Monitoring report form
(Version 05.1)

Complete this form in accordance with the Attachment "Instructions for filling out the monitoring report form" at the end of this form.

MONITORING REPORT		
Title of the project activity	Catalytic N_2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea	
UNFCCC reference number of the project activity	0922	
Version number of the monitoring report	2	
Completion date of the monitoring report	02/05/2016	
Monitoring period number and duration of this monitoring period	The 10th monitoring period (The 1st monitoring period for 2nd crediting period) 27/06/2014 -26/06/2015	
Project participant(s)	Hanwha Corporation	
Host Party	Republic of Korea	
Sectoral scope(s)	Category 5: Chemical industries	
Selected methodology(ies)	ACM0019 (N_2O abatement from nitric acid production)_V02.0.0	
Selected standardized baseline(s)	N/A	
Estimated amount of GHG emission reductions or net GHG removals by sinks for this monitoring period in the registered PDD	Total amount of estimated in PDD for this monitoring period: 242,526 tCO_2-eq. (Amount estimated in PDD for 2014: 124,918 tCO_2-eq Amount estimated in PDD for 2015: 117,609 tCO_2-eq) * 2014:188 days, 2015: 177 days, Total: 365 days	
Total amount of GHG emission reductions or net GHG removals by sinks achieved in this monitoring period	GHG emission reductions or net GHG removals by sinks reported up to 31 December 2012	GHG emission reductions or net GHG removals by sinks reported from 1 January 2013 onwards
	0 tCO_2-eq (starting date of monitoring period is after 31 December 2012)	203,384tCO_2-eq

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

>>

(a) Purpose of the project activity and the measures taken for GHG emission reductions or net GHG removals by sinks;

Catalytic N_2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea.
Nitrous Oxide (N_2O) is an undesired by-product of the nitric acid (HNO_3) production facility.

In order to produce nitric acid, ammonia (NH_3) is oxidized into NO—desired product[1]—with air on precious metal catalyst gauzes (usually platinum-rhodium alloys) in the ammonia burner of the nitric acid plants. Through this process, some amount of undesired N_2 and N_2O are formed as the gauzes' selective capability drop over time.

From the plant, Nitrous Oxide (N_2O), which is an undesired by-product of the nitric acid production process, is released into the atmosphere. Hanwha Corporation has one production line. The aim of the project activity is to reduce N_2O emissions by installation of DeN_2O Unit before the Stack, which is called Tertiary Catalyst System or Tail Gas System

(b) Brief description of the installed technology and equipment;

For the N_2O abatement project, Tertiary Catalyst System has been installed in the Nitric Acid Production Line, which consists of the catalyst, supplied by N.E.Chemcat Corporation, Japan as well as the reactor, supplied by Sumitomo Metal Mining Engineering Corporation, Japan. In order to monitor the N_2O reduction, the Automated Measuring Systems (AMS), including non-dispersion infrared absorption analyzer (NDIR) was installed, which is applicable to European standards and norms (EN 14181) or equivalent standards.

(c) Relevant dates for the project activity (e.g. construction, commissioning, continued operation periods, etc.);

HWC had operated from 1991 in Incheon city, but moved to Ulsan city in 2004.
And its commercial production was restarted on January in 2005.
The amount of nitric acid production was 85,300 ton/yr based on 100% nitric acid in 2005 and will be planed 85,300–89,000ton based on 100% nitric acid in 2006. And the amount of nitric acid production will be planed 97,020 tonnes of 100% nitric acid in 2007. (Production design capacity for 100% nitric acid: 107,100ton/yr).

(d) Total GHG emission reductions or net GHG removals by sinks achieved in this monitoring period (27/06/2014-26/06/2015) is **203,384 tCO_2-eq**.

A.2. Location of project activity

>>

(a) Host Party; Republic of Korea

(b) Region/state/province, etc.; Ulsan city

---

[1] At later stage, NO will be oxidized into NO_2 which absorbed in water to form acid (HNO_3).

Figure 1. Location of Ulsan, Republic of Korea

(c) City/town/community, etc.; 32, Sannam-gil, Onsan-eup, Ulju-gun
(As of January 1, 2014, Korea has officially moved away from the old addresses, which were based on things like land lots, and what order buildings were constructed in on a block, to a new, streamlined system based on street name and building number. The actual position has not changed.)

(d) Physical/geographical location.

Onsan district is in the southern part of Ulsan city and is industrial Area.
Hanwha Onsan plant is located on Onsan Industrial Area, the physical/geographical location of the Onsan plant site is:

- 32, Sannam-gil, Onsan-eup, Ulju-gun, Ulsan city
- The latitude of 35.4139980°N and the longitude of 129.3392106°E

A regional map is shown in below:

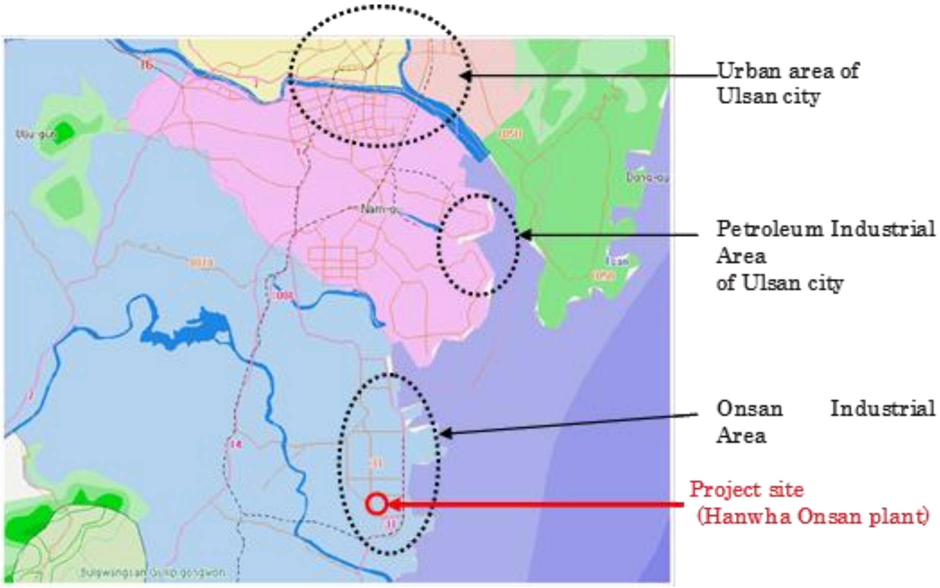


Figure 2. Location of Ulsan plant of HWC (Ulsan, Republic of Korea)

A.3. Parties and project participant(s)

Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate whether the Party involved wishes to be considered as project participant (yes/no)
Republic of Korea (host)	Hanwha Corporation (HWC) [owner and operator of the nitric acid plant]	No

A.4. Reference of applied methodology and standardized baseline

>>

(a) The applied methodology(ies) ;

ACM0019 Version 02.0.0 “N_2O abatement from nitric acid production”.

(b) Any tools and other methodologies to which the applied methodology(ies) refers ;

Version 03.0.0 “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” Version 02 “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”

(c) The applied standardized baseline(s), where applicable ;

No standardized baselines are used.

A.5. Crediting period of project activity

>>

(a) Type of crediting period ; Second crediting period (Renewable)

(b) Start date of crediting period ; 27/06/2014

(c) End date of crediting period ; 26/06/2021

(d) Length of crediting period ; 7 years

A.6. Contact information of responsible persons/entities

>>

(a) Contact information of the entity ; HANWHA Corporation

(b) Contact person; Woo Bom Je

(c) Title ; Manager

(d) Department ; Industrial Explosives Department, Chemical Business Team

(e) Email: woobj@hanwha.com

(f) Telephone ; +82-2-729-1899

For further information please refer to Appendix 1.

SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

>>

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

<u>Technologies</u>

HWC mainly produces chemical products such as explosive and nitric acid.
Ammonia is an important raw material for the production of the nitric acid.

Figure 3. Nitric Acid Plant of HWC

In the production process of nitric acid (HNO_3), NO is produced as an intermediate material from ammonia (NH_3). The associated chemical reactions of oxidizing ammonia and simultaneous unwanted reactions are as follows:

NH_3	+	$2O_2$	→	HNO_3	+	H_2O	(overall desired reaction)
$4NH_3$	+	$5O_2$	→	$4NO$	+	$6H_2O$	(desired in the NH_3 oxidization process)
$2NO$	+	O_2	→	$2NO_2$			(desired in the NO oxidization process)
$3NO_2$	+	H_2O	→	$2HNO_3$	+	NO	(desired in the NO_2 absorption process)

$4NH_3$	+	$3O_2$	→	$2N_2$	+	$6H_2O$	(undesired)
$4NH_3$	+	$4O_2$	→	$2N_2O$	+	$6H_2O$	(undesired)
$2NH_3$	+	$8NO$	→	$5N_2O$	+	$3H_2O$	(undesired)

Through the sixth and seventh reactions, some amount of N_2O is generated in the process.

Under no regulatory as well as no economically attractive condition, as in the case of Republic of Korea, the N_2O is released to the atmosphere as a part of exhaust gas.

The N_2O abatement technology is to introduce catalytic decomposition equipment at the tail gas downstream after the HNO_3 absorber and before the stack (tertiary method).[2] N_2O is decomposed as:

$$N_2O \rightarrow N_2 + (1/2)O_2$$

through the process.

