

MONITORING REPORT FOR REDUCTION OF GHG EMISSIONS IN PROPYLENE OXIDE PRODUCTION AT MTP HPPO MANUFACTURING CO., LTD.



Document Prepared By South Pole Carbon (Thailand) Co.,Ltd

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Project Title	REDUCTION OF GHG EMISSIONS IN PROPYLENE OXIDE PRODUCTION AT MTP HPPO MANUFACTURING CO., LTD.
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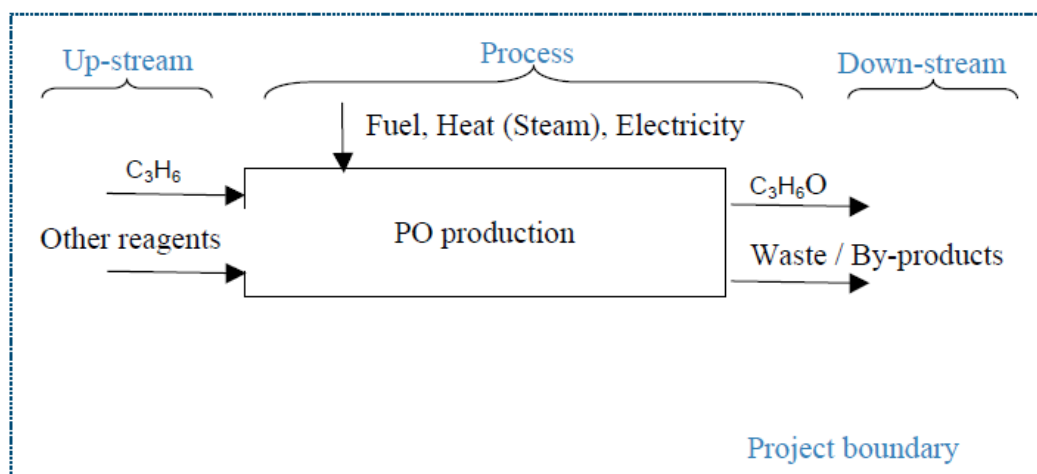
1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

By means of this Monitoring Report, greenhouse gas emission reductions achieved by the project activity titled “*Reduction of GHG Emissions in Propylene Oxide Production at MTP HPPO Manufacturing Co., Ltd.*” are being verified and certified as per requirements of the VCS Methodology, VM0023, Version 1 for the period of 04 October 2011 –to 31 March 2014.

The project involves a new process installation at a production facility of Propylene Oxide (PO) at MTP HPPO Manufacturing Co., Ltd, a joint venture between The Siam Cement Public Co., Ltd and The Dow Chemical Company, which is Hydrogen Peroxide-based Propylene Oxide (HPPO) technology instead of the conventional Chlorohydrin process. The conventional Chlorohydrin process is one of the typical processes in the Propylene Oxide industry that involves hydrochlorination process. In the Chlorohydrin process, Propylene (C_3H_6) is combined to hypochlorous acid to form a Chlorohydrin intermediate which is subsequently dechlorohydrinated to PO and leads to the formation of salts. While in the HPPO process, Propylene and Hydrogen peroxide is combined to produce PO.

The spatial extent of the project boundary encompasses PO manufacturing plant from reagents admission to the treatment of by-products and waste from process.



The project boundary encompasses also the project electricity system(s) and Heat/steam generation system that the PO plant is connected to.

The spatial extent of the project electricity system consists of the power plants that are physically connected through transmission and distribution lines to the project activity and that can be dispatched without significant transmission constraints. The project is connected to the Glow grid which in turn is connected to the national grid. Therefore, the national grid is considered as the ultimate connected grid.

The spatial extent for the heat (steam) system is similar, including the heat/steam generating systems that are physically connected to the project activity and that can be displaced without significant constraints. The heat (steam) requirements of the project are met by the steam extracted from the cogeneration plants of Glow grid. As the emissions get accounted in the electricity component therefore to avoid double counting and applying conservative principle

the emission factor for steam has been considered as zero. The fuel requirement is for incineration purpose. Natural gas is being used as the fuel.

As compared to the conventional processes based on Chlorohydrin technology, the HPPO technology reduces overall energy consumption, thus resulting in significant emission reductions. Furthermore, the HPPO technology diminishes the waste volume also significantly, and decreases the infrastructure requirements and physical footprint by using simpler raw material and avoiding co-products.

As per the VCS's guideline, the project is verified against the VCS standard. Further background information on the project activity is available on the V-C-S under project number 1502 : http://www.vcsprojectdatabase.org/#/project_details/1502. This verification is the 1st verification for this project in the 1st crediting period.

1.2 Sectoral Scope and Project Type

The project activity falls under the category 5, chemical industry. The project is a single project activity and not a grouped project.

1.3 Project Proponent

Organization name	MTP HPPO Manufacturing Co.,Ltd.
Contact person	Mr. Jirasak Singmaneechai
Title	Managing Director
Address	15th Floor, White Group Building II, 75 Soi Rubia, Sukumvit 42 Road, Prakanong, Klongtoey, Bangkok, Thailand.
Telephone	+66 2 365 7000
Email	Sjirasak@dow.com

1.4 Other Entities Involved in the Project

Organization name	South Pole Carbon (Thailand) Co.,Ltd.
Role in the project	Consultant
Contact person	Mr.Patrick Buergi
Title	Director
Address	2/22 Iyara Building, 6 th Floor, Chan Road , Thungwatdon Sathorn , Bangkok, Thailand - 10120
Telephone	+66 2 678 8979
Email	p.buergi@southpolecarbon.com

1.5 Project Start Date

The project start date is 04th October 2011 which is the actual commissioning date of the new HPPO technology at MTP HPPO Manufacturing Co.,Ltd.

1.6 Project Crediting Period

This crediting period of this project is 10 years. Starting from 04 October 2011 up to 03 October 2021. The crediting period may be renewed twice.

1.7 Project Location

The project activity is located at 10 Moo 2, Asia Industrial Estate, Banchang, Rayong, Thailand (<http://www.dow.com/thailand/about/locations.htm>). The coordinate of the production facility are:

Latitude: 12.7342 (12° 44' 03" N); Longitude 101.0485 (101° 02' 54" E)

[Source: <http://earthexplorer.usgs.gov/>]

The project location is also shown in the following figure.



