# CDM
# MONITORING REPORT # 23 rev.01
# of
# "N2O Emission Reduction in Paulinia, SP, Brazil"
# UNFCCC 0116

**From: April 1, 2009**
**To: April 26, 2009**


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## 1 Introduction

The purpose of this monitoring report is to calculate and clarify GHG emission reduction quantity achieved by this project for periodic verification.

This monitoring report covers the activity from April 1st, 2009 to April 26th, 2009 as the 23rd period.

Duration of the project activity period
The starting date of the project is defined as 11/19/2006.
Note: In the PDD the original starting date of the project activity is 01/01/2007. A demand to the UNFCCC for anticipating the actual start up of the project activity to 11/19/2006 was made and approved. The new starting date of the project activity has been updated on the UNFCCC website.

## 2. Reference

**Approved Baseline methodology** :
Baseline Methodology for decomposition of N2O from existing adipic acid production plants (AM0021/version 1)

**Approved Monitoring methodology** :
Monitoring Methodology for decomposition of N2O from existing adipic acid production plants (AM0021/version 1)

**Project Design Document** :
N2O Emission Reduction in Paulinia, SP, Brazil.
Version number of the document : 4
Date : October 12th, 2005

**CDM registration number :**
"N2O Emission Reduction in Paulinia, SP, Brazil" – UNFCCC ref number 0116

**Directly related EB guidance:**
EB45 Annex13 "Guidance to calculate adipic acid production in cases where it cannot be measured directly" version 1, February 13th 2009

## 3. Definition

- y : Monitoring period (in this report, see dates § 1)
- PDD : Project Design Document of this project "N2O Emission Reduction in Paulinia, SP, Brazil." Version number of the document: 4, issued on October, 12th, 2005

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# 4. General description of project

Project activity

Nitrous oxide (N2O) is a by-product of adipic acid production. It is of low toxicity but is a greenhouse gas (GHG), whose GWP is large (GWP=310 in the IPCC 2nd Assessment Report). Emissions of N2O will be controlled under the Kyoto Protocol. As far as we are aware, there are however no national or regional regulations or restrictions on the emission of N2O in Brazil. There are in fact no governmental regulations with quantified emission limits in any non-Annex I countries at this point.

In this project, Rhodia Poliamida e Especialidades Ltda. additionally installed N2O collection and a thermal decomposition process equipment to the currently operating adipic acid manufacturing plant. This installation reduces the GHG emissions, which would otherwise be released to the atmosphere if the project were not implemented.
The decomposition facility was installed in the factory site of Paulinia Rhodia Poliamida e Especialidades Ltda. in October 2006 and destruction of N2O was started in November 2006. The starting date of the project as well as the starting date of the first crediting period is defined as November 19th, 2006. It should be noted that the original starting date of the project activity is 01/01/2007 according to the PDD. However the start up of the project activity was anticipated to 11/19/2006, as formalized to and approved by the UNFCCC.

This project activity was registered at UNFCCC on December 25th, 2005 with the number 0116.

Technical description of the project

**Location of the project activity**

The decomposition facilities were installed in the factory site Rhodia Poliamida e Especialidades Ltda in Paulínia, SP, Brazil in October, 2006.

**Technology employed by the project activity**

A thermal oxidizer with 2 chambers is the technology used to decompose N2O.

Natural gas is fed with the off gas adipic acid production containing N2O and some air in a reduction chamber, where it burns (oxidizes) to carbon dioxide CO2 and water vapour. N2O is used as an oxidizer. Being oxygen deficient, the oxidation is not complete and carbon monoxide and hydrogen are present.

$$CH_4 + 4\ N_2O \rightarrow CO_2 + 2\ H_2O + 4\ N_2$$

The temperature in the furnace is kept at about 1300°C and under fuel rich conditions, so as to promote the complete decomposition of N2O while minimizing the formation of unwanted combustion by-products such as NO and NO2.

The gas is then quenched with air to complete the combustion of carbon monoxide and hydrogen at a temperature of about 950°C in a second chamber. Aqueous ammonia is injected to control the emission of NO and NO2.

Before release to the stack, the flue gas coming from the thermal oxidizer is used to produce superheated steam, which is fed into the existing on-site steam network.