The tertiary method applied by the project is similar to the well-established catalytic NO_X reduction processes as an end-of-pipe technology. There is no interference with the HNO_3 production process.[3]

For the configuration of the system, in general, catalytic decomposition system (DeN_2O unit) is equipped at the highest temperature point such as between tail gas heater and tail gas turbine for the tertiary method. However, for this plant, inlet temperature for DeN_2O unit (after the tail gas turbine) is relatively low [65–110℃ for HWC Plant].

In case that the DeN_2O unit is equipped between tail gas heater and turbine, some amount of fuel is needed for reheating the tail gas for such configuration. On the other hand, if the DeN_2O unit is equipped just after the turbine, high efficient catalytic system can be applied because the gas pressure is lowered close to atmospheric pressure. This reduces the fuel consumption in spite of the lower tail gas temperature.

The applied technology provided by N.E. Chemcat and Sumiko Eco-Engineering is chosen because it has almost no risks to decrease HNO_3 production as well as the operation of the equipment, higher N_2O decomposition rate, and total cost is lower than other technologies.

By introducing this technology, HWC obtains a clean technology which is not yet widely commercialized even in industrialized countries.

The DeN_2O equipment does not affect NO_X emissions.

It also includes the training course for operation of the DeN_2O equipment to ensure the proper handling of both, the N_2O abatement catalyst as well as the continuous and accurate N_2O monitoring system.

In addition, local engineering companies will enjoy job-creation benefits especially during engineering design, manufacturing of equipment parts and installation of equipment and catalyst.

---

[2] There are three group of methods to reduce N_2O emissions from HNO_3 production process:

- Primary method: N_2O is prevented from forming. This requires modifications to the precious metal ammonia oxidation gauzes or utilization of another ammonia oxidization catalyst to reduce N_2O formation.
- Secondary method: N_2O, once formed, is removed anywhere between the outlet of the ammonia oxidation gauzes and the inlet of the absorption tower.
- Tertiary method: N_2O is removed from the tail gas downstream of the absorption tower by catalytic destruction (either by catalytic decomposition or by catalytic reduction).

[3] The tertiary N_2O destruction technology will not result in HNO_3production increase. It means that there are no financial incentives for the implementation of the project activity.

Description of how services provided by the project would have been provided in baseline

In the baseline scenario no N_2O emissions would have been reduced at nitric plant of HWC and all N_2O would have been emitted to the atmosphere as there is no economic incentive to prevent its release.

Facilities, systems, equipment in operation prior to implementation of project activity

The nitric acid plant started commercial operation before the implementation of the CDM project activity, and there was no tertiary N_2O abatement technology installed in the respective nitric acid plant.
This is not applicable since there was no equipment of the tertiary N_2O abatement in operation prior to implementation of the project.

Flow diagram

As the project activity introduces tertiary N_2O abatement, any remaining N_2O emissions from the project plant and CO_2 emissions arising from the operation of the tertiary abatement system are included as project emissions in the project boundary.

The boundary of the project will be from the inlet of the Ammonia Oxidation Reactor to the outlet of the stack of the nitric acid plant (see Figure 4 below).

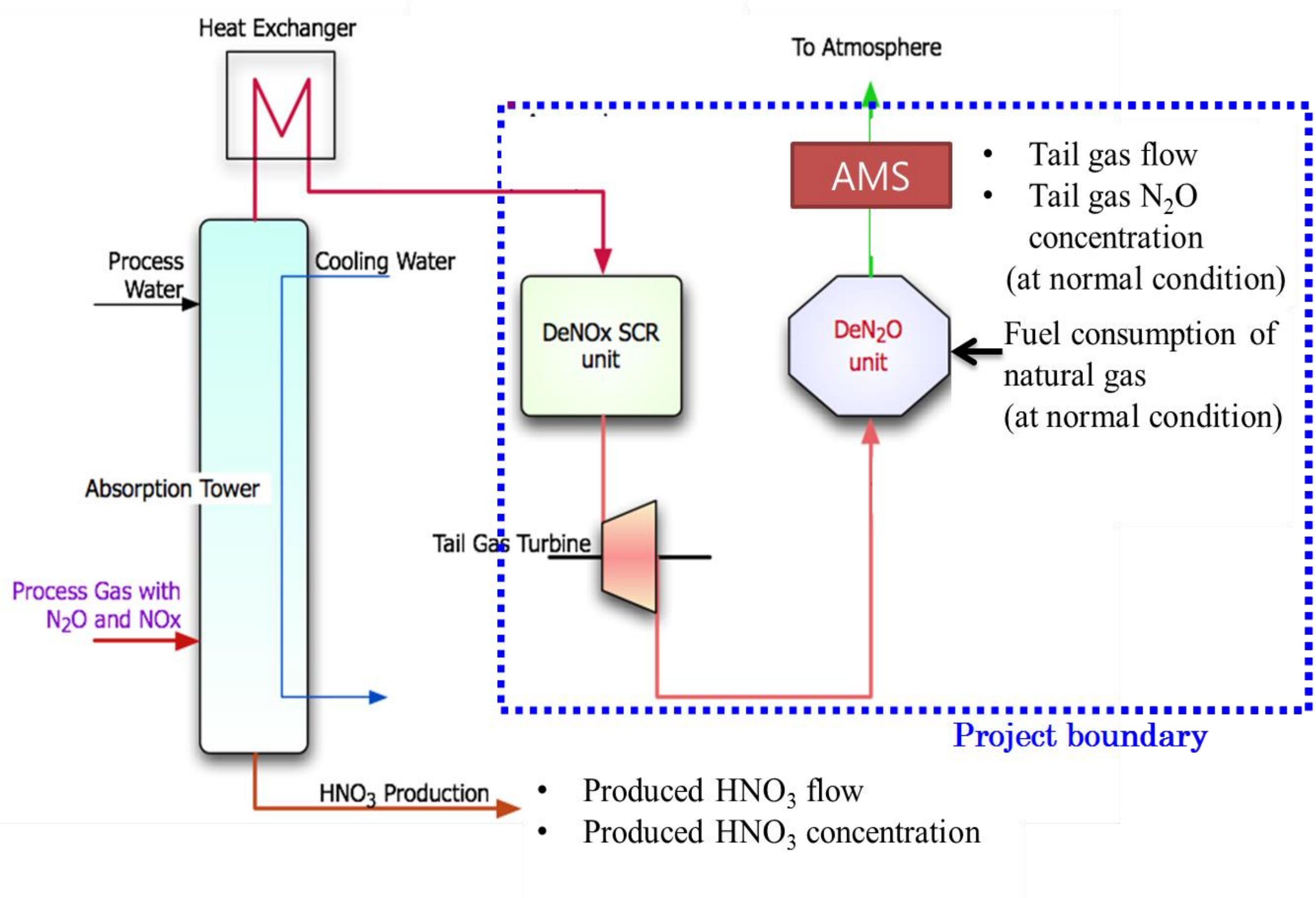


Figure 4. Configuration of the N_2O abatement system and tail gas flow

The spatial extent of the project boundary encompasses the facility and equipment for the nitric acid production process from the inlet of the ammonia burner to the outlet of the tail gas section.

List of facilities, systems, equipment in project scenario

The project activity introduces a tertiary N_2O abatement facility, physically located in the tail gas stream of the nitric acid plant. It is expected that the tertiary abatement facility will destroy N_2O emissions to a high extent. The remaining N_2O which is not destroyed and still present after the abatement facility is measured by the AMS downstream of the tertiary abatement measure and is considered as project emissions. Fossil fuels will be used when operating the tertiary abatement facility, for this reason emissions from this source are to be considered as well.

Description of how technology, measures, know-how were transferred to host country

The installation of the decomposition technology enables economic and technical benefits to the host country by providing direct and in-direct employment and transfer of thermal decomposition technology from Japan. For the N_2O abatement project, Tertiary Catalyst System has been installed in the Nitric Acid Production Line from Japan.
In order to monitor the N_2O reduction, the Automated Measuring Systems (AMS), including non-dispersion infrared absorption analyzer (NDIR) was installed, which is applicable to European standards and norms (EN 14181) or equivalent standards.

(b) Implementation status of the project activity during this monitoring period

The project has been implemented and is operated as per the registered with all physical features (technology, project equipment, and monitoring and metering equipment) in place, monitoring is done according to the applied methodology (ACM0019v2) and the monitoring plan. The operation of the project activity started in June 27, 2014(starting date of the project activity for the first crediting period was June 27, 2007).

(c) Actual operation of the Project Activity during the covered monitoring period

Production volume of Nitric Acid during the project period is 88,952 tons. whereas, $P_{product,max}$ specified in the PDD, based on the HWC's experienced maximum daily production is 107,100tons.

The monitoring period is 365 days from 27/06/2014 to 26/06/2015. Thus actual production of 88,952 tons is less than 107,100tons compared as annual basis.
Meantime, the operation of Nitric Acid Plant was stopped during the following period as below. No emission reduction is claimed during these downtimes:

<Shut-down of the nitric acid plant (DNA) during this monitoring period>

No	Downtime - Start		Downtime - End		Duration	Description of downtime reason
	Date	Time	Date	Time		
1	07/08/2014	01:00	16/08/2014	12:00	227 hours	Nitric acid plant was shut-down because of inventory control.
2	30/09/2014	03:00	07/10/2014	15:00	180 hours	Nitric acid plant was shut-down because of primary catalyst replaces & Major overhaul.