Figure 1 : Project Location

1.8 Title and Reference of Methodology

The emission reduction calculations and the monitoring plan are based on the approved VCS methodologies;

VM0023 : *Reduction of GHG emissions in Propylene Oxide production*
 Sectoral scope : 5
 Version : 01

Tools applied

Tool for the demonstration and assessment of additionality, Version 7.0;

Tool to calculate the emission factor for an electricity system, Version 4.0;

Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion , Version 2.

1.9 Other Programs

Not Applicable.

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

During June 2008, SCG-Dow Group, a joint venture between The Dow Chemical Company and The Siam Cement Group (SCG) broke ground on a 390,000tpa propylene oxide (PO) plant. Full capacity run was achieved in November 2011. The plant fulfilled all quality and production parameters. Commercial operations at the plant began in January 2012 after completing the full capacity performance test.

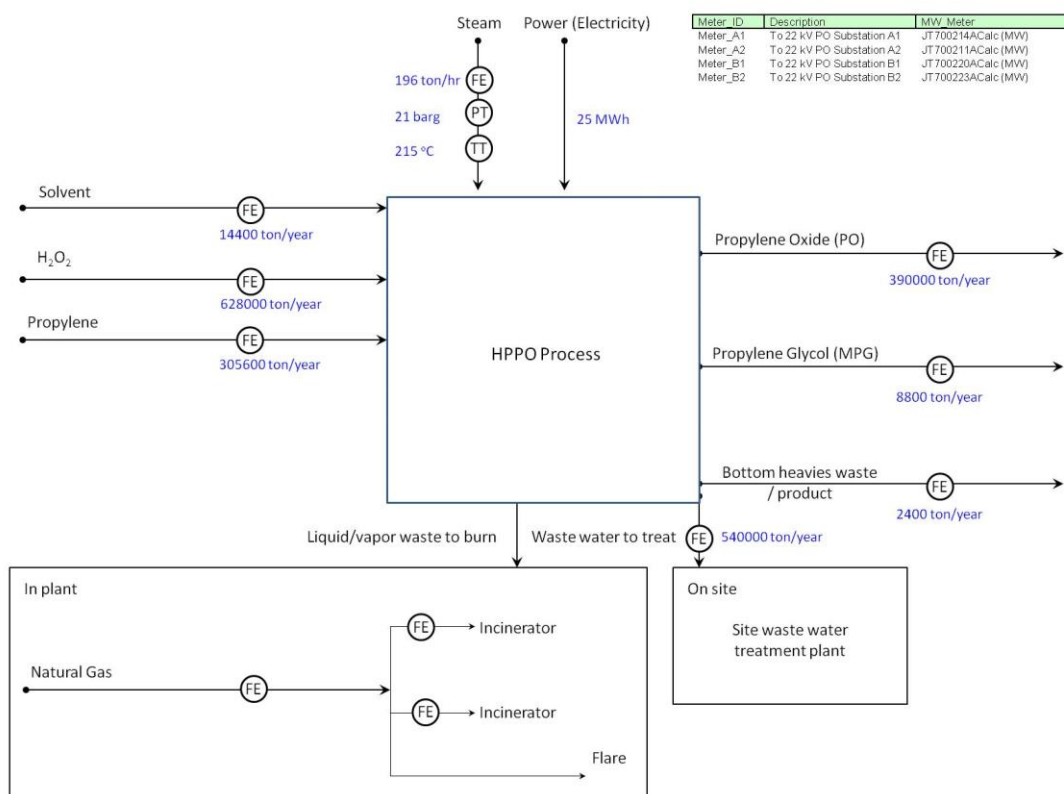


Figure 2 : Monitoring diagram

The above flow diagram from the registered PD has been followed as monitoring plan , as well as for plant's routine monitoring system.

Within this monitoring period , there were no significant occurrences of events , which affected the project activity within the project boundary.

2.2 Deviations

2.2.1 Methodology Deviations

There is no methodology deviation raised in this monitoring period.

2.2.2 Project Description Deviations

Description of deviation

The accuracy of the installed flow meters for monitoring the amount of PO_y and MeOH is not consistent with the accuracy identified in the registered PD , which is +/- 0.15% of reading.

The actual accuracy in the technical specification document is +/- 0.65% of reading for the same type and model of meter.

This model of flow meter has been installed since the commissioning of project activity and used for measuring the amount of of PO_y and MeOH for this entire monitoring period. These

flow meters were checked during the validation site visit. The value mentioned in the registered PD may be a typographical error.

Justification for project description deviation

The technical specification of the installed flow meters provided by the manufacturer's is ;

Brand	Rosemount
Type	Vortex
Model	8800DF020SA1N2D1E5T1CNQ4
Accuracy	+/- 0.65% of reading

Source : <http://www2.emersonprocess.com/siteadmincenter/PM%20Rosemount%20Documents/00813-0100-4004.pdf>

The accuracy of this type of flow meter reported in this monitoring report is changed from +/- 0.15% to be +/- 0.65% in **Table 4**.

This deviation does not impact the applicability of the methodology, additionality or the appropriateness of the baseline scenario, and the project remains in compliance with the applied methodology.

2.3 Grouped Project

This project is not grouped project.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data / Parameter	ECChlor-Alkali, y
Data unit	MWh/tCl ₂
Description	Energy consumption per tonne of Cl ₂ production in year y.
Source of data	Independent third party report from a recognized, credible source which must be reviewed by an appropriately qualified, independent organization or appropriate peer review group, or be published by a government agency.
Value applied:	2.2
Justification of choice of data or description of measurement methods and procedures applied	The membrane cell process is the preferred process for new PO production facilities. Thus, it is assumed that production of chlor-alkali in the baseline PO production facility is through the membrane cell process ¹ .
Purpose of the data	Calculation of baseline emissions
Comments	-

¹ <http://www.miga.org/documents/ChlorAlkali.pdf>

Data / Parameter	SSC _{CHPO}
Data unit	TJ/ton of PO
Description	Specific thermal energy consumption ratio in PO production through the CHPO-chlor-alkali process.
Source of data	Independent third party report
Value applied:	0.003864
Justification of choice of data or description of measurement methods and procedures applied	Steam consumption is converted conservatively into energy terms using enthalpy values and accounting for any condensate return
Purpose of the data	Calculation of baseline emissions
Comments	Nexant report on HPPO, Table 4.3 and 4.5 This parameter is not considered in both baseline scenario and is conservative since baseline thermal energy consumption is higher as compared to project.

