_{C,period} =$

$$(\sum_{i}^{n} F_{TE,i} \times CO_{N2O,i} \times M_i) \times GWP_{N2O}$$

$$+ [(\rho_{HC} \times Q_{HC,y} \times EF_{HC} \times OXID_{HC}/100) + (\rho_{CH4} \times Q_{CH4,y} \times EF_{CH4} \times OXID_{CH4}/100)]$$

$$+ [\rho_{CH4} \times Q_{CH4,y} \times GWP_{CH4} \times (1-OXID_{CH4}/100)]$$

PE_{period}	: Project emissions (tCO_2e)
PE_{ND}	: Project emissions from N_2O not destroyed (tCO_2e)
$HCE_{C,y}$	: Converted hydrocarbons emissions (tCO_2e)
HCE_{NC}	: Methane emissions (tCO_2e)
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 (Nm^3/hr)
$CO_{N2O,i}$	: N_2O concentration in the tail gas of the DF exit during interval i (tN_2O/m^3)
GWP_{CH4}	: Global warming potential of CH_4, 21 (: default value)
GWP_{N2O}	: Global warming potential of the nitrous oxide, 310 (: default value)
ρ_{CH4}	: Density of methane (tCH_4/m^3) , 0.000716
ρ_{HC}	: Density of HC (tHC/m^3)
EF_{CH4}	: CO_2 emission factor of CH_4 (tCO_2e/tCH_4), 2.75
EF_{HC}	: CO_2 emission factor of HC with two or more carbon molecule in natural gas

(tCO_2e/tHC)

$Q_{CH4,y}$: 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)

$OXID_{CH4}$: Oxidation factor of methane (%)

$OXID_{HC}$: Oxidation factor of HC(%), 100% (Fixed value)

Previously the converted hydrocarbon emissions ($HCE_{c,d}$) were calculated not in compliance with the registered PDD, i.e. the $HCE_{c,d}$ was calculated without multiplying the theoretical emission factor of methane (EF_{CH4}), in the emission reductions calculation spreadsheet submitted with the monitoring report version 2.3 to request issuance, and this verification of the Project was requested for review. Then PP revised the emission reductions calculation spreadsheet to calculate $HCE_{c,d}$ according to the registered PDD. This latest revised emission reductions calculation spreadsheet is submitted with the monitoring report version 3.0.

Bureau Veritas Certification 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 /31/ and the monitoring report version 3.0 /4/ are consistent with the documented evidences. Bureau Veritas Certification 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} = 17,877.253tCO_2e.

[Leakage emissions]

As per the registered PDD, heat exchange is conducted in De-N_2O system, and the installation of the N_2O 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.

[Emission reductions]

Therefore, the emission reductions during the monitoring period from 09/06/2011 to 31/08/2011 are calculated as:

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

= 162,628.267 - 17,877.253 - 0

= 144,751 tCO_2e

The emission reductions are recalculated for the periods when special events happened. Bureau Veritas Certification has checked the information and data records /14/ during these periods and can confirm that the information provided in the monitoring report and the emission reductions is consistent with the data records /14/. Bureau can conclude the recalculation

method is conservative. The data of the volume flow rate and N_2O concentration at the inlet and outlet of the destruction facility have been excluded from the emission reduction calculation, which is conservative since the N_2O quantity at the outlet cannot be more than the N_2O quantity at the inlet of the destruction facility because of its N_2O destruction function. Natural gas input for re-heating the tail gas (Q_{NG-1}) and CH_4 concentration at destruction facility outlet (CO_{CH4-1}) are included to calculate the project emissions.

[Comparison of ERs]

The monitoring report calculates the daily average emission reductions during this monitoring period. Compared to the expected daily average emission reductions, the actual daily average emission reductions are lower. Hence the emission reductions claimed during this monitoring period are lower than the corresponding estimated emission reductions in the registered PDD /1/.

✌ Corresponding to the paragraph 209 of VVM version 01.2, Bureau Veritas Certification can confirm that:

- The data used for the determination of the emission reductions are available and monitored in accordance with the registered monitoring plan.
- The data used in anthropogenic emission reductions' calculation of this monitoring period have been verified and found consistent with those prescribed in the registered PDD.
- The appropriate methods and formulae for calculating baseline emissions, project emissions and leakages has been properly followed the methodology and registered PDD;
- The assumptions, emission factors and default values that were applied in the monitoring report and the calculations have been justified.

4 VERIFICATION OPINION

Bureau Veritas Certification has performed the 1st periodic verification of N2O Abatement Project of Capro Corporation, CDM Registration Reference Number 4665, owned by Capro Corporation; Hyosung Ebara Engineering Co., Ltd.; and Hyosung Corporation Which is located in Bugok-dong, Nam-gu, Ulsan, the south-eastern part of the Republic of Korea, and applying the methodology AM0028 Version 05. The verification was performed based on the requirements set by the CDM and relevant guidance provided by CMP and the CDM Executive Board.

The verification consisted of the following three phases: i) desk review of the project design and the baseline and monitoring plan; ii) follow-up on-site interviews with project stakeholders; iii) resolution of outstanding issues and the issuance of the final verification report and opinion.

The management of Capro Corporation; Hyosung Ebara Engineering Co., Ltd.; and Hyosung Corporation is responsible for the preparation of the GHG emissions data and the reported GHG emissions reductions of the project on the basis set out within the project Monitoring Plan in the registered PDD. The development and maintenance of records and reporting procedures in accordance with that plan, including the calculation and determination of GHG emission reductions from the Project, are the responsibility of the management of the Project.