3	30/12/2014	18:00	01/01/2015	14:00	44 hours	Nitric acid plant was shut-down because of control problem for the part by NH_3 ratio, reason for W/W (warm water) pump cavitation.
4	11/02/2015	01:00	14/02/2015	13:00	84 hours	Nitric acid plant was shut-down because of primary catalyst replaces & Major overhaul.
5	03/03/2015	16:00	04/03/2015	13:00	21 hours	Nitric acid plant was shut-down because of compressor flow control valve malfunction.
6	20/05/2015	22:00	01/06/2015	13:00	279 hours	Nitric acid plant was shut-down because of primary catalyst replaces & Major overhaul.
7	13/06/2015	09:00	15/06/2015	07:00	46 hours	Nitric acid plant was shut-down because of main power failure.

The operation of DeN_2O unit was stopped during the following period as below:

<Underperforming or failed of DeN_2O unit during this monitoring period>

No	Downtime - Start		Downtime - End		Duration	Description of downtime reason
	Date	Time	Date	Time		
1	12/07/2014	04:00	12/07/2014	10:00	6 hours	DeN_2O Unit was shut-down because of lack of steam.
2	25/07/2014	10:00	30/07/2014	12:00	122 hours	DeN_2O Unit was shut-down because of lack of steam.
3	01/08/2014	06:00	01/08/2014	21:00	15 hours	DeN_2O Unit was shut-down because of lack of steam.
4	16/08/2014	16:00	17/08/2014	06:00	14 hours	DeN_2O Unit was shut-down because of lack of steam.
5	18/08/2014	08:00	19/08/2014	16:00	32 hours	DeN_2O Unit was shut-down because of lack of steam.
6	07/10/2014	17:00	08/10/2014	01:00	8 hours	The N_2O outlet concentration data was not normalize. The maximum measuring range of NDIR for outlet is 500ppm. Thus, More than 500 ppm was deemed to not working properly with conservative approach.
7	23/10/2014	10:00	25/10/2014	15:00	53 hours	DeN_2O Unit was shut-down because of lack of steam.
8	11/11/2014	10:00	11/11/2014	24:00	14 hours	DeN_2O Unit was shut-down because of lack of steam.

9	18/11/2014	11:00	18/11/2014	24:00	13 hours	The N_2O outlet concentration data was not normalize. The maximum measuring range of NDIR for outlet is 500ppm. Thus, More than 500 ppm was deemed to not working properly with conservative approach.
10	30/12/2014	17:00	30/12/2014	18:00	1 hours	DeN_2O Unit was shut-down because of control problem for the part by NH_3 ratio, reason for W/W (warm water) pump cavitation.
11	01/01/2015	17:00	01/01/2015	22:00	5 hours	The N_2O outlet concentration data was not normalize. The maximum measuring range of NDIR for outlet is 500ppm. Thus, More than 500 ppm was deemed to not working properly with conservative approach.
12	04/03/2015	17:00	04/03/2015	19:00	2 hours	The N_2O outlet concentration data was not normalize. The maximum measuring range of NDIR for outlet is 500ppm. Thus, More than 500 ppm was deemed to not working properly with conservative approach.
13	20/05/2015	21:00	20/05/2015	22:00	1 hours	The N_2O outlet concentration data was not normalize. The maximum measuring range of NDIR for outlet is 500ppm. Thus, More than 500 ppm was deemed to not working properly with conservative approach.
14	01/06/2015	16:00	03/06/2015	14:00	46 hours	DeN_2O Unit was shut-down because of lack of steam.
15	15/06/2015	10:00	15/06/2015	14:00	4 hours	The N_2O outlet concentration data was not normalize. The maximum measuring range of NDIR for outlet is 500ppm. Thus, More than 500 ppm was deemed to not working properly with conservative approach.

During this monitoring period, events has no effect on the applicability of the methodology.

B.2. Post-registration changes

B.2.1. Temporary deviations from registered monitoring plan, applied methodology or applied standardized baseline

>>

Temporary deviation from registered monitoring plan have applied to this monitoring period. Temporary deviation request was approved on April 26th, 2016. PRC ref is PRC-0922-001.

B.2.2. Corrections

>>

No corrections have applied to this monitoring period neither to any previous monitoring periods.

B.2.3. Changes to start date of crediting period

>>

No changes have applied to this monitoring period.

B.2.4. Inclusion of a monitoring plan to the registered PDD that was not included at registration

>>

No inclusion has applied to this monitoring.

B.2.5. Permanent changes from registered monitoring plan, applied methodology or applied standardized baseline

>>

No changes have applied to this monitoring period.

B.2.6. Changes to project design of registered project activity

>>

No changes have applied to this monitoring period.

B.2.7. Types of changes specific to afforestation or reforestation project activity

>>

Not applicable to this project activity.

SECTION C. Description of monitoring system

>>

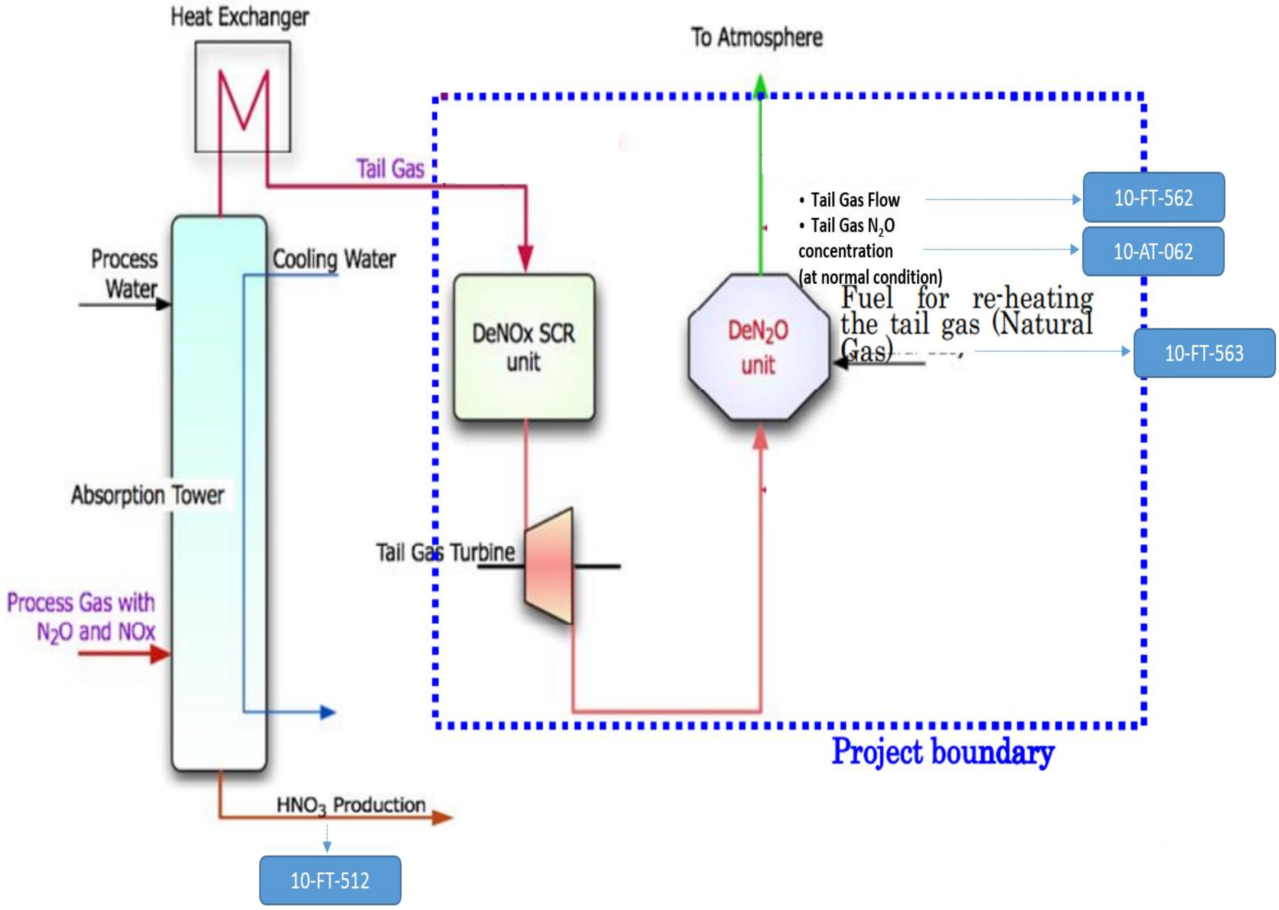
(a) Monitoring plan and methodology

The approved consolidated baseline and monitoring methodology ACM0019 “N_2O abatement from nitric acid production” (Version 02.0.0) and of the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Version 03.0.0) and of the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” (Version 02) was applied to this project activity.

This approved monitoring methodology is applicable to the project activities that abate N_2O emissions either by catalytic decomposition or catalytic reduction of N_2O in the tail gas of nitric acid plants (i.e. tertiary destruction). The present project activity satisfies applicability conditions.