Data / Parameter	SEC _{CHPO}
Data unit	MWh/ton of PO
Description	Specific electrical energy consumption ratio in PO production through the CHPO-chlor-alkali process.
Source of data	Independent third party report
Value applied:	0.100
Justification of choice of data or description of measurement methods and procedures applied	Electrical energy required per ton of the PO in the CHPO process excluding the chlor-alkali production
Purpose of the data	Calculation of baseline emissions
Comments	Nexant report on HPPO, Table 4.5

Data / Parameter	p _{eHP}
Data unit	tCO ₂ / tH ₂ O ₂
Description	Quantity of CO ₂ that would be emitted per ton of H ₂ O ₂
Source of data	Independent third party report
Value applied:	0.533
Justification of choice of data or description of measurement methods and procedures applied	Amount of CO ₂ expected to be released per ton of the H ₂ O ₂ production based on Life Cycle Assessment (LCA) study
Purpose of the data	Calculation of baseline emissions

Comments	Sourced from certified environmental product declaration (EPD) for hydrogen peroxide
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Data / Parameter	p _{eSol}
Data unit	tCO ₂ /tonne of solvent
Description	Quantity of CO ₂ emitted per tonne of solvent
Source of data	Table 3.12, Chapter 3: Chemical Industry Emissions, IPCC 2006 report
Value applied:	0.310
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of the data	Calculation of project emissions
Comments	-

Data / Parameter	C _{aWaste,Baseline}
Data unit	tC/ ton of PO
Description	Carbon amount in the waste stream combusted in the incinerator in the baseline per ton of PO
Source of data	-
Value applied:	-
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of the data	Calculation of baseline emissions
Comments	Excluded for simplification

Data / Parameter	f _{ci,Baseline}
Data unit	Ratio
Description	Quantity of fossil fuel combusted in the incinerator in the baseline per ton of PO production
Source of data	-
Value applied:	-
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of the data	Calculation of baseline emissions

Comments	Excluded for simplification
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Data / Parameter	EF _{EL,y}
Data unit	tCO ₂ /MWh
Description	Emission factor for electricity generation in year y
Source of data	Electricity Generating Authority of Thailand (EGAT)
Value applied:	0.5113
Justification of choice of data or description of measurement methods and procedures applied	The emission factor is calculated according to the latest 'Tool to calculate the emission factor for an electricity system' Version 4.0 provided by Thailand Greenhouse Gas Management Organization (Public Organization): TGO.
Purpose of the data	Calculation of baseline and project emissions
Comments	Although the emission factor provided by the Thai DNA refers to version 2.2.1 of the tool. However the changes from version 2.2.1 to version 4.0 of the tool do not impact the computation in the context of Thailand.

3.2 Data and Parameters Monitored

Data / Parameter	PO _y								
Data unit	tonnes								
Description	Quantity of PO produced in year y								
Source of data	Plant records								
Description of measurement methods and procedures to be applied	Flow-rate meters and cross-check with stock verification records.								
Frequency of monitoring/recording	Continuous monitoring, integrated daily and at least monthly recordings								
Value monitored:	<table> <tr> <td>2011</td><td>62,167</td></tr> <tr> <td>2012</td><td>321,724</td></tr> <tr> <td>2013</td><td>357,912</td></tr> <tr> <td>2014</td><td>89,387</td></tr> </table>	2011	62,167	2012	321,724	2013	357,912	2014	89,387
2011	62,167								
2012	321,724								
2013	357,912								
2014	89,387								
Monitoring equipment	Presented in								
QA/QC procedures to be applied	Meters are calibrated regularly , every 60 months or 5 years , according to the shutdown plan of HPPO plant.								
Purpose of the data	Calculation of baseline and project emissions								

Calculation method	Not applicable
Comments	

Data / Parameter	Sol _y								
Data unit	tonnes								
Description	Quantity of make-up solvent used in year y.								
Source of data	PO production facility records.								
Description of measurement methods and procedures to be applied	Flow-rate meters, mass meters, cross-check with stock verification records.								
Frequency of monitoring/recording	Data monitoring is continuous and aggregate recording must be performed at least monthly.								
Value monitored:	<table> <tr> <td>2011</td><td>5,049</td></tr> <tr> <td>2012</td><td>19,061</td></tr> <tr> <td>2013</td><td>21,634</td></tr> <tr> <td>2014</td><td>4,366</td></tr> </table>	2011	5,049	2012	19,061	2013	21,634	2014	4,366
2011	5,049								
2012	19,061								
2013	21,634								
2014	4,366								
Monitoring equipment	Presented in								
QA/QC procedures to be applied	Meters are calibrated regularly , every 60 months or 5 years , according to the shutdown plan of HPPO plant.								
Purpose of the data	Calculation of project emissions								
Calculation method	Not applicable								
Comments	Note that sol _y , as found in equation 12, is used only for ex-ante estimations, and its value must be estimated based upon the design details of the project. For ex-post calculations, "sol _y X PO _y " is represented by Sol _y in equation 12, the value of which is monitored in accordance with the procedures described above.								