Bureau Veritas Certification has verified the project Monitoring Report version 3.0 /4/ dated 25/09/2012 for the reporting period as indicated below. Bureau Veritas Certification confirms that the Project is implemented and described in validated and registered project design document. Installed equipments being essential for generating emission reductions run reliably and are calibrated appropriately. The monitoring system is in place and the Project is generating GHG emission reductions.

Bureau Veritas Certification can confirm that the GHG emission reductions are calculated without material misstatements. Our opinion relates to the Project's GHG emission and resulting GHG emission reductions reported and related to the validated and registered project baseline, monitoring plan and its associated documents. Based on the evidence and information that are considered necessary to guarantee that GHG emission reductions are appropriately calculated, Bureau Veritas Certification confirms the following statement:

Reporting period	:	09/06/2011 to 31/08/2011
Baseline emissions	:	162,628.267 t CO_2 equivalents
Project emissions	:	17,877.253 t CO_2 equivalents
Leakage emissions	:	0 t CO_2 equivalents
Emission Reductions (ER)	:	144,751 tCO_2 equivalents

Ms. (Coco) Geng Yan
Internal Technical Reviewer
27/09/2012

Mr. (Ernesto) Tan Wenbin
Team Leader
27/09/2012

5 REFERENCES

Documents reviewed:

/1/ Registered PDD version 8.1 dated 24/05/2011, CDM ref no.4665
/2/ Validation Report revision 4.1, dated 01/06/2011
/3/ Monitoring Report Version 1.1 of this monitoring period
/4/ Monitoring Report Version 3.0 dated 25/09/2012 of this monitoring period
/5/ AM0028 Version 05 - *Catalytic N2O destruction in the tail gas of Nitric Acid Plants or Caprolactam Production*
/6/ Validation and Verification Manual Version 01.2 dated 30/07/2010
/7/ Guidelines on completeness check of requests for issuance(EB48 Annex68)
/8/ Record of construction start dated on 16/11/2010
/9/ Record of trial run after loading N_2O decomposition catalyst dated 23/03/2011
/10/ Record of Installing of Measuring instruments including AMS dated 15/04/2011
/11/ Record of commissioning start of Plant 1 dated 20/04/2011
/12/ Record of commissioning start of Plant 2 dated 27/04/2011
/13/ Record of completing construction of N_2O abatement system dated 02/05/2011
/14/ Data records stored in the EEU and HDD
/15/ Supplier information on catalyst delivery confirmation document
/16/ Statement on the Volumetric Expansion Factor (VEF) by CRI Catalyst Company dated 05/2011
/17/ Process shutdown log
/18/ Production Log
/19/ AMS records
/20/ PKS records
/21/ European Norm EN 14181:2004 Stationary source emissions - Quality assurance of automated measuring systems
/22/ Air quality - Evaluation of the suitability of a measurement procedure by comparison with a required measurement uncertainty (ISO 14956:2002)
/23/ QAL 1 records of the AMS monitoring equipments
/24/ Reports of QAL2 tests conducted from 23/05/2011 to 27/05/2011 and from 26/09/2011 to 29/09/2011 for the AMS installed for the Plant 1 and Plant 2, issued by AIRTEC
/25/ QLA3 zero/span test records
/26/ Calibration records of the monitoring equipments
/27/ Accreditation certificates of the calibration organizations
/28/ Test report of the D-EMS 2000 System dated 07/2011
/29/ CDM Monitoring & Management Manual
/30/ CDM and monitoring internal training records
/31/ Emission Reductions Calculation Spreadsheet

Persons interviewed:

List persons interviewed during the verification or persons that contributed with other information that are not included in the documents listed above.

Capro Corporation
Mr. Heo, Gyu-Ho
Mr. Han, Sueng-Bae
Mr. Choi, Jong-Hee
Mr. Choi, Cheong-Jeong
Mr. Bae, Ik-Jin
Mr. Lee, Dae-Geun

Hyosung Ebara Engineering Co., Ltd.
Mr. Lee, Ho-Soo
Ms. Lee, Hyun-Jung

Hyosung Corporation
Mr. Choi, Yung-Yul

6 CURRICULA VITAE OF THE DOE'S VERIFICATION TEAM MEMBERS

Mr. (Ernesto) Tan Wenbin	Bureau Veritas Certification, China	Team Leader, Climate Change Lead Verifier. He holds a bachelor degree in Geology and a master degree in Structural Geology. Before joining BV, he gained more than 2 years' technical experience in Petroleum Exploitation and Storage & Transportation sector, and more than 3 year's technical experiences in coal mining sector in P.R China. He obtained the certificate of CDM Lead Verifier and Lead Auditor for ISO 14001.
Mr. (Jony) Li Qing	Technical Specialist Bureau Veritas Certification, China	He holds a Bachelor Degree in chemical engineering and technology. Before joining BV in 2011, he had about one year experience of chemical plant director, two years experience of chemical plant flue gas analysis, and more than three years experience of chemical plant corrosion monitoring. He obtained the certificate of CDM Verifier, Lead Auditor for ISO 14001.
Ms. (Coco) Geng Yan	Bureau Veritas Certification, China	Internal Reviewer, Climate Change Lead Verifier. She holds a Master Degree in Ecology and a bachelor degree in Forestry. She has 2 years of experience in CDM in P.R China. She obtained the certificate of CDM Verifier in 2010, Lead Auditor for ISO 14001 and has successfully completed the course assessment for ISO 14064.