(b) Data collection procedure

Please see the figure below for position of monitoring parameters for the project. Respective data from each monitoring points are generated, aggregated, recorded, calculated and reported as follows.
Data collection flow of the monitoring system is as per the chart below :



Parameter	Data description	Data generation	Measured by		Aggregation/Recording		Calculation		Reporting
$F_{i,t}$	Volume flow rate at the exit of the destruction facility	Outlet of DeN_2O	Multi-point sampling tube type flow meter with D/P transmitter. Absolute pressure transmitter and Resistance Temperature Detector.	→	ABB data logging system	→	Excel spread sheet (According to ACM0019)	→	By Hanwha Corporation (HWC)
Q_{NG}	Hydrocarbon (Natural gas) input	DeN_2O	Integral Orifice flow meter with temperature, pressure measuring unit for auto compensation						
Natural gas contents information			Ingredients label by the natural gas supplier		By handling				
$P_{product,y}$	Plant output of HNO_3	Outlet of absorption tower	Coriolis Mass Flow Measuring System		DCS system (Distributed control system)				

1. **Organization structure of Hanwha's project team, including the role and responsibility of the personnel**

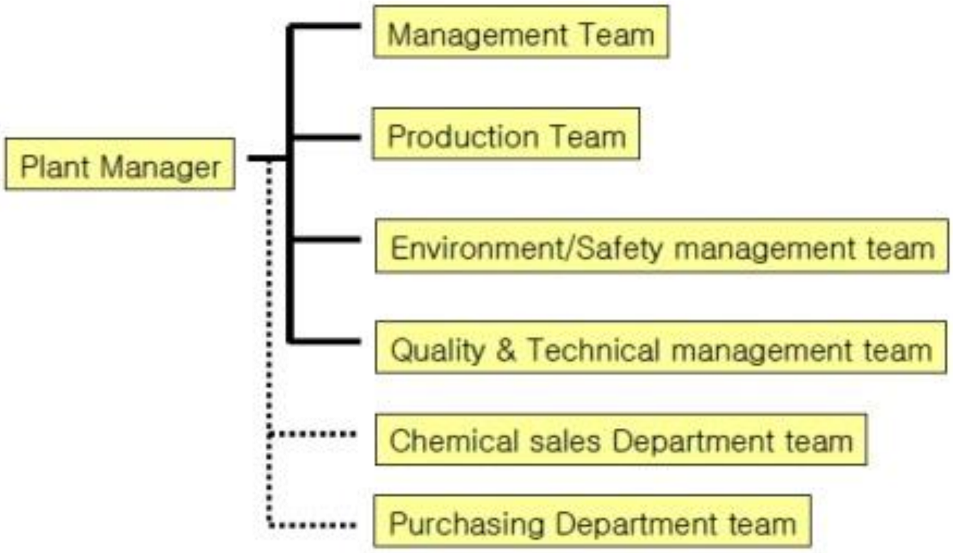
HWC has been operating the nitric acid plants since the commissioning of the plant and has sufficient and well-experienced staffs. HWC has been in production of the nitric acid for number of years and measurement of various production parameters including operation of analyzers which are managed by Production team. The monitoring of the N_2O for the project will be responsible by Production team and the operation and maintenance of the N_2O Monitoring system will incorporate the ISO 9001-2000 and EN14181 standard procedures. The Monitoring of the relevant data will be done by the N_2O Monitoring system and recorded onto the electric media.

In case deviation in the Monitoring data is found, Production Team engineer will study the operating parameters of the nitric acid plant to identify the reason for the deviation and take remedial measures.

If there are no changes in the operating parameters of nitric acid plant, the Monitoring system will be examined. Once the default is identified, Quality & Technical Management team and Environment & Safety Management team will introduce a correction to the default. Production team engineer will report such irregular event to Plant Manager.

HWC has trained the staff selected for the operation of the relevant monitoring systems and ensures that the operational standards required for the appropriate handling of the equipment is maintained throughout the crediting period.

An illustrative scheme of the operational and management structure is as follows:

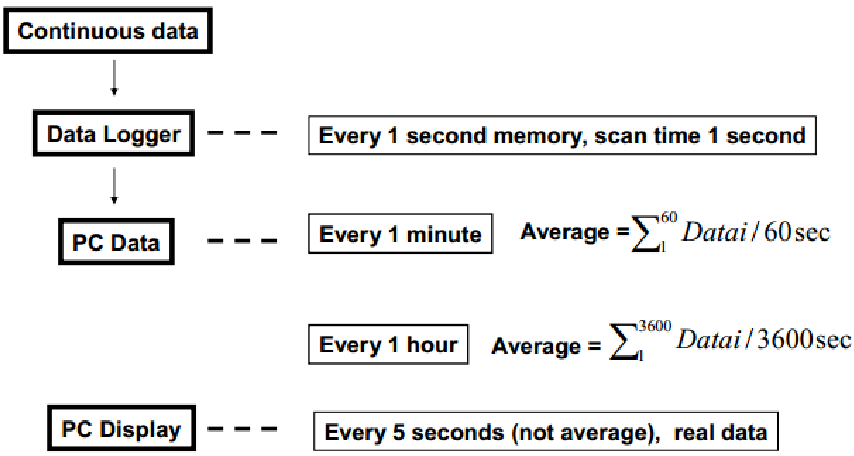


2. **Emergency procedures for the monitoring system**

In case of emergency or any deviation in the monitoring data is found, production team engineer shall study the operating parameters of the nitric acid plant to identify the reason for the deviation and take remedial measures. If there is no change in the operating parameter of nitric acid plant, the monitoring system shall be examined. Once the default is identified, quality & technical management team and environment & safety management team shall introduce a correction to the default. Production team engineer shall report such irregular event to plant manager. For others concerning good monitoring practice and performance characteristics including such as EN14181 or equivalent standards available in the Republic of Korea specified.

3. **Monitoring and calculation details of N_2O concentration & tail gas measurement**

Following method is applied:



4. **Calibration and maintenance**

All measuring and analytical instruments are calibrated as defined in the approved methodology ACM0019 version2. Calibration procedures have been incorporated in Hanwha Corporation's quality management system and procedures.

The measurement equipments are calibrated on regular intervals as recommended by the manufacturers. Additionally, selected staffs from Hanwha Corporation participate in initial training and are trained to operate measurement system.

For other concerning good monitoring practice and performance characteristics including such as EN14181 or equivalent standards available in Republic of Korea specified in AM0028 version 3, which is mentioned in Annex 4 of concerned PDD.

Information of calibration of each equipment is as below:

Instrument Overview: Hanwha		
Instrument		TAG Number
AMS (Auto Measuring System) Instrument	Destruction Facility Outlet Analyzer	10-AT-062(A1062)
	Outlet Tail Gas Flow	10-FT-562(F1562)
	Natural Gas Flow to Destruction Facility	10-FT-563(F1563)
AOR Instrument	HNO_3(Nitric Acid) Flow	10-FT-512(F1512)

In the following, it is described how the procedures given in EN 14181 for QAL1-3 have been applied at the plant.

QAL1

In accordance with EN14181, the monitoring system for N_2O concentration measurements has been proven suitable for its measuring task (parameter and composition of the flue gas) by use of the QAL1 procedure as specified by EN ISO 15267 or equivalent standards. This standard's objective is to prove that the total uncertainty of the results obtained from the AMS meets the specification for uncertainty stated in the applicable regulations. Such suitability testing has to be carried out under specific conditions by an independent third-party on a specific testing site.

Monitoring equipment for N_2O concentration measurement and tail gas flow measurement was installed at suitable points in the tail gas of the nitric acid plant.

The Analyser is QAL1 tested according to EN 14181 for the measurement of N_2O. And the tail gas flow meter is QAL2, QAL3 and AST tested as an alternative routes in QAL1 according to EN 14181. Regarding the compliance with the EN14181, the suitability test of QAL1 was not available for the flowmeter during the 1st crediting period and thus, it's required the temporary deviation as per paragraph 100 of EB47th meeting report. Thus, prior approval for temporary deviation from the registered monitoring plan submitted to the Board on 23/12/2015 and it was approved on 24/04/2016.

QAL2

QAL2 is a procedure for the determination of the calibration function and its variability. According to EN14181, the QAL2 test was conducted by an independent "testing house" or laboratory which is accredited according to EN ISO/IEC 17025. The QAL2 tests are performed on suitable AMS that have been correctly installed and commissioned on-site (as opposed to QAL1 which is conducted off-site).

A calibration function was established from the results of a number of parallel measurements performed with a Standard Reference Method (SRM). The variability of the measured values obtained with the AMS is then evaluated by the independent qualified "testing house". QAL2 tests are to be performed at least every 5years according to EN 14181.

AST in addition, Annual Surveillance Tests (AST) is conducted in accordance with EN 14181; these are a series of measurements with independent measurement equipment in parallel to the existing AMS. The AST tests are performed annually. If a full QAL2 test is

performed (at least every 5 years), an additional AST test is not necessary in that same year.

QAL2 and AST Test for N_2O and volume flow combined with measurements of the moisture content of the tail gas. AST was done by SGS Environmental Services.

Details on QAL2-tests can be found in the parameter section within D.2.

QAL3

QAL3 describes the on-going quality assurance and maintenance procedures and documentation for the AMS conducted by the plant operator. With this documentation it can be demonstrated that the AMS is in control during its operation so that it continues to function within the required specifications.

In essence, the instrumentation personnel perform QAL3 procedures through the established calibration procedures as outlined for the applicable parameter in section D.2.

N2O-Analyser Zero Calibration

Manual zero calibration is undertaken according to plant internal requirements based on vendor suggestions. Certified gas is being used. Additional automatic zero calibration is undertaken on daily basis (every 10 days) using ambient air.

N2O-Analyser Span calibration

For automatic span calibrations the URAS 26 Analyser is equipped with a “Calibration Cuvette” (gas filled adjustment cells), which is installed as part of the analyser. The automatic calibration is done after every 10 days. Manual calibration checks are performed according to plant internal requirements and vendor suggestions with certified calibration gas. The calibration results and subsequent actions are all documented as part of the CDM procedure. In addition, the analyser room and equipment is visually inspected on a regular basis.