Data / Parameter	EF _{CO₂,i,y}
Data unit	tCO ₂ /TJ
Description	Weighted average CO ₂ emission factor of fossil fuel used during year y
Source of data	Default value from IPCC Table 2.3 : Default emission factors for stationary combustion in manufacturing industries and construction ²

² http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf

Description of measurement methods and procedures to be applied	Onsite observation				
Frequency of monitoring/recording	Annually				
Value monitored:	<table border="1"> <tr> <td>Type</td><td>tCO₂/TJ</td></tr> <tr> <td>Natural gas</td><td>56.1</td></tr> </table>	Type	tCO ₂ /TJ	Natural gas	56.1
Type	tCO ₂ /TJ				
Natural gas	56.1				
Monitoring equipment	-				
QA/QC procedures to be applied	-				
Purpose of the data	Calculation of baseline and project emissions				
Calculation method	-				
Comments	International publicly available data				

Data / Parameter	$\eta_{\text{Boiler},y}$
Data unit	%
Description	Efficiency of the steam generating system
Source of data	-
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	-
Value monitored:	-
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of baseline and project emissions
Calculation method	-
Comments	This parameter is not considered in both baseline and project scenario and is conservative since baseline energy consumption is higher as compared to project. Source: Nexant report on HPPO, Table 4.3 & 4.5

Data / Parameter	$SC_{\text{HPPO},y}$
Data unit	TJ
Description	Thermal energy consumption in the PO production through HPPO process in year y
Source of data	Plant records
Description of measurement methods and procedures to be applied	Steam consumption would be converted conservatively into energy terms using enthalpy values and accounting for any condensate return.

Frequency of monitoring/recording	Calculated								
Value monitored:	<table> <tr> <td>2011</td><td>343</td></tr> <tr> <td>2012</td><td>1,396</td></tr> <tr> <td>2013</td><td>1,280</td></tr> <tr> <td>2014</td><td>287</td></tr> </table>	2011	343	2012	1,396	2013	1,280	2014	287
2011	343								
2012	1,396								
2013	1,280								
2014	287								
Monitoring equipment	Presented in								
QA/QC procedures to be applied	Cross-checking with thermal energy purchase receipt from the thermal supplier								
Purpose of the data	Calculation of project emissions								
Calculation method	The respective enthalpies should be determined based on the mass (or volume) flows, the temperatures and, in case of superheated steam, the pressure. Steam tables or appropriate thermodynamic equations may be used to calculate the enthalpy as a function of temperature and pressure.								
Comments	<i>This parameter is not considered in both baseline and project scenario and is conservative since baseline thermal energy consumption is higher as compared to project.</i> Source: Nexant report on HPPO, Table 4.3 & 4.5								

Data / Parameter	EC _{HPPO,y}								
Data unit	MWh								
Description	Electrical energy consumption in the PO production through HPPO process in year y								
Source of data	Plant records								
Description of measurement methods and procedures to be applied	Electrical consumption to be monitored continuously and the average specific electrical energy consumption to be calculated based on PO production								
Frequency of monitoring/recording	Continuous monitoring, integrated daily and at least monthly recordings								
Value monitored:	<table> <tr> <td>2011</td><td>55,428</td></tr> <tr> <td>2012</td><td>217,095</td></tr> <tr> <td>2013</td><td>227,688</td></tr> <tr> <td>2014</td><td>57,069</td></tr> </table>	2011	55,428	2012	217,095	2013	227,688	2014	57,069
2011	55,428								
2012	217,095								
2013	227,688								
2014	57,069								
Monitoring equipment	Presented in								

QA/QC procedures to be applied	Meters are calibrated regularly , every 60 months or 5 years , according to the shutdown plan of HPPO plant.
Purpose of the data	Calculation of project emissions
Calculation method	-
Comments	

Data / Parameter	Q _{Propylene,y}									
Data unit	Tonnes									
Description	Quantity of propylene used in year y.									
Source of data	PO production facility records									
Description of measurement methods and procedures to be applied	Flow-rate meters, mass meters, cross-check with stock verification records.									
Frequency of monitoring/recording	Data monitoring is continuous and aggregate recording must be performed at least monthly									
Value monitored:	<table><tr><td>2011</td><td>50,849</td></tr><tr><td>2012</td><td>253,606</td></tr><tr><td>2013</td><td>285,016</td></tr><tr><td>2014</td><td>71,720</td></tr></table>		2011	50,849	2012	253,606	2013	285,016	2014	71,720
2011	50,849									
2012	253,606									
2013	285,016									
2014	71,720									
Monitoring equipment	Presented in									
QA/QC procedures to be applied	Meters are calibrated regularly , every 60 months or 5 years , according to the shutdown plan of HPPO plant.									
Purpose of the data	Calculation of project emissions									
Calculation method	-									
Comments	-									

Data / Parameter	Q _{By-product,y}	
Data unit	Tonnes	
Description	Quantity of by-product produced in year y.	
Source of data	PO production facility records	
Description of measurement methods and procedures to be applied	Flow-rate meters, mass meters, cross-check with stock verification records.	
Frequency of monitoring/recording	Data monitoring is continuous and aggregate recording must be performed at least monthly.	

Value monitored:	<table> <tr> <td>2011</td><td>943</td></tr> <tr> <td>2012</td><td>1,855</td></tr> <tr> <td>2013</td><td>3,303</td></tr> <tr> <td>2014</td><td>903</td></tr> </table>	2011	943	2012	1,855	2013	3,303	2014	903
2011	943								
2012	1,855								
2013	3,303								
2014	903								
Monitoring equipment	Presented in								
QA/QC procedures to be applied	Meters are calibrated regularly , every 60 months or 5 years , according to the shutdown plan of HPPO plant.								
Purpose of the data	Calculation of project emissions								
Calculation method	-								
Comments	Excluded for simplification.								