Ms. An Baifang	Technical Specialist Bureau Bosun Safety Technology Co.,Ltd.	She holds a bachelor degree in Chemical Mechanic. She gained 8 years directly experience in operation and inspection Chemical Processing. She is a Certified Supervision Engineer and she possesses professional qualification of UT-2, MT-2, PT-2, Pressure vessel Inspector, ISO 9000 Internal Auditor and OHSAS 18001 Internal Auditor. She was involved in 20 plus chemical engineering including Hydrocracking Installation, Gasoline Refining Installation, Ethylene Installation, Synthetic Ammonia Installation, ARGG Installation, Sulfur Recovery Installation and Polypropylene Installation in China since 2006.

APPENDIX A: CDM PROJECT VERIFICATION PROTOCOL

Table 1 Verification requirements based on the Clean Development Mechanism Validation and Verification Manual (Version 01.2)

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
1. Compliance of the monitoring report with the guidelines for completing the monitoring report form					
A.1. Brief description of the project activity					
1.1. Is the description of the project activity to be presented in this section a brief summary of the detailed description given in the section B.1 Implementation status of the project activity?	EB 54	Ann 34	Yes. Section A.1 provide the description of the project activity to be presented in this section a brief summary of the detailed description given in the section B.1 Implementation status of the project activity.	OK	OK
1.2. Does this description include:	EB 54	Ann 34			
1.2.1. Purpose of the project activity and the measures taken to reduce greenhouse gas emissions?	EB 54	Ann 34	Yes. Section A.1: Purpose of the project activity and the measures taken to reduce greenhouse gas emissions: The proposed project is to reduce N_2O emissions of the tail gas emitted from Caprolactam production process in	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
			Capro Corporation by installing catalytic N_2O destruction system.		
1.2.2. Brief description of the installed technology and equipments?	EB 54	Ann 34	Yes. Section A.1: N_2O treatment system for this project is CRI N_2O abatement system, which is N_2O 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 N_2O decomposition process that does not require the addition of any reductant and its pressure drop is small.	OK	OK
1.2.3. Relevant dates for the project activity (e.g. construction, commissioning, continued operation periods, etc.)?	EB 54	Ann 34	Section A.1 of the MR includes the relevant dates. ~~CAR-1 Please revise the relevant dates in the monitoring report (section A.1 and B.1) according to the documented evidence.~~ Relevant dates in the section A.1 and B.1 of the monitoring report were revised according to the documented evidence. Bureau Veritas Certification has checked the documented evidence and can confirm that the revised dates are consistent with the evidence. This CAR is closed.	~~CAR-1~~	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
1.2.4. Total emission reductions achieved in this monitoring period?	EB 54	Ann 34	Yes. Section A.1: 144,751 tCO_2e	OK	OK
A.2. Project participants					
1.3. Are the project participants listed?	EB 54	Ann 34	Yes. The project participants listed in the section A.2 are consistent with the project participants of the Project list on the UNFCCC website.	OK	OK
A.3. Location of project activity					
1.4. Is complete information of the location of the project activity: town, city, country and GPS coordinates provided?	EB 54	Ann 34	Yes. Section A.3: The Project is located in Bugok-dong, Nam-gu, Ulsan, the south-eastern part of the Republic of Korea. The coordinates of the Project are 35.4958N latitude, 129.3280E longitude.	OK	OK
A.4. Technical description of the project					
1.5. Are a description of the technology applied in the project activity and detailed technical process, including diagrams provided?	EB 54	Ann 34	Yes. They are included in the Section A.4 of the MR: Caprolactam is produced by cyclohexane, ammonia, and sulphur as its primary raw materials. Within the Caprolactam production process, ammonia is oxidized in AOR to generate NO and NO_2, which are going to be the	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
			reactants for Ammonium nitrite. Nitrous oxide (N2O) is generated as an undesired by-product through the side reaction of Ammonia oxidation as follows: $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$ (Main reaction) $2NO + O_2 \rightarrow 2NO_2$ (Desired in the NO oxidation process) $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$ (Side reaction) $4NH_3 + 4O_2 \rightarrow 2N_2O + 6H_2O$ (Side reaction) De-N_2O system for this project is to destruct the N_2O included in tail gas by catalyst without any reducing agent. $2N_2O \rightarrow 2N_2 + O_2$ 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”. 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.		
A.5. Title, reference and version of the baseline and monitoring methodology applied to the project activity					