Flow meter calibration procedures

The flow meter is checked during the QAL2 and AST tests by an independent laboratory by comparison to a standard reference method (SRM) as stated above. It is a physical device which will not have drift.

Therefore, it is sufficient to regularly inspect its physical condition by means of visual and electric checks of the probe. It shall be cleaned if deemed necessary.

The suitability test of QAL1 was not available for the flowmeter during the 1st crediting period and thus, it’s required the temporary deviation as per paragraph 100 of EB 47th meeting report. Thus, prior approval for temporary deviation from the registered monitoring plan submitted to the Board on 23/12/2015 and it was approved on 24/04/2016.

SECTION D. More information of calibration of each instrument has been submitted to the DOE. Data and parameters

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

Data/parameter:	**Operating pressure**
Unit	KPa
Description	Operating pressure of the ammonia burner
Source of data	Manufacturer specifications
Value(s) applied	**high pressure**
Choice of data or measurement methods and procedures	The parameter is used to determine whether the nitric acid plant operates at a low, medium or high pressure. According to the operating pressure of the ammonia burner in first crediting period, high pressure's default N_2O baseline emission factor is used for this project.
Purpose of data	Calculation of baseline emissions
Additional comments	-

Data/parameter:	**$EF_{historical}$**
Unit	kg N_2O/t HNO_3
Description	Historical baseline emission factor of the nitric acid plant
Source of data	Historical information from issuance reports of CDM-PDD documents
Value(s) applied	**9.47 kg N_2O/t HNO_3**
Choice of data or measurement methods and procedures	For plants that used AM0028 in the first crediting period: use the lowest baseline emission factor obtained in one calendar year, from 1 January to 31 December, obtained during the first crediting period;
Purpose of data	Calculation of baseline emissions
Additional comments	This value will remain constant over the second and third crediting period

Data/parameter:	**$EF_{default,y}$**
Unit	kg N_2O/t HNO_3
Description	Default emission factor according to the operating pressure of the ammonia burner in year y (related to 100 per cent pure acid)
Source of data	According to the PDD/ ACM0019(ver2.0)\
Value(s) applied	**12.4 kgN_2O/tHNO_3 (for the year 2014)** **12.2 kgN_2O/tHNO_3 (for the year 2015)**
Choice of data or measurement methods and procedures	Specified in the methodology

Purpose of data	Calculation of baseline emissions
Additional comments	This default N_2O baseline emission factor will vary every year. In the year 2013 the emission factors will be 5.5; 8.4; and 12.6 kg N_2O/t HNO_3 for low, medium and high pressure ammonia burners. For each subsequent year, the emission factors will decrease by 0.2 kg N_2O/t HNO_3 until they reach a value of 2.5 or 2.4. After reaching the values of 2.5 or 2.4 the emission factor will remain constant over time:

Year	**Low pressure (0 – 200 kPa)**	**Medium pressure (200 – 600 kPa)**	**High pressure (Over 600 kPa)**
2014	5.3	8.2	**12.4**
2015	5.1	8.0	**12.2**
2016	4.9	7.8	**12**
2017	4.7	7.6	**11.8**
2018	4.5	7.4	**11.6**
2019	4.3	7.2	**11.4**
2020	4.1	7	**11.2**
2021	3.9	6.8	**11**
2022	3.7	6.6	**10.8**
2023	3.5	6.4	**10.6**
2024	3.3	6.2	**10.4**
2025	3.1	6	**10.2**
2026	2.9	5.8	**10**
2027	2.7	5.6	**9.8**
2028	2.5	5.4	**9.6**
2029	2.5	5.2	**9.4**
2030	2.5	5.0	**9.2**

Data/parameter:	**$EF_{new,y}$**
Unit	kg N_2O/t HNO_3
Description	Baseline N_2O emission factor for nitric acid production in year y (related to 100 per cent pure acid)
Source of data	According to the PDD/ ACM0019(ver2.0)
Value(s) applied	**3.50 kgN_2O/tHNO_3 (for the year 2014)** **3.40 kgN_2O/tHNO_3 (for the year 2015)**
Choice of data or measurement methods and procedures	Specified in the methodology

Purpose of data	Calculation of baseline emissions
Additional comments	The baseline N_2O emission factor for nitric acid production will vary every year. In year 2005 the emission factor will be 5.1 and then it will decrease every year until it reaches a final value of 2.5 in the year 2020. The value of 2.5 will remain constant after 2020, as provided in the following table:

Year	Emission factor (kgN2O/t HNO_3)
2014	3.50
2015	3.40
2016	3.20
2017	3.00
2018	2.80
2019	2.70
2020	2.50
2021	2.50
2022	2.50
2023	2.50
…	…
Yean n	2.50

Data/parameter:	$P_{product,max}$
Unit	t Product
Description	Design capacity of nitric acid production during the first crediting period
Source of data	Project operator
Value(s) applied	**107,100 $tHNO_3$/yr**
Choice of data or measurement methods and procedures	Specified in PDD 107,100 $tHNO_3$/yr was calculated by HWC's experienced maximum production and operating days. Corresponding values given in the first crediting period by project operator, design capacity of nitric production apply over second crediting period.
Purpose of data	Calculation of baseline emissions
Additional comments	This parameter is only for project activities applying case 1

Data/parameter:	GWP_{N2O}
Unit	t CO_2e/t N_2O
Description	Global warming potential of N_2O valid for the commitment period
Source of data	Relevant decisions by the CMP
Value(s) applied	**298**
Choice of data or measurement methods and procedures	As per EB 69 Report, Annex 3 the GWP of N_2O is defined in the 2nd commitment period (starting 1/1/2013) as 298 tCO_2/tN_2O.
Purpose of data	Calculation of baseline and project emissions
Additional comments	-

Parameters from the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 03.0.0)

Data/parameter:	**Ru**
Unit	$Pa.m^3/kmol.K$
Description	Universal ideal gases constant
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 03.0.0)
Value(s) applied	**8,314**
Choice of data or measurement methods and procedures	Specified in tool
Purpose of data	Calculation of project emissions
Additional comments	-

<table>
<tr><th>Data/parameter:</th><th>MM_i</th></tr>
<tr><td>Unit</td><td>kg/kmol</td></tr>
<tr><td>Description</td><td>Molecular mass of greenhouse gas i</td></tr>
<tr><td>Source of data</td><td>Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 03.0.0)</td></tr>
<tr><td>Value(s) applied</td><td><table><tr><th>Compound</th><th>Structure</th><th>Molecular mass (kg / kmol)</th></tr><tr><td>Nitrous oxide</td><td>N_2O</td><td>44.02</td></tr></table></td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>Specified in tool</td></tr>
<tr><td>Purpose of data</td><td>Calculation of project emissions</td></tr>
<tr><td>Additional comments</td><td>-</td></tr>
</table>

Data/parameter:	P_n
Unit	Pa
Description	Total pressure at normal conditions
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 03.0.0)
Value(s) applied	**101,325Pa**
Choice of data or measurement methods and procedures	Flow of the gaseous stream is expressed in normalized cubic meters.
Purpose of data	Calculation of project emissions
Additional comments	-

Data/parameter:	T_n
Unit	K
Description	Temperature at normal conditions
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 03.0.0)
Value(s) applied	**273.15 K**

Choice of data or measurement methods and procedures	Flow of the gaseous stream is expressed in normalized cubic meters.
Purpose of data	Calculation of project emissions
Additional comments	-

D.2. Data and parameters monitored

Data/parameter:	**$P_{production,y}$**
Unit	t HNO_3
Description	Nitric acid produced in year y
Measured/calculated/default	Measured
Source of data	Production Report and flow meter (The flow of nitric acid is measured using nitric acid flow meter.) The nitric acid production (as 100% HNO_3) is calculated based on produced nitric acid flow and produced HNO_3 concentration. Produced nitric acid flow is automatically monitored.
Value(s) of monitored parameter	**88,952 t HNO_3** An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.
Monitoring equipment	• Instrument Type : Coriolis Mass Flow Measuring System • Manufacture : Endress + Hauser • Model : Proline Promass 80I • Serial number : J405D802000 • Accuracy class Mass flow liquids : 0.15(Promass 80I) • Calibration frequency : 15 months • Date of last calibration : 16/06/2014 • Validity : 15/09/2015 • Measuring point : At the product line before storage tanks
Measuring/reading/recording frequency:	Measuring frequency : Continuously Reading frequency : Continuously (1 s) Recording frequency : Continuously (Hourly)
Calculation method (if applicable):	This parameter is calculated as follows : $P_{product,y} = Q_{HNO3} * C_{HNO3}$ Where: Q_{HNO3}: Total mass flow of produced nitric acid monitored (not converted to 100% base) in a year y (ton/h) C_{HNO3}: Average mass concentration of produced nitric acid (not pure) (%)
QA/QC procedures:	Periodic calibration will be performed according to manufacturer's recommendations. The quality assurance and quality control procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2000.
Purpose of data:	Calculation of baseline emissions
Additional comments:	Parameter is automatically monitored. Details on HNO_3 concentration can be found in Appendix 2.

Data/parameter:	**h_y**
Unit	h
Description	Number of hours of operation in year y
Measured/calculated/default	Measured
Source of data	Measurements by nitric acid flow meter has been chosen in order to determine whether or not the nitric acid plant is in operation.