Data / Parameter	FC _{i,y}																																								
Data unit	Nm ³ and/or MMBTU																																								
Description	Quantity of NG combusted in the incinerator during the year y																																								
Source of data	NG supplied by PTT																																								
Description of measurement methods and procedures to be applied	Measured through turbine meter The values from PTT invoice is higher than monitored values from turbine meter. Hence, the values from invoice are used applied in the calculation for conservativeness.																																								
Frequency of monitoring/recording	-																																								
Value monitored:	<table><tr><td></td><td>NG</td><td>NG</td><td>NG</td><td>NG - ER cal</td></tr><tr><td>Source</td><td>Invoice</td><td>MMBTU to TJ</td><td>Rpt_Energy consumption</td><td>Rpt_Energy consumption</td></tr><tr><td>Meter</td><td>PTT</td><td>0.00105587</td><td>DOW (Tox No.1,2)</td><td>DOW (Tox No.1,2)</td></tr><tr><td>Unit</td><td>MMBTU</td><td>TJ</td><td>m3</td><td>TJ</td></tr><tr><td>2011</td><td>138,874</td><td>147</td><td>2,663,207</td><td>115</td></tr><tr><td>2012</td><td>515,988</td><td>545</td><td>10,495,944</td><td>454</td></tr><tr><td>2013</td><td>303,093</td><td>320</td><td>5,241,471</td><td>227</td></tr><tr><td>2014</td><td>84,873</td><td>90</td><td>1,536,048</td><td>67</td></tr></table>		NG	NG	NG	NG - ER cal	Source	Invoice	MMBTU to TJ	Rpt_Energy consumption	Rpt_Energy consumption	Meter	PTT	0.00105587	DOW (Tox No.1,2)	DOW (Tox No.1,2)	Unit	MMBTU	TJ	m3	TJ	2011	138,874	147	2,663,207	115	2012	515,988	545	10,495,944	454	2013	303,093	320	5,241,471	227	2014	84,873	90	1,536,048	67
	NG	NG	NG	NG - ER cal																																					
Source	Invoice	MMBTU to TJ	Rpt_Energy consumption	Rpt_Energy consumption																																					
Meter	PTT	0.00105587	DOW (Tox No.1,2)	DOW (Tox No.1,2)																																					
Unit	MMBTU	TJ	m3	TJ																																					
2011	138,874	147	2,663,207	115																																					
2012	515,988	545	10,495,944	454																																					
2013	303,093	320	5,241,471	227																																					
2014	84,873	90	1,536,048	67																																					
Monitoring equipment	Presented in																																								
QA/QC procedures to be applied	The meter belongs to PTT and installed on PTT skid.																																								
Purpose of the data	Calculation of project emissions																																								
Calculation method	-																																								
Comments	-																																								

Data / Parameter	COEF _{i,y}
Data unit	tCO ₂ /t of Natural gas

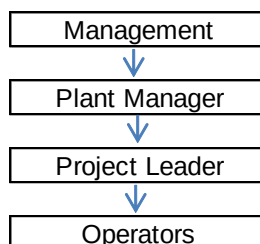
Description	CO2 emission coefficient of Natural gas
Source of data	IPCC
Description of measurement methods and procedures to be applied	Publicly available national data
Frequency of monitoring/recording	As per the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion", Version 2
Value monitored:	2.6928
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of the data	Calculation of project emissions
Calculation method	Based on option B, equation 4 of the tool. NCV = 48.0 TJ/Gg (IPCC 2006, Energy volume: Overview, Table 1.2) EF = 56.1 Tons/TJ (IPCC 2006, Energy volume: Overview, Table 1.4)
Comments	Excluded for simplification from the calculation of project emissions.

3.3 Monitoring Plan

Monitoring Management

The required monitoring equipment are installed and monitoring procedures followed as mentioned in section 4.2 of the VCS-PD. The data is recorded on a continuous basis or as indicated in section 4.2 and recorded in the logs. The data is kept in both soft and hard copy format and proper data backups maintained. The calibration of monitoring equipment is done on regular intervals at site, based on master equipments traceable to industry/national standards.

All the staff are trained by the company on how to operate the plant as well as monitor the required data under the VCS methodology. General outline of operation and management of the project activity is as follows:



Monitoring System

All meters are recorded under MES (Manufacturing Execution Suit / IP21) server according to DOW standard.

ARCHIVING

- Archiving is the process to save the IP21 process data and retain it for 5 or 75 years
- Archiving jobs are run by the IBM BUR (Backup & Restore) team every two weeks
- Archive jobs are monitored for failure and Service Request cases are submitted for investigation
- Random archive restores to verify that the process works are not performed
- The MES Archiving website at the link below has details on the archive data restore procedures

BACKUPS

- Backups are performed to restore the system in the event of a catastrophic failure
- Backups of the server are performed daily by the IBM BUR (Backup & Restore) team
- Backups are done on the C,D,E drives (the other drives can be rebuilt and restored)
- Backups are retained for 30 days
- Backup jobs are monitored for failure by the BUR team and Service Request cases are submitted for investigation

Quality assurance and quality control

The project leader monitors the overall plant's performance, ensuring proper and timely calibration (in accordance with the manufacturer specifications or national standard) of systems, data acquisition and storage. Erroneous data or uncertainties found in measurement of the monitoring devices for the project (i.e. flow rate, electricity meters, etc.) are included in the quality assurance and quality control procedures for individual monitoring parameters as per Section 4.2 of VCS PD.

Data storage and filling

All monitoring data are stored in logs and in electronic format as excel sheets. Primary source of data for emission reduction calculation is derived from the electronic system while in case of emergency or data error, support monitoring data from the log book is used instead. The monitoring records shall be archived for a period of the crediting period plus two years.

Emergency procedure

The project activity is not expected to result in any emergency that can result in substantial emissions.

- The recorded data is stored and backed up via MES system to prevent the loss of historical data.
- The hard copies are collected and controlled as per the ISO 9001 requirements.

However, since unexpected emergency situations might affect the completeness or accuracy of monitored data. Apart from general provisions described topic above and below of this section, the operator also take measures to avoid data loss and inaccuracies under such circumstances. Following an emergency situation, the staff responsible for operation and monitoring of the plant shall be made aware of any event from the previous day or previous shift and plan to promptly rectify the situation. In case of problems with any equipment or machines, immediate action shall be taken to restore regular operation of such affected devices.

Uncertainty in data

Some uncertainties may result due to malfunction of meters, calibration issues and wrong data collection (gaps in manual log sheets, human errors by plant operators). The operator is expected to put best efforts to prevent such errors, however regular internal audits shall rectify any such uncertainty in the monitored data.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

Baseline emissions for the chosen baseline scenario are calculated as follows:

$$BE_y = BE_{Upstream,y} + BE_{Process,y} \quad (1)$$

Where:

BE_y	Baseline emission in year y (tCO ₂)
$BE_{Upstream,y}$	Emissions associated with the baseline reagents required for the production of PO in year y (tCO ₂)
$BE_{Process,y}$	Emissions due to energy usage (heat and electricity) for transforming the baseline reagents into the final product (PO) and also for waste and by-product treatment in year y (tCO ₂)

Up-stream emissions ($BE_{Upstream,y}$):

The up-stream emissions are on account of the various reagents used in the process. The reagents used in the baseline (CHPO-Chlor-Alkali process) are C₃H₆, Cl₂ and NaOH. The emissions associated with C₃H₆ has however not been accounted as its usage would be essentially the same as in the project activity. The emissions associated with Chlor-Alkali production have been accounted as these are generally not found naturally and are to be produced in an industrial facility.