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
1.6. Are the complete reference of the methodology applied and tools whenever is applicable included?	EB 54	Ann 34	Yes. Section A.5: AM0028 Version 05 *Catalytic N2O destruction in the tail gas of Nitric Acid Plants or Caprolactam Production*	OK	OK
A.6. Registration date of the project activity					
1.7. Is the registration date of the project activity provided?	EB 54	Ann 34	Yes. Section A.6: 09/06/2011.	OK	OK
A.7. Crediting period of the project activity and related information (start date and choice of crediting period)					
1.8. Is the crediting period of the project activity and related information (start date and choice of crediting period) provided?	EB 54	Ann 34	Yes. Section A.7: 09/06/2011 - 08/06/2021 (fixed)	OK	OK
1.9. Does the description also include changes to the start date of the crediting period post-registration that have been accepted by the Board, when applicable?	EB 54	Ann 34	There was no post-registration change to the start date of the crediting period.	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
A.8. Name of responsible person(s)/entity(ies)					
1.10. Is the contact information of the person(s)/entity(ies) responsible for completing the monitoring report form (CDM-MR) provided?	EB 54	Ann 34	Yes. It is included in the section A.8 of the MR.	OK	OK
B.1. Implementation status of the project activity					
1.11. Does this section include a description of the implementation and operational status of the project as of this monitoring period in accordance with the latest version of the CDM Validation and Verification Manual (CDM-VVM)?	EB 54	Ann 34	Yes.	OK	OK
1.12. Does the description include inter alia:	EB 54	Ann 34		OK	OK
1.12.1. The starting date of operation of the project activity? For project activities that consist of more than one site, the report shall clearly describe the status of	EB 54	Ann 34	~~Starting date: pending on CAR-1.~~ The Project consists of one site only and the implementation is not phased.	~~Pending~~	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
implementation and starting date of operation for each site. For CDM project activities with phased implementation, the report shall indicate the progress of the proposed CDM project activity achieved in each phase.					
1.12.2. The information regarding the actual operation of the project activity during this monitoring period, including information on special events, for example overhaul times, downtimes of equipment, exchange of equipment, etc?	EB 54	Ann 34	Section B.1 of the monitoring report provides the information regarding the actual operation of the project activity, including the operation information of the AORs, Ammonia Oxidation Catalyst, and Plant output of Caprolactam. ~~CAR-2 Please correct the calculated results of the actual average data of the operation of AORs and the Plant output of Caprolactam, the number of days outside permit range, and the information of the special events according to the monitored information.~~ Bureau Veritas Certification can confirm that the actual average data of the operation of AORs and the Plant output of Caprolactam, the number of days outside permit range, and the information of the special events are revised correctly. This CAR is closed.	~~CAR-2~~	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
1.12.3. A brief description of: (i) events or situations that occurred during the monitoring period, which may impact the applicability of the methodology, and (ii) how the issues resulting from these events or situations are being addressed?	EB 54	Ann 34	~~CL-1 Whether there were special events or situations that occurred during the monitoring period which may impact the applicability is required to be described in the Section B.1 of the monitoring report.~~ Bureau Veritas Certification can confirm that there were no special events or situations that occurred during the monitoring period which may impact the applicability and it is described in the section B.1 of the revised monitoring report. This CL is closed.	~~CL-1~~	OK
B.2. Revision of the monitoring plan					
1.13. Is it indicated if the monitoring plan has been revised?	EB 54	Ann 34	Yes. Section B.2: The monitoring plan was not revised and no revision is pending.	OK	OK
1.14. Is the date of approval, if revised, included?	EB 54	Ann 34	N/A.	OK	OK
B.3. Request for deviation applied to this monitoring period					
1.15. Is any deviation applied to this	EB 54	Ann 34	Yes. Section B.3:	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
monitoring period indicated?			No request for deviation was applied during this monitoring period.		
1.16. Is the reference number, if any deviation applied, included?	EB 54	Ann 34	N/A.	OK	OK
B.4. Notification or request of approval of changes					
1.17. Is any notification or request of approval of changes from the project activity as described in the registered CDM-PDD indicated?	EB 54	Ann 34	Yes. Section B.4: No notification or request of approval of changes has been made.	OK	OK
1.18. Is the date of approval, if applicable, included?	EB 54	Ann 34	N/A.	OK	OK
C. Description of the monitoring system					
1.19. Is a description of the monitoring system provided?	EB 54	Ann 34	Section C of the MR contains the information of monitoring points, Data Collection Procedure, Organization Structure, roles and responsibilities of personnel, roles and responsibilities of personal, Emergency procedures, reporting, Quality assurance of AMS, Conservative calculation on tail gas flow, and	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
			Training. Bureau Veritas Certification has checked the information provided in the section C of the monitoring report through document review and onsite inspection and interviews, and can confirm that the information of the monitoring system complies with the monitoring plan and the actual situations.		
1.20. Does this section include data collection procedures (information flow including data generation, aggregation, recording, calculation and reporting), organizational structure, roles and responsibilities of personnel, and emergency procedures for the monitoring system?	EB 54	Ann 34	The Section C of the MR contains all the required data collection procedures. ~~CAR-3 Please revise the value of Volumetric Expansion Factor (VEF) according to the documented evidence.~~ Bureau Veritas Certification has checked the documented evidence Statement on the Volumetric Expansion Factor (VEF) by CRI Catalyst Company dated 05/2011 /16/, and can confirm that the revised value is consistent with this evidence. This CAR is closed.	~~CAR-3~~	OK
1.21. Does this include line diagrams showing all relevant monitoring points?	EB 54	Ann 34	Yes.	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
D. Data and parameters					
1.22. Does this section include parameters used to calculate baseline, project, and leakage emissions as well as other relevant parameters required by the approved methodology and the monitoring plan; and specific information on how data and parameters have been monitored during the monitoring period?	EB 54	Ann 34	Yes. Section D of the MR includes all the parameters used to calculate baseline, project, and leakage emissions and specific information on how data and parameters have been monitored during the monitoring period.	OK	OK
1.23. Are data that is determined only once for the crediting period but are used after registration of the project activity included in the section D.1.?	EB 54	Ann 34	Yes. The data that is determined only once for the crediting period but are used after registration of the project activity is included under section D.1, and the information is checked and found consistent with the registered PDD.	OK	OK
1.24. For each parameter the following information, using the tables provided, is provided:					
1.24.1. Value of monitored parameter in the period for the purpose of calculating emission reductions? To report multiple values, a table may be used and included	EB 54	Ann 34	Yes. The values of monitored parameters in the period for the purpose of calculating emission reductions are included in the section D of the MR according to the requirements.	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
in this monitoring report or include references to spreadsheet. For default value (such as an IPCC value), where it is ex-post confirmed, the most recent value shall be applied.					
1.24.2. Description of the equipment used to monitor each parameter, including details on accuracy class, and calibration information (frequency, date of calibration and validity), if applicable as per monitoring plan?	EB 54	Ann 34	Yes. ~~CAR-4 The description of the equipments used to monitor each parameter, i.e. details on accuracy class, and calibration information (frequency, date of calibration and validity) is required to be included in the section D.2 of the monitoring report.~~ Bureau Veritas Certification has checked the documented evidence /26/ and can confirm that the included information of the details on accuracy class, and calibration information (frequency, date of calibration and validity) in the section D.2 of the monitoring report are consistent with the documented evidence. This CAR is closed.	~~CAR-4~~	OK
1.24.3. Measuring and recording method: how the parameters are measured/calculated, specifying the	EB 54	Ann 34	Yes. The measuring and recording method is included in the tables of the section D.2.	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