Value(s) of monitored parameter	**7,879 hours** An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.
Monitoring equipment	• Instrument Type : Coriolis Mass Flow Measuring System • Manufacture : Endress + Hauser • Model : Proline Promass 80I • Serial number : J405D802000 • Accuracy class Mass flow liquids : 0.15(Promass 80I) • Calibration frequency : 15 months • Date of last calibration : 16/06/2014 • Validity : 15/09/2015 Measuring point : At the product line before storage tanks
Measuring/reading/recording frequency:	Measuring frequency : Continuously Reading frequency : Continuously (1 s) Recording frequency : Continuously (Hourly)
Calculation method (if applicable):	N/A
QA/QC procedures:	Hanwha's maintenance and testing regime including calibration based on the vendor requirement.
Purpose of data:	Calculation of baseline/project emissions
Additional comments:	Records to be maintained during project's lifetime. The data monitored and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs.

Data/parameter:	**$h_{r,y}$**
Unit	h
Description	Number of hours of operation in year y where: For tertiary N_2O abatement. The abatement system is by-passed, underperforming or failed
Measured/calculated/default	Measured
Source of data	Measuring device (Please refer to "calculation method" below)
Value(s) of monitored parameter	**336 hours** An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.
Monitoring equipment	Please refer to "calculation method" below.
Measuring/reading/recording frequency:	Measuring frequency : Continuously Reading frequency : Continuously Recording frequency : Continuously (Hourly)
Calculation method (if applicable):	Nitric acid plant has used AM0028 in the first crediting period, accordingly the abatement system is deemed to be by-passed, not working or failed in the hour h in year y if: $$F_{N2O,tailgas,h} > EF_{existing,y} \times P_{NA,h}$$ The parameters mentioned above will be determined and monitored as explained in the respective sections of this monitoring report: ▪ $P_{NA,h}$ see parameter $P_{production,y}$ ▪ $F_{N2O,tail\ gas,h}$ see parameters $V_{t,db,n}$, $v_{i,t,db}$ and $C_{H2O,t,db,n}$ ▪ $EF_{existing,y}$ needs not to be monitored, since it´s fixed for the crediting period.
QA/QC procedures:	Hanwha's maintenance and testing regime including calibration based on the vendor requirement.
Purpose of data:	Calculation of baseline/project emissions

Additional comments:	Records to be maintained during project's lifetime. The parameter $P_{NA,h}$ (Nitric acid produced in the hour h) represents the hourly value of $P_{production,y}$ and is used for determining $h_{r,y}$ as described in section 5.3.3 of the applied methodology.

Parameters from the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 03.0.0)

Data/parameter:	**$V_{t,db}$**
Unit	Nm^3dry gas/h
Description	Volumetric flow of the gaseous stream in time interval *t* on a dry basis
Measured/calculated/default	Measured
Source of data	Flow meter
Value(s) of monitored parameter	**265,590,172 Nm^3 dry gas** **(total volume from 27/06/2014 – 26/06/2015, from the actual data)** An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.

Monitoring equipment

- ***Differential Pressure Transmitter***

Tag	1st equipment	2nd equipment
Type(Maker/Model)	Differential Pressure Transmitter (Honeywell/STD924-E1H-00000-S2)	
Serial Number	0553 05121501010 (Instrument No. : 10-FT-562)	0712 07030214002 (Instrument No. : 10-FT-562)
Accuracy class	0.075%	0.075%
Calibration frequency	15months	15months
Date of last calibration	29/09/2014	12/09/2013
Validity	29/09/2014~28/12/2015	12/09/2013~11/12/2014
Measuring point	At the tail gas duct after DeN_2O unit	
Measuring range	0~60,000 Nm^3/hr	

- ***Absolute Pressure Transmitter***

Tag	1st equipment	2nd equipment
Type(Maker/Model)	Absolute Pressure Transmitter (Honeywell/STG 944-E1G-00000-S1)	
Serial Number	0712 07030214003 (Instrument No. : 10-PT-362)	9853 00002001004 (Instrument No. : 10-PT-362)
Accuracy class	0.075%	0.075%
Calibration frequency	15months	15months
Date of last calibration	29/09/2014	12/09/2013
Validity	29/09/2014~28/12/2015	12/09/2013~11/12/2014
Measuring point	At the tail gas duct after DeN_2O unit	
Measuring range	-0.1~0.1 bar	

- ***Resistance Temperature Detector***

Tag	1st equipment	2nd equipment
Type(Maker/Model)	Resistance Temperature Detector (WISE controls / R221+ MTM)	
Serial Number	WS-7M423 (Instrument No. : 10-TT-162)	WS-7M140 (Instrument No. : 10-TT-162)
Accuracy class	0.3%	0.3%
Calibration frequency	15months	15months
Date of last calibration	30/09/2014	12/09/2013
Validity	30/09/2014~29/12/2015	12/09/2013~11/12/2014
Measuring point	At the tail gas duct after DeN_2O unit	
Measuring range	0~500deg C	

Measuring/reading/recording frequency:	Measuring frequency : Continuously Reading frequency : Continuously Recording frequency : Continuously (Hourly)

Calculation method (if applicable):	(a) Throughout the crediting periods of the project activity, the N_2O concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is to be installed and maintained throughout the crediting period based on the European Norm 14181 (2004), or any more recent update of that standard; (b) The monitoring system should provide separate hourly average values for the N_2O concentration and the volume or mass flow of the tail gas based on two seconds (or shorter) interval readings that are recorded and stored electronically. These N_2O data sets shall be identified by means of a unique time/date key indicating when exactly the values were observed; (c) The correction factors derived from the calibration curve of the QAL2 audit for the monitoring components as determined during the QAL2-test in accordance with EN14181 must be applied to both the N2O concentration and the volume or mass flow of the tail gas. This can either be applied automatically to the raw data recorded by the data storage system at the plant or it can be applied to the calculated hourly averages as part of the calculation of project emissions; (d) If data for either the N_2O concentration or the volume or mass flow of the tail gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour shall be replaced with the maximum value of N_2O concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the N_2O concentration nor the volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of N_2O calculated during the monitoring period shall be applied to any such hour. Values observed during five operating hours before and after a plant start-up and shut-down shall not be used for the determination of the maximum values; (e) In the case that the N2O concentration and the volume or mass flow of the tail gas and by-pass are automatically converted to normal conditions by the AMS during the monitoring process, the parameters Pt and Tt do not need to be monitored except, if applicable, for the purpose of determining the moisture content in the gaseous stream. Applied correction factor of $v_{t,db}$: 1.036×flow[m^3/h]+0.00
QA/QC procedures:	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications. According to EN 14181, the flowmeter will be tested and calibrated by an external laboratory with EN ISO IEC 17025 Accreditation. The QAL2 test is conducted once every 3 years; the AST test is conducted once per year. Every 3 years the AST test is part of the QAL2 test. Regarding the compliance with the EN14181, the suitability test of QAL1 was not available for the flowmeter during the 1st crediting period and thus, it is required the temporary deviation as per paragraph 100 of EB 47th meeting report. Therefore, prior approval for temporary deviation from the registered monitoring plan submitted to the Board on 23/12/2015 and it was approved by EB on 24/04/2016.
Purpose of data:	Calculation of project emissions
Additional comments:	According to applied tool, parameter is to be monitored in Option A (which is the case for the project activity) The data monitored and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs.

Data/parameter:	$V_{i,t,db}$
Unit	m^3 gas i/m^3 dry gas
Description	Volumetric fraction of greenhouse gas i in a time interval t on a dry basis

<table>
<tr><td>Measured/calculated/default</td><td>Measured</td></tr>
<tr><td>Source of data</td><td>Non-dispersion infrared absorption analyzer (NDIR)</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>1.977 m³ /Nm³ dry gas
(total volumetric fraction from 27/06/2014 – 26/06/2015, from the actual data)
An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.</td></tr>
<tr><td>Monitoring equipment</td><td>▪ NDIR N2O Analyzer
<table>
<tr><td>Tag</td><td>QAL2</td><td>AST</td><td>QAL3</td></tr>
<tr><td>Type(Maker/Model)</td><td colspan="3">NDIR N_2O Analyzer(ABB / AO2040 / Uras 26)</td></tr>
<tr><td>Serial Number</td><td colspan="3">3.346996.7 (Instrument No. : 10-AT-062)</td></tr>
<tr><td>Accuracy class</td><td colspan="3">0.02%</td></tr>
<tr><td>Calibration frequency</td><td>3 years</td><td>12 months</td><td>every 10 days</td></tr>
<tr><td>Date of last calibration</td><td>13/01/2014~
15/01/2014</td><td>15/01/2015~
16/01/2015</td><td>18/06/2015</td></tr>
<tr><td>Validity</td><td>until
14/01/2017</td><td>until
15/01/2016</td><td>Date of last calibration in this monitoring period : until 27/06/2015

Other QAL3 tests within this monitoring period were conducted every 10 days on average within the validity.</td></tr>
<tr><td>Measuring point</td><td colspan="3">At the tail gas duct after DeN_2O unit</td></tr>
<tr><td>Measuring range</td><td colspan="3">0~500ppmv</td></tr>
</table></td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>Measuring frequency : Continuously
Reading frequency : Continuously
Recording frequency : Continuously (Hourly)</td></tr>
</table>