The emissions associated with Chlor-Alkali production are calculated as follows:

$$BE_{Upstream,y} = be_{Chlor-Alkali,y} \times PO_y \quad (2)$$

Where:

$be_{Chlor-Alkali,y}$	Quantity of CO ₂ that would be emitted from Chlor-Alkali production per unit of PO in year y (tonnes)
PO_y	Quantity of PO produced in year y (tonnes)

The Chlor-Alkali process involves the electrolysis of aqueous sodium chloride (brine) in a membrane cell. The CO₂ emissions associated with Chlor-Alkali production are calculated as follows:

$$be_{Chlor-Alkali,y} = \left(\frac{71}{58} \right) \times ec_{Chlor-Alkali,y} \times EF_{EL,y} \quad (3)$$

Where:

$ec_{Chlor-Alkali, y}$	Energy consumption per ton of Cl_2 production in year y (MWh/t Cl_2)
$EF_{EL, y}$	Emission factor for electricity generation in year y (tCO ₂ /MWh)
71/58	Ratio between the molecular weights of Cl_2 and C_3H_6O (mass units/mass units)

Process emissions ($BE_{Process, y}$):

The process emissions would arise due to energy usage (heat, electricity etc.) for transforming the reagents into the final product and also from waste treatment.

The emissions associated with energy usage will be calculated as follows:

$$BE_{Process, y} = BE_{Heat, y} + BE_{Elec, y} + BE_{Waste, y} \quad (4)$$

Where:

$BE_{Heat, y}$	Emissions due to thermal energy (heat/steam) for transforming the baseline reagents into the final product (PO) and also for waste treatment in year y (tCO ₂)
$BE_{Elec, y}$	Emissions due to electrical energy for transforming the baseline reagents into the final product (PO) and also for waste treatment in year y (tCO ₂)
$BE_{Waste, y}$	Emissions due to treatment of waste products in year y (tCO ₂)

The CO₂ emissions from thermal energy (heat/steam) will be calculated as follows:

$$BE_{Heat, y} = SSC_{CHPO} \times PO_y \times EF_{Steam, y} \quad (5)$$

Where:

SSC_{CHPO}	Specific thermal energy consumption ratio in the PO production through CHPO process (TJ/ton of PO).
$EF_{Steam, y}$	Emission factor for thermal energy generation in year y (tCO ₂ /TJ)

The emission factor for thermal energy generation would be calculated as follows:

$$EF_{Steam, y} = EF_{CO_2, i, y} / \eta_{Boiler, y} \quad (6)$$

Where:

$EF_{CO_2, i, y}$	Weighted average CO ₂ emission factor of fuel type i in year y (tCO ₂ /TJ).
$\eta_{Boiler, y}$	Efficiency of the steam generating system

The CO₂ emissions from electrical energy will be calculated as follows:

$$BE_{Elec, y} = SEC_{CHPO} \times PO_y \times EF_{El, y} \quad (7)$$

Where:

SEC_{CHPO}	Specific electrical energy consumption ratio in the PO production through CHPO process (MWh/tonne of PO).
$EF_{El, y}$	Emission factor for electricity generation in year y (tCO ₂ /MWh)

The specific energy consumption ratios (thermal/electrical) will be sourced from independent third party reports.

The CO₂ emissions from waste treatment will be calculated as follows:

$$BE_{Waste,y} = \left(\frac{44}{12} \right) \times (CA_{Waste,Baseline}) + FC_{i,Baseline} \times COEF_i \quad (8)$$

Where:

$CA_{Waste, Baseline}$ Carbon amount in the waste stream derived from the carbon amount in the Propylene feed, PO and by-products in the baseline (tonnes).

$44/12$ Ratio between the molecular weights of CO₂ and Carbon (mass units/mass units)

$FC_{i,Baseline}$ Quantity of fuel type i combusted in the incinerator in the baseline (mass or volume unit/year)

$COEF_i$ CO₂ emission coefficient of fuel type i (tCO₂/mass or volume unit)

The “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion” should be referred to calculate the CO₂ emission coefficient.

The carbon amount in the waste stream and fuel combusted in the incinerator could be presented in terms of PO output.

For simplification and as a conservative approach, the emissions linked to waste and by-products will be neglected.

4.2 Project Emissions

Project emissions are calculated as follows:

$$PE_y = PE_{Upstream,y} + PE_{Process,y} \quad (9)$$

Where:

PE_y Project emissions in the year y, (tCO₂)

$PE_{Upstream,y}$ Emissions associated with the project reagents for the production of PO in year y (tCO₂)

$PE_{Process,y}$ Emissions due to energy usage (heat, electricity etc.) for transforming the project reagents into the final product (PO) and also for waste treatment in year y (tCO₂)

Up-stream emissions ($PE_{Upstream,y}$):

The upstream emissions are based on the various reagents used in the PO production process. The reagents used in the project scenario (HPPO process) are C₃H₆ and H₂O₂. However, the emissions associated with C₃H₆ are not accounted for as its usage would be essentially the same as in the baseline activity. The emissions associated with H₂O₂

production have been included as this compound is generally not found naturally and is produced in an industrial facility. Further, since the reaction is carried out in solvents³, the emissions associated with the make-up solvent are considered as well.

The upstream emissions are calculated as follows:

$$PE_{Upstream,y} = PE_{Upstream,H_2O_2,y} + PE_{Upstream,Solvent,y} \quad (10)$$

The emissions associated with H₂O₂ production are calculated as follows:

$$PE_{Upstream,H_2O_2,y} = \left(\frac{34}{58}\right) \times pe_{HP} \times PO_y \quad (11)$$

Where:

pe_{HP}	Quantity of CO ₂ that would be emitted per tonne of H ₂ O ₂ (tCO ₂ /tH ₂ O ₂)
PO_y	Quantity of PO produced in year y (tonnes)
34/58	Ratio between the molecular weights of H ₂ O ₂ and C ₃ H ₆ O (mass units/mass units)

The emissions associated with make-up solvent are calculated as follows:

$$PE_{Upstream,Solvent,y} = pe_{Sol} \times sol_y \times PO_y \quad (12)$$

Where:

pe_{Sol}	Quantity of CO ₂ that is emitted per tonne of solvent (tCO ₂ /tonne of solvent)
sol_y	Quantity of solvent required per tonne of PO in year y (tonnes)
PO_y	Quantity of PO produced in year y (tonnes)

Note that sol_y , as found in equation 12 above, is used only for ex-ante estimations, and its value must be estimated based upon the design details of the project. For ex-post calculations, " $sol_y \times PO_y$ " is represented by Sol_y in equation 12 above, the value of which is monitored.