measurement and recording frequency?					
1.24.4. Source of data: logbooks, daily records, surveys, etc?	EB 54	Ann 34	Yes. The source of data is included in the tables of the section D.2.	OK	OK
1.24.5. Where relevant, the calculation method of the parameter?	EB 54	Ann 34	Yes. The calculation method of the parameter where relevant is included in the tables of the section D.2.	OK	OK
1.24.6. The QA/QC procedures applied (if applicable per monitoring plan)?	EB 54	Ann 34	Yes. The QA/QC procedures applied (if applicable per monitoring plan) is included in the tables of the section D.2.	OK	OK
1.24.7. Include information about appropriate emission factors, IPCC default values and any other reference values that have been used in the calculation of emission reductions?	EB 54	Ann 34	Yes. Information about appropriate emission factors, IPCC default values and any other reference values that have been used in the calculation of emission reductions is included in the section D.	OK	OK
E.1. Baseline emissions calculation					
1.25. Does this section include all formulae used and description to calculate the baseline emissions applying actual values?	EB 54	Ann 34	Yes. All formulae used and description to calculate the baseline emissions applying actual values are included in the section E.1 of the MR. $BE_{period} = \left(\sum_{i}^{n} F_{TI,i} \times CI_{N2O,i} \times M_i \right) \times GWP_{N2O}$ ~~Pending on CAR-6.~~	~~Pending CAR-5~~	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
			~~CAR-5 Please correct the values of parameters which are found inconsistent with the evidence provided in the section E of the monitoring report.~~ Bureau Veritas Certification can confirm that the revised monitoring report indicate the corrected values of the parameters in the section E, which are consistent with the revised emission reductions calculation spreadsheet. This CAR is closed.		
1.26. Was a table used and included in this monitoring report or include references to spreadsheet?	EB 54	Ann 34	Yes.	OK	OK
E.2. Project emissions calculation					
1.27. Does this section include all formulae used and description to calculate the project emissions applying actual values?	EB 54	Ann 34	Yes. All formulae used and description to calculate the project emissions applying actual values are included in the section E.2 of the MR.	~~Pending~~	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
			$PE = \left(\sum_{i}^{n} F_{TE,i} \times CO_{N2O,i} \times M_i \right) \times GWP_{N2O} + \left[\begin{array}{l} \left(\rho_{HC} \times Q_{HC,y} \times EF_{HC} \times OXID_{HC} / 100 \right) \\ + \left(\rho_{CH4} \times Q_{CH4,y} \times EF_{CH4} \times OXID_{CH4} / 100 \right) \end{array} \right] + \left[\rho_{CH4} \times Q_{CH4,y} \times GWP_{CH4} \times \left(1 - OXID_{CH4} / 100 \right) \right]$ ~~Pending on CAR-5.~~		
1.28. Was a table used and included in this monitoring report or include references to spreadsheet?	EB 54	Ann 34	Yes.	OK	OK
E.3. Leakage calculation					
1.29. Does this section include all formulae used and description to calculate the leakage applying actual values?	EB 54	Ann 34	Yes. The emission by leakage is accounted as zero.	OK	OK
1.30. Was a table used and included in this monitoring report or include references to spreadsheet?	EB 54	Ann 34	N/A.	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
E.4. Emission reductions calculation/table					
1.31. Does this section include the formulae used to calculate the emission reductions and the total of the emission reductions achieved during the monitoring period?	EB 54	Ann 34	Yes. In the section E.4 of the MR. Emissions reductions $ER_{period} = BE_{period} – PE_{period} – LE_{period}$	OK	OK
1.31.1. Total baseline emissions:	EB 54	Ann 34	Yes.	OK	OK
1.31.2. Total project emissions:	EB 54	Ann 34	Yes.	OK	OK
1.31.3. Total leakage:	EB 54	Ann 34	Yes.	OK	OK
1.31.4. Total emission reductions:	EB 54	Ann 34	Yes.	OK	OK
E.5. Comparison of actual emission reductions with estimates in the CDM-PDD					
1.32. Does this section include a comparison of actual values of the emission reductions achieved during the monitoring period with the estimations in	EB 54	Ann 34	Yes. In the section E.5 of the MR. The daily average of the actual emission reductions claimed in the monitoring period is lower than the estimate in registered PDD.	~~Pending~~	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
the registered CDM-PDD?			~~Pending on CAR-5.~~		
E.6. Remarks on difference from estimated value in the PD					
1.33. Is an explanation of the cause of any increase in the actual emission reductions achieved during the current monitoring period (e.g. higher water availability, higher load plant factor, etc), including all information (i.e. data and/or parameters) that is different from that stated in the registered CDM-PDD provided?	EB 54	Ann 34	N/A.	OK	OK
2. *Project implementation in accordance with the registered project design document*					
2.1. Are all physical features of the proposed CDM project activity proposed in the registered PDD in place?	VVM	196	Yes. Bureau Veritas Certification has checked on-site and through documents review and confirm that all the physical features of the proposed CDM project activity proposed in the registered PDD are in place. De-N_2O system for this project is to destruct the N_2O included in tail gas by catalyst without any reducing agent.	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
			$2N_2O \rightarrow 2N_2 + O_2$ 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”. 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. The monitoring system and monitoring equipments complies with the requirements in the registered PDD.		
2.2. Have the project participants operated the proposed CDM project activity as per the registered PDD?	VVM	196	Yes. The project participant Capro Corporation; Hyosung Ebara Engineering Co., Ltd.; and Hyosung Corporation Has operated the Project as per the registered PDD. The tertiary N_2O abatement catalyst technology is applied and N_2O emissions were reduced.	OK	OK
2.3. Was an on-site visit conducted?	VVM	196	Yes. The on-site visit of this verification has been conducted on	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
			02/02/2012 by Mr. (Ernesto) Tan Wenbin and Mr. (Jony) Li Qing, climate change specialist of Bureau Veritas Certification (China). The audit purpose and methodology were briefed in the opening meeting participated by the following persons. Capro Corporation Mr. Heo, Gyu-Ho Mr. Han, Sueng-Bae Mr. Choi, Jong-Hee Mr. Choi, Cheong-Jeong Mr. Bae, Ik-Jin Mr. Lee, Dae-Geun Hyosung Ebara Engineering Co., Ltd. Mr. Lee, Ho-Soo Ms. Lee, Hyun-Jung Hyosung Corporation Mr. Choi, Yung-Yul		
2.4. If not, justify the rationale of the decision.	VVM	196	N.A.	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
2.5. Does the implementation or operation of CDM project activity conform with the description contained in the registered PDD?	VVM	197	Yes.	OK	OK
2.6. If not, which are the potential impacts due to these changes, according to the relevant guidelines established by the Executive Board (EB48-§73)?	VVM	197	N.A.	OK	OK
2.7. Was any change identified close to the boundary of the project activity but outside it?	VVM	197	No.	OK	OK
2.8. If yes, which are the potential impacts due to these changes?	VVM	197	N.A	OK	OK
2.9. Was a notification or a request for approval of changes from the project activity as described in the registered PDD submitted prior to the conclusion of the verification/certification for the corresponding?	VVM	197	No.	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
3. *Compliance of the monitoring plan with the monitoring methodology*					
3.1. Is the validated monitoring plan in accordance with the approved methodology applied by the proposed CDM project activity?	VVM	200	Yes. The registered Monitoring Plan (MP) in accordance with the methodology AM0028 Version 05 has been applied by the CDM project activity. The monitoring organization has been set up and in functions. All monitoring staffs have been trained and the training records have been provided and verified. The monitoring procedures are in place and function. All parameters indicated in the MP have been measured and recorded in the respective documents. The QA/QC procedures are in place and function.	OK	OK
3.2. If no, was a request for revision of the monitoring plan was done? (The DOE may request for revision of the monitoring plan covering the monitoring period under verification, for approval by CDM Executive Board)	VVM	201	N.A.	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
3.3. Are there any monitoring aspects of the project activity that are not specified in the methodology, particularly in the case of small-scale methodologies(e.g. additional monitoring parameters, monitoring frequence and calibration frequence)?	VVM	202	No.	OK	OK
4. *Compliance of monitoring with the monitoring plan*					
4.1. Have all issues identified in the validation report to be verified during verification been resolved by the project participant and are there any open issues identified in the previous verification?	VVM	190	There is no open issue identified in the validation report. This is the first periodic verification.	OK	OK
4.2. Have the monitoring plan and the applied methodology been properly implemented and followed by the project participants?	VVM	205	Yes. The MP and the metholodgy AM0028 Version 05 have been properly implemented and followed by the PP.	OK	OK
4.3. Have all parameters stated in the	VVM	205			