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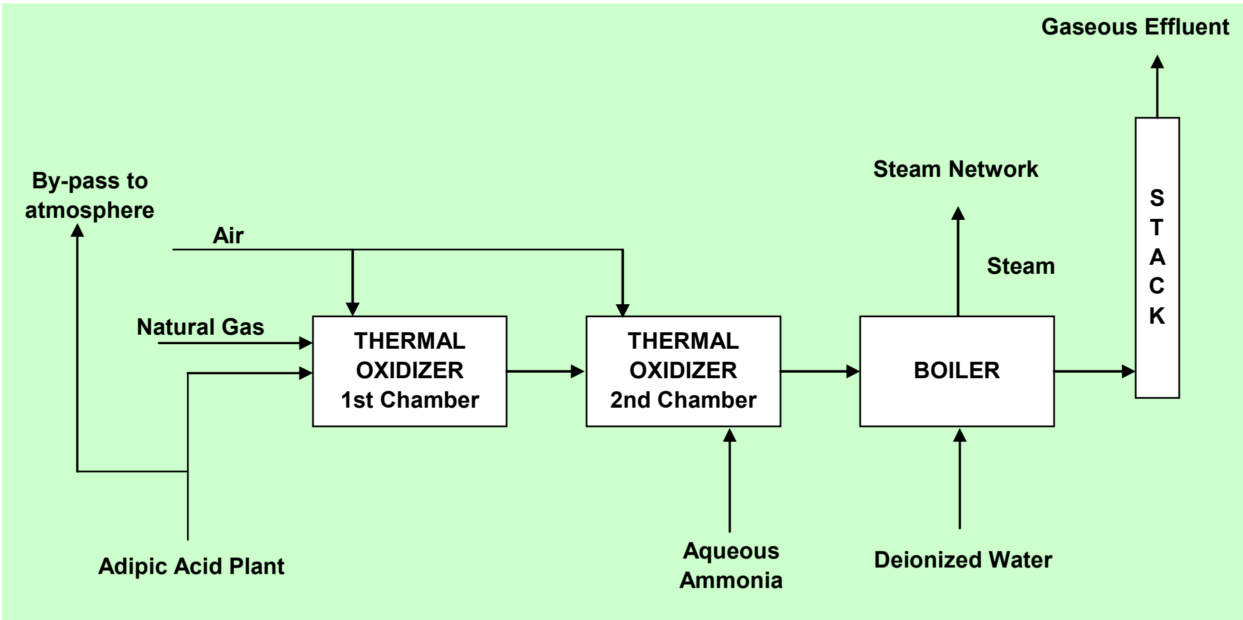
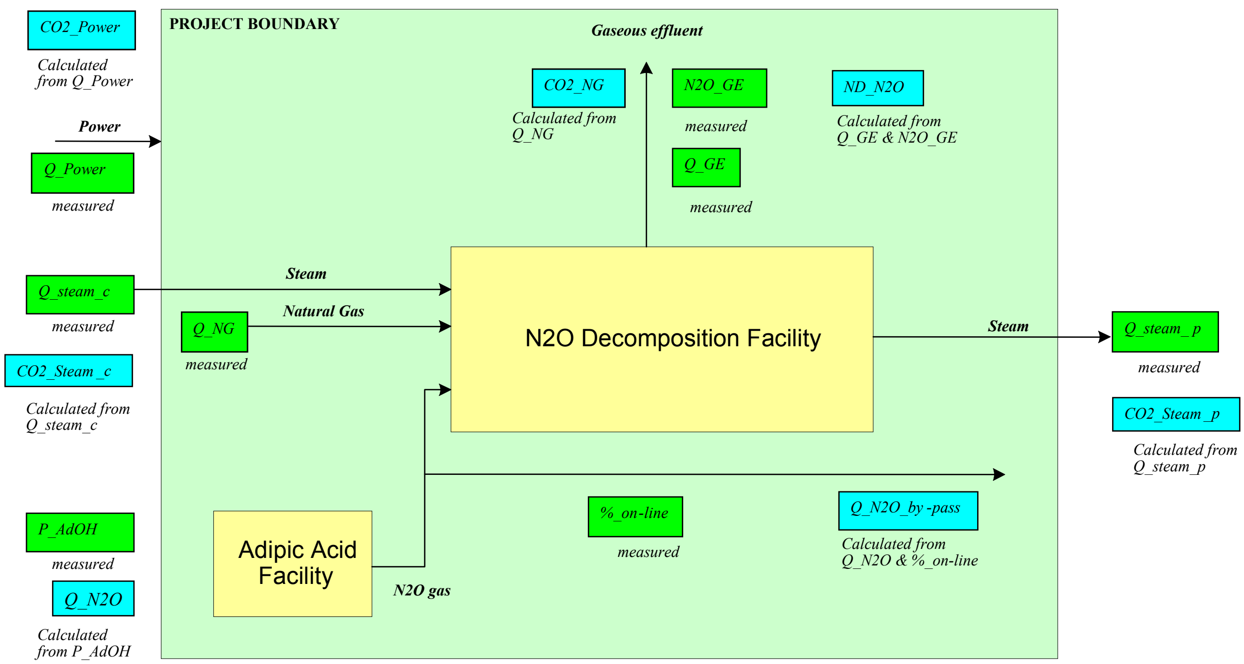