³ Typically solvents of polar nature are used, such as alcohols, ketones, ethers, etc.

Process emissions ($PE_{Process,y}$):

The process emissions arise from the energy usage (eg, heat and electricity) required for transforming the reagents into the final product, and for by-product and waste treatment.

The process emissions are calculated as follows:

$$PE_{Process,y} = PE_{Heat,y} + PE_{Elec,y} + PE_{Waste,y} \quad (13)$$

Where:

$PE_{Heat,y}$ Emissions due to thermal energy (heat/steam) for transforming the project reagents into the final product in year y (tCO₂)

$PE_{Elec,y}$ Emissions due to electrical energy for transforming the project reagents into the final product in year y (tCO₂)

$PE_{Waste,y}$ Emissions due to treatment of waste products in year y (tCO₂)

The CO₂ emissions from thermal energy (heat/steam) are calculated as follows:

$$PE_{Heat,y} = SSC_{HPPO,y} \times PO_y \times EF_{Steam,y} \quad (14)$$

Where:

$SSC_{HPPO,y}$ Specific thermal energy consumption ratio in PO production through the HPPO process in year y (TJ/tonne of PO)

$EF_{Steam,y}$ Emission factor for thermal energy generation in year y (tCO₂/TJ)

Note that SSC_{HPPO} , as found in equation 14 above, is used only for ex-ante estimations, and its value must be estimated based upon the design details of the project. For ex-post calculations, " $SSC_{HPPO,y} \times PO_y$ " is represented by SC_{HPPO} in equation 14 above, the value of which is monitored.

The emission factor for thermal energy generation is the same as calculated for the baseline emissions.

The CO₂ emissions from electrical energy are calculated as follows:

$$PE_{El,y} = SEC_{HPPO,y} \times PO_y \times EF_{El,y} \quad (15)$$

Where:

$SEC_{HPPO, y}$ Specific electrical energy consumption ratio in PO production through the HPPO process in year y (MWh/tonne of PO)

$EF_{El, y}$ Emission factor for electricity generation in year y (tCO₂/MWh)

Note that SEC_{HPPO} , as found in equation 15 above, is used only for ex-ante estimations, and its value must be estimated based upon the design details of the project. For ex-post calculations, " $SEC_{HPPO} \times PO_y$ " is represented by EC_{HPPO} in equation 15 above, the value of which is monitored.

The emission factor for electricity generation is the same as calculated for the baseline emissions.

The CO₂ emissions from waste treatment are calculated as follows:

$$PE_{Waste, y} = \left(\frac{44}{12} \right) \times (CA_{Waste, y}) + FC_{i, y} \times COEF_{i, y} \quad (16)$$

Where:

$CA_{Waste, y}$ Carbon amount in the waste stream derived from the carbon amount in the propylene feed, solvent, PO and by-products in year y (tonnes)

$44/12$ Ratio between the molecular weights of CO₂ and carbon (mass units/mass units)

$FC_{i, y}$ Quantity of fuel type i combusted in the incinerator in year y (mass or volume unit/year)

$COEF_{i, y}$ CO₂ emission coefficient of fuel type i in year y (tCO₂/mass or volume unit)

The CDM Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion must be used to calculate the CO₂ emission coefficient.

The carbon amount in the waste stream must be calculated as follows:

$$CA_{Waste, y} = CA_{Propylene, y} + CA_{Solvent, y} - (CA_{PO, y} + CA_{Byproducts, y}) \quad (17)$$

Where:

$CA_{Propylene, y}$ Carbon amount in the propylene feed in year y (tonnes)

$CA_{Solvent, y}$ Carbon amount in the solvent used in year y (tonnes)

$CA_{PO, y}$ Carbon amount in PO produced in year y (tonnes)

$CA_{Byproducts, y}$ Carbon amount in the by-products in year y (tonnes)

The total amount of carbon in a particular product is a function of the respective carbon fraction and the quantity of the product, expressed as follows:

$$CA_{x,y} = ca_{x,y} \times Q_{x,y} \quad (18)$$

Where:

$CA_{x,y}$	Carbon amount in the product x in year y (tonnes)
$ca_{x,y}$	Carbon fraction in the product x in year y (mass units/mass units)
$Q_{x,y}$	Quantity of the product x in year y (tonnes)
x	propylene, solvent, PO, by-product, waste

4.3 Leakage

No leakage emissions are considered. The main emissions potentially giving rise to leakage in the context of the project are emissions arising due to construction of the PO production facility and transportation of reagents. These emissions sources are excluded as these would be higher in the baseline scenario as compared to project scenario.

4.4 Net GHG Emission Reductions and Removals

Year	Baseline emissions or removals (tCO ₂ e)	Project emissions or removals (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net GHG emission reductions or removals (tCO ₂ e)
Year 2011 (Oct-Dec)	88,784	82,320	0	6,464
Year 2012	459,473	335,831	0	123,641
Year 2013	511,155	358,122	0	153,033
Year 2014 (Jan-Mar)	127,660	89,897	0	37,762
Total	1,187,072	866,170	0	320,900