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
monitoring plan, the applied methodology and relevant CDM Executive Board decisions been sufficiently monitored and updated as applicable, including:					
4.3.1. Project emission parameters?	VVM	205	Yes. All the parameters, for project emission calculation are included and sufficiently monitored and updated.	OK	OK
4.3.2. Baseline emission parameters?	VVM	205	Yes. All the parameters for baseline emission calculation are included and sufficiently monitored and updated.	OK	OK
4.3.3. Leakage parameters?	VVM	205	According to the registered PDD and the methodology AM0028 Version 05, no leakage calculation is required.	OK	OK
4.3.4. Management and operational system: the responsibilities and authorities for monitoring and reporting are in accordance with the responsibilities and authorities stated in the monitoring plan?	VVM	205	Yes. The responsibilities and authorities for monitoring and reporting are in accordance with the responsibilities and authorities stated in the monitoring plan.	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
4.4. Is the accuracy of equipment used for monitoring in accordance with the relevant guidance provided by the CDM Executive Board and is controlled and calibrated in accordance with the monitoring plan?	VVM	205	Yes. The accuracy of equipment used for monitoring is in accordance with the relevant guidance provided by the CDM Executive Board and is controlled and calibrated in accordance with the monitoring plan.	OK	OK
4.4.1. Are monitoring results consistently recorded as per approved frequency?	VVM	205	Yes.	OK	OK
4.4.2. Have quality assurance and quality control procedures been applied in accordance with the monitoring plan monitoring plan?	VVM	205	Yes. The QA/QC procedures have been documented in the *CDM Monitoring and Management Manual* and applied in accordance with the MP.	OK	OK
4.4.1. Has the calibration of those measuring equipments that have an impact on the claimed emission reductions been conducted by the project participants at a frequency specified in the applied monitoring methodology and/or the monitoring	EB 52	Ann 60	Yes. ~~Pending on CAR-4.~~	~~Pending~~	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
plan?					
5. *Assessment of data and calculation of greenhouse gas emission reductions*					
5.1. Is a complete set of data for the specified monitoring period is available? (If no, i.e., only partial data are available because activity levels or non-activity parameters have not been monitored in accordance with the registered monitoring plan, the DOE shall opt to either make the most conservative assumption theoretically possible in finalizing the verification report, or raise a request for deviation prior to submitting request for issuance if appropriate).	VVM	208	A complete set of data including monitoring results and QA/QC records which can cover the monitoring period has been provided to Bureau Veritas Certification.	OK	OK
5.2. Has information provided in the monitoring report been cross-checked with other sources such as plant log books, inventories, purchase records, laboratory analysis?	VVM	208	Yes. The information provided in the monitoring report has been cross-checked with plant log books and l inventories, etc.	OK	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
5.3. Have calculations of baseline emissions, proposed CDM 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?	VVM	208	Yes. As per methodology AM0028 Version 05, no leakage calculation is required. The baseline emissions are determined by the following formula as per the methodology: $BE_{period} = \left(\sum_{i}^{n} F_{TI,i} \times CI_{N2O,i} \times M_i \right) \times GWP_{N2O}$ The project emissions are determined by the following formula as per the methodology: $PE = \left(\sum_{i}^{n} F_{TE,i} \times CO_{N2O,i} \times M_i \right) \times GWP_{N2O} + \left[\begin{array}{l} \left(\rho_{HC} \times Q_{HC,y} \times EF_{HC} \times OXID_{HC} / 100 \right) \\ + \left(\rho_{CH4} \times Q_{CH4,y} \times EF_{CH4} \times OXID_{CH4} / 100 \right) \end{array} \right] + \left[\rho_{CH4} \times Q_{CH4,y} \times GWP_{CH4} \times \left(1 - OXID_{CH4} / 100 \right) \right]$ The leakage $LE_{perid} = 0$ Emission reductions are being determined using the formula as given in the Section B.6.3 of the PDD.	~~CAR 6~~	OK