Calculation method (if applicable):	(f) Throughout the crediting periods of the project activity, the N_2O concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is to be installed and maintained throughout the crediting period based on the European Norm 14181 (2004), or any more recent update of that standard; (g) The monitoring system should provide separate hourly average values for the N_2O concentration and the volume or mass flow of the tail gas based on two seconds (or shorter) interval readings that are recorded and stored electronically. These N_2O data sets shall be identified by means of a unique time/date key indicating when exactly the values were observed; (h) The correction factors derived from the calibration curve of the QAL2 audit for the monitoring components as determined during the QAL2-test in accordance with EN14181 must be applied to both the N2O concentration and the volume or mass flow of the tail gas. This can either be applied automatically to the raw data recorded by the data storage system at the plant or it can be applied to the calculated hourly averages as part of the calculation of project emissions; (i) If data for either the N_2O concentration or the volume or mass flow of the tail gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour shall be replaced with the maximum value of N_2O concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the N_2O concentration nor the volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of N_2O calculated during the monitoring period shall be applied to any such hour. Values observed during five operating hours before and after a plant start-up and shut-down shall not be used for the determination of the maximum values; (j) In the case that the N2O concentration and the volume or mass flow of the tail gas and by-pass are automatically converted to normal conditions by the AMS during the monitoring process, the parameters Pt and Tt do not need to be monitored except, if applicable, for the purpose of determining the moisture content in the gaseous stream. Applied correction factor of $v_{i,t,db}$ *: 0.999×N2O[ppm]+0.00*
QA/QC procedures:	According to EN 14181, the analyzer will be tested and calibrated by an external laboratory with EN ISO IEC 17025 Accreditation. The QAL2 test is conducted once every 3 years; the AST test is conducted once per year. Every 3 years the AST test is part of the QAL2 test. ABB AO2040 Uras26 which is fitted with integral calibration check cell is used. Calibration is done manually and will be recorded on the data logging system. The calibration is carried out within every 10 days. Calibration is intended to be done by the plant operator with routine procedure for QAL-3 certification of the system.
Purpose of data:	Calculation of project emissions
Additional comments:	According to applied tool, parameter is to be monitored in Option A (which is the case for the project activity) The data monitored and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs.

Data/parameter:	$C_{H2O,t,db,n}$
Unit	mg H_2O/m^3 dry gas
Description	Moisture content of the gaseous stream at normal conditions, in time interval t
Measured/calculated/default	Measured
Source of data	Measurements according to the USEPA CF42 method 4 - Gravimetric determination of water content

Value(s) of monitored parameter	**0.0041 kgH_2O/m^3 dry gas**(AST in 15/01/2015~16/01/2015) **0.0070 kgH_2O/m^3 dry gas**(QAL2 in 13/01/2014~15/01/2014) Option A of the tool can be applied, as the moisture content is less than 0.05 kg H_2O/m^3 dry gas.
Monitoring equipment	N/A
Measuring/reading/recording frequency:	Measuring / Reading / Recording: Yearly Measurements will coincide with the Annual Surveillance Test (associated with requirements of the EN 14181 standard) or the calibration of the flow meter for the gaseous stream.
Calculation method (if applicable):	N/A
QA/QC procedures:	According to the USEPA CF42 method 4
Purpose of data:	Calculation of project emissions
Additional comments:	Monitoring is required if Option 1 described in the “Determination of the absolute humidity of the gaseous stream” section of the tool is applied, or as one of the ways of proving that the gaseous stream is dry (necessary for Options A or D). The data monitored and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs.

Data/parameter:	**$FC_{i,j,y}$**
Unit	Nm^3/y
Description	Quantity of natural gas combusted in the tertiary N_2O abatement facility during the year y
Measured/calculated/default	Measured
Source of data	Integral orifice meter with temperature, pressure compensation
Value(s) of monitored parameter	**150,583.8 Nm^3/y** **(total volume from 27/06/2014 – 26/06/2015, from the actual data)** An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.

<table>
<tr><td>Monitoring equipment</td><td>

▪ ***Differential pressure transmitter with pressure,/temperature application for compensation***

<table>
<tr><td>Tag</td><td>1st equipment</td><td>2nd equipment</td></tr>
<tr><td>Type (Maker/Model)</td><td>Differential pressure transmitter with pressure,/temperature application for compensation (Honeywell/YSMA125-E1H-00000-1C,CC,F1,MB,MC,S3,(SM)+XXXX)</td><td>Differential pressure transmitter with pressure,/temperature application for compensation (Rosemount/Emerson, 3095MFCCS020N040T32BA1AQ4I5M5)</td></tr>
<tr><td>Serial Number</td><td>0712C2932575001001 (Instrument No. 10-FT-563)</td><td>02357885 (Instrument No. 10-FT-563)</td></tr>
<tr><td>Accuracy class</td><td>±0.2%</td><td>±0.075%</td></tr>
<tr><td>Calibration frequency</td><td>15 months</td><td>15 months</td></tr>
<tr><td>Date of last calibration</td><td>29/09/2014</td><td>12/09/2013</td></tr>
<tr><td>Validity</td><td>29/09/2014~28/12/2015</td><td>12/09/2013~11/12/2014</td></tr>
<tr><td>Measuring point</td><td colspan="2">At the Burner Inlet of DeN_2O unit</td></tr>
<tr><td>Measuring range</td><td colspan="2">0~100 Nm^3/hr</td></tr>
</table>

</td></tr>
<tr><td>Measuring/reading/recording frequency:</td><td>Measuring frequency : Continuously
Reading frequency : Continuously
Recording frequency : Continuously (Hourly)</td></tr>
<tr><td>Calculation method (if applicable):</td><td>N/A</td></tr>
<tr><td>QA/QC procedures:</td><td>Hanwha's maintenance and testing regime including calibration based on the vendor requirement.</td></tr>
<tr><td>Purpose of data:</td><td>Calculation of project emissions</td></tr>
<tr><td>Additional comments:</td><td>N/A</td></tr>
</table>

Data/parameter:	$W_{C,i,y}$
Unit	tC/tNG
Description	Weighted average mass fraction of carbon in natural gas in year y
Measured/calculated/default	Calculated
Source of data	Values provided by the fuel supplier in invoices (Data from local supplier, Kyungdong City Gas Corporation)
Value(s) of monitored parameter	**0.758 tC/tNG** An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.
Monitoring equipment	N/A
Measuring/reading/recording frequency:	Monthly
Calculation method (if applicable):	N/A
QA/QC procedures:	N/A
Purpose of data:	Calculation of project emissions
Additional comments:	N/A

Data/parameter:	$\rho_{i,y}$
Unit	t/Nm^3

Description	Weighted average density of natural gas in year y
Measured/calculated/default	Measured
Source of data	Values provided by the fuel supplier in invoices (Data from local supplier, Kyungdong City Gas Corporation)
Value(s) of monitored parameter	**0.000787 t/Nm^3** An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.
Monitoring equipment	N/A
Measuring/reading/recording frequency:	daily
Calculation method (if applicable):	N/A
QA/QC procedures:	N/A
Purpose of data:	Calculation of project emissions
Additional comments:	N/A

D.3. Implementation of sampling plan

>>

Not applicable for the project activity.

SECTION E. Calculation of emission reductions or GHG removals by sinks

E.1. Calculation of baseline emissions or baseline net GHG removals by sinks

>>

Baseline emissions are calculated as follows:

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

Where:

BE_y	=	Baseline emissions in year y (t CO_2e)
$P_{product,max}$	=	Design capacity (t HNO_3)
$P_{product,y}$	=	Production of nitric acid in year y (t HNO_3)
$EF_{existing,y}$	=	N_2O emission factor for nitric acid plants that have used AM0028 in the first crediting period in year y (kg N_2O/t HNO_3)
$EF_{new,y}$	=	Baseline N_2O emission factor for nitric acid production in year y (kg N_2O/t HNO_3)
GWP_{N2O}	=	Global Warming Potential of N_2O valid for the commitment period
h_y	=	Number of hours in year y during which the plant was in operation (h)

The values for this monitoring period are:

Year / Period	BE_y	$EF_{existing,y}$	$EF_{new,y}$	$P_{production,y}$	$P_{production,max}$	h_y	$h_{r,y}$	GWP_{N2O}
	tCO_2-e	$kgN_2O/tHNO_3$	$kgN_2O/tHNO_3$	$tHNO_3$	$tHNO_3$	h	h	-
27/06/2014 ~ 31/12/2014	120,469	9.47	3.50	44,569	55,164	4,075	278	298
01/01/2015 ~ 26/06/2015	119,968	9.47	3.40	44,383	51,936	3,804	58	298
Total	**240,437**			**88,952**	**107,100**	**7,879**	**336**	**298**

Determination of the baseline N_2O emission factor for nitric acid plants that have used AM0028 in the first crediting period ($EF_{exisitng,y}$) will be calculated as follows:

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

Where:

$EF_{existing,y}$ = N_2O emission factor for nitric acid plants that have used AM0028 in the first crediting period in year y (kg N_2O/t HNO_3)

$EF_{historical}$ = Historical baseline emission factor of the nitric acid plant (kg N_2O/t HNO_3)

$EF_{default,y}$ = Default emission factor according to the operating pressure of the ammonia burner in year y (kg N_2O/t HNO_3)

If the monitoring period spans across two (or more) calendar years, the baseline emissions (BEy) shall be calculated separately for each calendar year, first establishing $EF_{existing,y}$, $EF_{new,y}$, $EF_{default,y}$ and then applying this to the nitric acid production of that calendar year.