APPENDIX 1: OTHER REFERENCE INFORMATION

Table 1 : Summary of monitoring parameter

Parameter	Unit	PD value	2011	2012	2013	2014
PO _y	tonnes	390,000	62,167	321,724	357,912	89,387
Sol _y	tonnes	14,440	5,049	19,061	21,634	4,366
EF _{CO2,i,y}	tCO2/TJ	56.1	56.1	56.1	56.1	56.1
SC _{HPP0,y}	tonnes		368,149	1,499,443	1,374,612	308,676
	kJ/kg		931	931	931	931
	TJ	1,460.11	343	1,396	1,280	287
EC _{HPP0,y}	MWh	200,000	55,428	217,095	227,688	57,069
Q _{Propylene,y}	tonnes	305,600	50,849	253,606	285,016	71,720
Q _{By-product,y}	tonnes	8,800	943	1,855	3,303	903
FC _{i,y}	Nm3	4,800,000	2,663,207	10,495,944	5,241,471	1,536,048
COEF _{i,y}	tCO2/t NG	2.6928	2.6928	2.6928	2.6928	2.6928

Table 2 : Energy consumption data cross-checked with invoices

NG					STEAM			POWER				
NG	NG	NG	NG - ER cal	NG	Steam	Steam - ER cal	Steam	Power (PO + WWTP)	Power (WWTP-PU)	Power (PO)	Power (PO) - ER cal	Power
Invoice	MMBTU to TJ	Rpt_Energy consumption	Rpt_Energy consumption	Diff	Invoice	Rpt_Energy consumption	Diff	Invoice	Rpt_Energy consumption (PU)	Deduction from invoice	Rpt_Energy consumption	Diff
PTT	0.00105587	DOW (Tox No.1,2)	DOW (Tox No.1,2)	Average	Glow	DOW	Average	Glow	DOW		DOW	Average
MMBTU	TJ	m3	TJ	-31%	Tons	Tons	-1%	MWh	MWh	MWh	MWh	-1%
138,874	147	2,663,207	115	-27%	395,330	368,149	-7%	63,507	7,566	55,941	55,428	-1%
515,988	545	10,495,944	454	-20%	1,562,525	1,499,443	-4%	251,775	31,743	220,032	217,095	-1%
303,093	320	5,241,471	227	-41%	1,370,025	1,374,612	0%	262,101	32,030	230,071	227,688	-1%
84,873	90	1,536,048	67	-35%	290,626	308,676	6%	64,856	7,961	56,895	57,069	0%

Table 3 : Metering data cross-checked with stock report

Parameter	Unit	Source	Reference	2011	2012	2013	2014
PO _y	tonnes	Flow meter	Production number : Rpt_PO production	62,167	321,724	357,912	89,387
		Stock	Logistic number : Rpt_PO production	63,705	320,866	355,742	88,885
		Diff (%)		-2.47%	0.27%	0.61%	0.56%
Sol _y	tonnes	Flow meter (t/h)	Rpt_raw data	5,049	19,061	21,634	4,366
		Stock	GMID 00369989 : Rpt_Stock Checking	5,719	17,795	19,757	4,172
		Diff (%)		-13.3%	6.6%	8.7%	4.4%
Q _{H2O2,y}	tonnes	Stock	Logistic number : Rpt_PO production	41,059	206,731	228,697	55,877
		Flow meter	Operation number : Rpt_PO production	41,668	206,453	232,294	57,386
		Diff (%)		1.46%	-0.13%	1.55%	2.63%
Q _{Propylene,y}	tonnes	Stock	Logistic number : Rpt_PO production	50,842	253,600	284,960	71,788
		Flow meter	Operation number : Rpt_PO production	50,849	253,606	285,016	71,720
		Diff (%)		-0.01%	0.00%	-0.02%	0.09%
Q _{By-product,y}	tonnes	Flow meter (t/h)	Rpt_raw data	943	1,855	3,303	903
		Stock	GMID 00375015 : Rpt_Stock Checking	862	1,780	3,207	842
		Diff (%)		8.56%	4.06%	2.90%	6.71%

Table 4 : Summary information of monitoring equipment

	Upstream			Downstream		
	C3H6	H2O2	MeOH	PO	PG	
Tag no.	FT-1164-01	FT-1170-00	FT-7409-02	FT-4311-18	FT-4311-20	FT722001
S/N	D303621600	D404A802000	6015616	6015584	6050847	A1071567
Type	Coriolis Mass Flow Meter	Coriolis Mass Flow Meter	Vortex	Vortex	Vortex	Ultrasonic
Brand	Endress+Hauser	Endress+Hauser	ROSE MOUNT	ROSE MOUNT	ROSE MOUNT	KROHNE
Model	PROMASS 80F	PROMASS 80F	8800DF020 SA1N2D1E5 T1CNQ4	8800DF040 SA3N2D1E5 T1CNQ4	8800DF040S A3N2D1E5T1CNQ4	UFM3030/ UFS3000
Accuracy % of reading	0.15%	0.15%	+/- 0.65%	+/- 0.65%	+/- 0.65%	0.5%
Installation date		13-Jan-11	13-Jun-11	25-Feb-11		4-Jun-11
Calibration date	4-Jun-10	16-Apr-10	8-May-10	29-Apr-10	16-Nov-11	17-May-10

	Utilities							
	Natural gas	Mass steam	Temp steam	Pressure Steam	Electricity			
Tag no.	PTT	FT-9500-01	TT950001	PT950001	JT700214ACalc	JT700211ACalc	JT700220ACalc	JT700223ACalc
S/N	NA	2209215	210000853587001	2284871	BF0908074313	BF0908074311	BF0908074317	BF0908074314
Type	Turbine meter	Probar flowmeter (Pitot type)	RTD (PT100)	Pressure transmitter	7KG7750-0GA01-00AA0	7KG7750-0GA01-00AA0	7KG7750-0GA01-00AA0	7KG7750-0GA01-00AA0
Brand	NA	ROSEMOU NT	ABB	ROSEMOU NT	Siemens	Siemens	Siemens	Siemens
Model	NA	3051SFADS240ZCHFS3A3D0072AA1B2G9E1F2F0052	A5Y0W9S3D1D6P3D2L1H4/OPT	3051CA3A02A1BK6H2L4T1P1C N	SIMEAS P50	SIMEAS P50	SIMEAS P50	SIMEAS P50
Accuracy % of reading	NA	0.8%	+/- 0.06	+/- 1	+/- 0.5%	+/- 0.5%	+/- 0.5%	+/- 0.5%
Installation date	NA		5-Apr-11	6-Apr-11				
Calibration date	NA	5-Jan-11	17-May-11	17-May-11	14-May-10	14-May-10	14-May-10	14-May-10