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
			$ER_{period} = BE_{period} – PE_{period} – LE_{period}$ ~~CAR-6 Bureau Veritas Certification found that the emission reductions are not calculated using formulae in the emission reductions calculation spreadsheet and the results are not traceable. Please provide the version of the emission reduction calculation spreadsheet using formulae (Equations in the MS-Excel) which enable the traceable calculation of the emission reductions to calculate the emission reductions.~~ Emission reductions calculation spreadsheet was revised to use the formulae to calculate the emission reductions and enable the calculated results traceable, and Bureau Veritas Certification can confirm that the calculation of the emission reductions is correct in the revised spreadsheet. The Project was requested for review as the converted hydrocarbon emissions ($HCE_{c,d}$) were calculated not in compliance with the registered PDD in the emission reductions calculation spreadsheet submitted with the monitoring report version 2.3 to request issuance, the PP revised the emission reductions calculation spreadsheet to calculate $HCE_{c,d}$ according to the registered PDD. This latest revised emission reductions calculation spreadsheet is submitted with the monitoring report		

CHECKLIST QUESTION	Ref.	§	COMMENTS	Draft Concl	Final Concl
			version 3.0. After this revision, the emission reductions are revised to be 144,751tCO_2e calculated using formulae. The revision on the emission reductions results from correcting the calculation method in the emission reductions calculation spreadsheet. This CAR is closed.		
5.4. Have any assumptions used in emission calculations been justified?	VVM	208	No. There are no assumptions in emission calculations.	OK	OK
5.5. Have appropriate emission factors, IPCC default values and other reference values been correctly applied?	VVM	208	Yes.	OK	OK

Table 2 Resolution of Corrective Action / Clarification / Forward Action Requests

Draft report clarifications and corrective action requests by verification team	Ref. to checklist question in table 1	Summary of project participant response	Verification team conclusion
CAR-1 Please revise the relevant dates in the monitoring report (section A.1 and B.1)	1.2.3	Relevant dates in the section A.1 and B.1 of the monitoring report were revised according to the documented evidence.	Bureau Veritas Certification has checked the documented evidence and can confirm that the revised dates are consistent with the evidence. This CAR is closed.
CAR-2 Please correct the calculated results of the actual average data of the operation of AORs and the Plant output of Caprolactam, the number of days outside permit range, and the information of the special events according to the monitored information.	1.12.2	Revised correctly. Please look at Section B.1 in MR, and refer to emission reductions calculation spreadsheet.	Bureau Veritas Certification has checked the emission reductions calculation spreadsheet and found that the directly monitored information is consistent with the monitoring records /14/ and there is no revision on the directly monitored values provided in the emission reductions calculation spreadsheet. After the project participant corrected the calculation process in the emission reductions calculation spreadsheet, the project participant attained the corrected results of