The values for this monitoring period are:

Year / Period	$EF_{existing,y}$	$EF_{historical,y}$	$EF_{default,y}$ (for high pressure)
	tCO_2-e	$kgN_2O/tHNO_3$	$kgN_2O/tHNO_3$
27/06/2014 ~ 31/12/2014	**9.47**	**9.47**	**12.40**
01/01/2015 ~ 26/06/2015	**9.47**	**9.47**	**12.20**

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

>>

Project emissions are calculated as follows:

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

Where:

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

The values for this monitoring period are:

Year / Period	PE_y	$PE_{N2O,y}$	$PE_{CO2,tertiary,y}$
	tCO_2-e	tCO_2-e	tCO_2-e
27/06/2014 ~ 26/06/2015	**37,052**	**36,723**	**329**

Project emissions of N_2O from the project plant ($PE_{N2O,y}$)

The amount of N_2O emissions from the project activity are the emissions from the N_2O contained in the tail gas stream of the plant which is released to the atmosphere.

Accordingly, $PE_{N2O,y}$ is determined as follows:

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

Where:

$PE_{N2O,y}$	=	Project emissions of N_2O from the project plant in year y (t CO_2e)
GWP_{N2O}	=	Global warming potential of N_2O valid for the commitment period
$F_{N2O,tail\ gas,h}$	=	Mass flow of N_2O in the gaseous stream of the tail gas in the hour h (kg N_2O/h)
h_y	=	Number of hours in year y during which the plant was in operation (h)
$h_{r,y}$	=	Number of hours (h) in year y where: For tertiary N_2O abatement. The abatement system is by-passed, underperforming or failed

The values for this monitoring period are:

Year / Period	$PE_{N2O,y}$	$F_{N2O,tail\ gas,y}$	h_y	$h_{r,y}$	GWP_{N2O}
	tCO_2-e	kg N_2O/h	h	h	-
27/06/2014 ~ 26/06/2015	**36,723**	**133,304**	**7,879**	**336**	**298**

Determination of $F_{N2O,tail\ gas,h}$

The amount of N_2O emissions from the tail gas stream of the project plant shall be determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream".
In applying the tool, the following provisions apply:

(a) Throughout the crediting periods of the project activity, the N_2O concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is to be installed and maintained throughout the crediting period based on the European Norm 14181 (2004), or any more recent update of that standard;

(b) The monitoring system should provide separate hourly average values for the N_2O concentration and the volume or mass flow of the tail gas based on two seconds (or shorter)

interval readings that are recorded and stored electronically. These N_2O data sets shall be identified by means of a unique time/date key indicating when exactly the values were observed;

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

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

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

For measuring of $F_{N2O,tail\ gas,h,}$ this project meet the above conditions:

According to the applied tool the mass flow of greenhouse gas i in the gaseous stream in time interval t ($F_{i,t}$) is calculated based on measurements of (a) the total volume flow or mass flow of the gas stream, (b) the volumetric fraction of the gas in the gaseous stream and (c) the gas composition and water content.
The flow and volumetric fraction may be measured on a dry basis or wet basis. The tool covers the possible measurement combinations, providing six different calculation options to determine the mass flow of a particular greenhouse gas (Option A to F).

Based on the currently available information Option A (measurement options for option A: volume flow of gaseous stream on dry basis, volumetric fraction on dry or wet basis) of the tool will be applied, which states two ways how to demonstrate that the gaseous stream is dry. These are:

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

This project applied Option A since the measured moisture content of the gaseous stream was less than 0.05 kg H_2O/m^3 dry gas during the first crediting period.

The mass flow of greenhouse gas i ($F_{i,t}$) [4] is determined as follows:

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

with

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

[4] $F_{i,t}$ corresponds to the parameter $F_{N2O,tail\ gas,h}$ of the methodology ACM0019.

Where:

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

The values for this monitoring period are:

Year / Period	$F_{N2O,tail\ gas,y}$	$\rho_{i,y}$	$V_{t,db,n}$	$V_{i,t,db}$
	kg N_2O/h	Kg/m^3	m^3dry gas/ h	Nm^3 N_2O gas /m^3 dry gas
27/06/2014 ~ 26/06/2015	**133,304**	**1.964**	**265,590,172**	**1.977**

<u>Project emissions from the operation of the tertiary N_2O abatement facility $PE_{CO2,tertiary,y}$</u>

This emission source only needs to be estimated if a tertiary N_2O abatement facility is installed under the project activity and if fossil fuels are used to operate the facility or re-heat the gas after the facility.

The emissions related to the operation of the N_2O destruction facility include only on-site emissions due to the fossil fuel use as input to the N_2O destruction facility:

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

Where:

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

Project proponents shall use the latest version of the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” to calculate the project emissions related to fossil fuels used in year y.

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

The values for this monitoring period are:

Year / Period	$PE_{CO2,tertiary,y} = PE_{FF,y} = PE_{FC,j,y}$
	tCO_2-e

27/06/2014 ~ 26/06/2015	**329**

According to the applied tool CO_2 emissions from fossil fuel (natural gas) combustion in process j(tertiary N_2O abatement facility) are calculated based on the quantity of fuels combusted and the CO_2 emission coefficient of those fuels, as follows:

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

Where:

$PE_{FC,j,y}$	=	Are the CO_2 emissions from fossil fuel combustion in process j during the year y (tCO_2/yr);
$FC_{i,j,y}$	=	Is the quantity of fuel type i combusted in process j during the year y (mass or volume unit/yr);
$COEF_{i,y}$	=	Is the CO_2 emission coefficient of fuel type i in year y (tCO2/mass or volume unit)
i	=	Are the fuel types combusted in process j during the year y

According to the applied tool, the CO_2 emission coefficient $COEF_{i,y}$ can be calculated using one of the two Options, depending on the availability of data on the fossil fuel type i.

Option A of the definition of CO_2 emission factor of natural gas according to "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (Version 02) is preferable subject to the data availability. Option A is applicable as necessary data of natural gas composition are available by the fuel supplier and project proponent. Thus the Option A is applied in order to define CO_2 emission factor of natural gas.
The CO_2 emission coefficient $COEF_{i,y}$ is calculated based on the chemical composition of the fossil fuel type i, using the following approach:

If $FC_{i,j,y}$ is measured in a volume unit:

$$COEF_{i,y} = W_{C,i,y} \times \rho_{i,t} \times 44/12$$

Where:

$COEF_{i,y}$	=	Is the CO_2 emission coefficient of fuel type i (tCO_2/mass or volume unit);
$W_{C,i,y}$	=	Is the weighted average mass fraction of carbon in fuel type i in year y(tC/mass unit of the fuel)
$\rho_{i,y}$	=	Is the weighted average density of fuel type i in year y (mass unit/volume unit of the fuel)
i	=	Are the fuel types combusted in process j during the year y

The values for this monitoring period are:

Year / Period	$PE_{FC,j,y}$	$FC_{i,j,y}$	$COEF_{i,y}$
	tCO_2	Nm^3	tCO_2/ Nm^3
27/06/2014 ~ 26/06/2015	**329**	**150,583**	**0.00219** **$w_{c,I,y}$: 0.7578 tC/tNG** **ρ_{NG} : 0.7874 kg/Nm^3** **$w_{c,I,y} \times \rho_{NG} \times 44/12 \times 10^{-3}$**

For detailed calculation please refer to excel spread sheet.

E.3. Calculation of leakage

>>

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

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

Item	Baseline emissions or baseline net GHG removals by sinks (t CO_2e)	Project emissions or actual net GHG removals by sinks (t CO_2e)	Leakage (t CO_2e)	GHG emission reductions or net GHG removals by sinks (t CO_2e) achieved in the monitoring period		
				Up to 31/12/2012	From 01/01/2013	Total amount
Total	240,437	37,052	0	N/A	203,384	203,384

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

Item	Values estimated in ex ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO_2e)	242,526 (365 days)	203,384 (365 days)

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

>>

Compared to PDD, value of emission reductions was reduced around 16%.
The emissions reductions in this monitoring period are 202,885 tonnes of CO_2 equivalents. The yearly expected emissions reductions for the relevant period according to the registered PDD are 242,526 tonnes of CO_2 equivalents in 365 days.
The reason for this difference is that Nitric Acid plant & DeN_2O unit shutdowns in this monitoring period. DeN_2O unit was not operated due to the replacement of primary catalyst and the following reason.

- Nitric acid plant was shut-down because of inventory control.
- Nitric acid plant & DeN_2O Unit was shut-down because of primary catalyst replaces and major overhaul.
- DeN_2O Unit was shut-down because of lack of steam.
- Emergency shut-down because of main power failure.
- Emergency shut-down because of W/W (warm water) pump cavitation.
- Emergency shut-down because of compressor flow control valve malfunction.

Appendix 1. Contact information of project participants and responsible persons/entities

Project participant and/or responsible person/ entity	☒ Project participant ☒ Person/entity responsible for completing the CDM-MR-FORM
Organization name	HANWHA Corporation
Street/P.O. Box	86, Cheonggyecheon-ro, Jung-gu, Seoul, Korea
Building	23F. Hanwha Bldg.
City	Seoul
State/region	
Postcode	04541
Country	Republic of Korea
Telephone	+82-2-729-1899
Fax	+82-2-729-1821
E-mail	woobj@hanwha.com
Website	http://www.hanwha.com/content/hanwha/en.html
Contact person	Mr.Bom Je Woo
Title	Manager
Salutation	
Last name	Woo
Middle name	
First name	Bom Je
Department	Industrial Explosives Department, Chemical Business Team
Mobile	
Direct fax	+82-2-729-1821
Direct tel.	+82-2-729-1899
Personal e-mail	woobj@hanwha.com

Appendix 2. Emission reduction calculation

An excel book containing monitored data and calculations of baseline emissions, project emissions and emission reductions and additional checks and information is attached:

Hanwha_10th CERs_June 26 2014~June 26 2015_v2.0