Draft report clarifications and corrective action requests by verification team	Ref. to checklist question in table 1	Summary of project participant response	Verification team conclusion
			the actual average data of the operation of AORs and the Plant output of Caprolactam, and the number of days outside permit range. The information in the monitoring report was corrected accordingly. Bureau Veritas Certification has also checked the records of the special events and can confirm that the information of special events provided in the monitoring report is consistent with the records. Bureau Veritas Certification can confirm that the emission reductions are correctly recalculated accordingly. This CAR is closed.
CAR-3 Please revise the value of Volumetric Expansion Factor (VEF) according to the documented evidence.	1.20	The value of VEF was revised to be 0.001.	Bureau Veritas Certification has checked the documented evidence Statement on the Volumetric Expansion Factor (VEF) by CRI Catalyst Company dated 05/2011

Draft report clarifications and corrective action requests by verification team	Ref. to checklist question in table 1	Summary of project participant response	Verification team conclusion
			/16/, and can confirm that the revised value is consistent with this evidence. This CAR is closed.
CAR-4 The description of the equipments used to monitor each parameter, i.e. details on accuracy class, and calibration information (frequency, date of calibration and validity) is required to be included in the section D.2 of the monitoring report.	1.24.2	Revised correctly. Please look at the section D.2 of the monitoring report.	Bureau Veritas Certification has checked the documented evidence /26/ and can confirm that the included information of the details on accuracy class, and calibration information (frequency, date of calibration and validity) in the section D.2 of the monitoring report are consistent with the documented evidence. This CAR is closed.
CAR-5 Please correct the values of parameters which are found inconsistent with the evidence provided in the section E of the monitoring report.	1.25	Revised correctly the values of data in the section E of the MR.	Bureau Veritas Certification can confirm that the revised monitoring report indicate the corrected values of the parameters in the section E, which are consistent with the revised emission reductions calculation spreadsheet.

Draft report clarifications and corrective action requests by verification team	Ref. to checklist question in table 1	Summary of project participant response	Verification team conclusion
			This CAR is closed.
CAR-6 Bureau Veritas Certification found that the emission reductions are not calculated using formulae in the emission reductions calculation spreadsheet and the results are not traceable. Please provide the version of the emission reduction calculation spreadsheet using formulae (Equations in the MS-Excel) which enable the traceable calculation of the emission reductions to calculate the emission reductions.	5.3	Submitted the revised emission reductions calculation spreadsheet using formulae (Equations in the MS-Excel) to calculate the emission reductions. In the emission reductions calculation spreadsheet submitted with the monitoring report version 2.3, the converted hydrocarbon emissions ($HCE_{c,d}$) were calculated not in compliance with the registered PDD, i.e. the $HCE_{c,d}$ was calculated without multiplying the theoretical emission factor of methane (EF_{CH4}). After the Project was requested for review, the calculation of the $HCE_{c,d}$ is corrected in the emission reductions calculation spreadsheet and calculated as: $HCE_{c,d} = [(\rho_{HC} \times Q_{HC,y} \times \underline{\boldsymbol{EF_{HC}}} \times OXID_{HC}/100) + (\rho_{CH4} \times Q_{CH4,y} \times$	Bureau Veritas Certification compared the directly monitored values of the monitoring parameters provided in the revised emission reductions calculation spreadsheet to the original version spreadsheet and the data records /14/, and can confirm that there is no revision to the directly monitored values of the monitoring parameters, and the directly monitored values are consistent with the data records. Emission reductions calculation spreadsheet was revised to use the formulae to calculate the emission reductions and enable the calculated results traceable, and Bureau Veritas Certification can confirm that the calculation of the emission reductions is correct in the revised spreadsheet. The revision on the emission reductions results

Draft report clarifications and corrective action requests by verification team	Ref. to checklist question in table 1	Summary of project participant response	Verification team conclusion
		$EF_{CH4} \times OXID_{CH4}/100)] + [\rho_{CH4} \times Q_{CH4,y} \times GWP_{CH4} \times (1\text{-}OXID_{CH4}/100)]$ The latest revised emission reductions calculation spreadsheet is submitted with the monitoring report version 3.0. After revision, the emission reductions are revised to be 144,751tCO_2e calculated using formulae.	from correcting the calculation method in the emission reductions calculation spreadsheet. The Project was requested for review as the converted hydrocarbon emissions ($HCE_{c,d}$) were calculated not in compliance with the registered PDD in the emission reductions calculation spreadsheet submitted with the monitoring report version 2.3 to request issuance, the PP revised the emission reductions calculation spreadsheet to calculate $HCE_{c,d}$ according to the registered PDD. This latest revised emission reductions calculation spreadsheet is submitted with the monitoring report version 3.0. This CAR is closed.
CL-1 Whether there were special events or situations that occurred during the monitoring period which may impact the applicability is required to be described in the Section B.1 of	1.12.3	Explained in the Section B in MR.	Bureau Veritas Certification can confirm that there were no special events or situations that occurred during the monitoring period which may impact the

Draft report clarifications and corrective action requests by verification team	Ref. to checklist question in table 1	Summary of project participant response	Verification team conclusion
the monitoring report.			applicability and it is described in the section B.1 of the revised monitoring report. This CL is closed.