## 5. Baseline methodology

Approved baseline methodology AM 0021 / version 1: "Baseline methodology for decomposition of N2O from existing adipic acid production plants" is applied to this project.

The project boundary related to the baseline methodology is shown below and this project boundary is used and explained in the PDD.
Potential sources of anthropogenic emissions by sources of GHG within the project boundary and emissions which are not included in the project boundary are also shown in below.




## 6. Applicability of the methodology

Approved monitoring methodology AM 0021 / version 1 is applied to this project.
This methodology is applicable to projects which decompose N2O from an adipic acid production plant under the following conditions:

- either catalytic or thermal decomposition of the N2O by-product of adipic acid production at existing production plants
- The methodology is spatially generic, being applicable across regions where the data (both related and project activity as well) exist to undertake the assessment
- The methodology is applicable only for installed capacity (measured in tonnes of adipic acid per year) that exists by the end of the year 2004.

The present project satisfies these conditions as:

- Thermal decomposition of the N2O by-product of adipic acid production was implemented in an existing production plant
- All required data (see following paragraph) are available and used
- The production of adipic acid within the current year is below the installed capacity that exists by the end of the year 2004 as defined in the PDD.

For the sake of clarity, the amount of Emission Reductions can exceed the amount calculated in a year period in the PDD in "SECTION E. Estimation of GHG emissions by sources" as all data in the PDD were conservative, in particular the performance of the N2O abatement unit (in fact, the actual efficiency has been > 85%, and the destruction rate > 99%).

## 7. **Monitored Parameters**

According to the methodology AM 0021/version 1 and the Monitoring Plan, the data being collected to monitor the GHG reduction are given in the table below:

| **ID** | **Data variable** | **Source of data** | **Data unit** | **Recording frequency** | **Reference** |
|---|---|---|---|---|---|
| Q_GE | Volume of effluent gas leaving the stack | Flow meter | $Nm^3$ | Monthly | Appendix 1 |
| $N_2O$_GE | Concentration of $N_2O$ in the effluent gas | Laser diode online analyzer | ppm | Monthly | Appendix 2 |
| ND_N2O | Quantity of $N_2O$ in the effluent gas leaving the stack | Calculated from Q_GE and $N_2O$_GE | kg | Monthly | Appendix 3 |
| Q_NG | Amount of natural gas burned | Natural gas meter | $Nm^3$ | Monthly | Appendix 4 |
| NGC | Natural gas composition required for calculation of E_NG | Gas supplier | - | Monthly | Appendix 5 |
| %_on-line | % of production time the position switch on the by-pass valve is closed | Position switches on bypass valve | % of production time | Monthly | Appendix 6 |
| Q_N2O_by-pass | N2O by passing the decomposition facility | Calculated from Q_N2O and %_on-line | kg | Monthly | Appendix 7 |

| ID | Data variable | Source of data | Data unit | Recording frequency | Reference |
|---|---|---|---|---|---|
| P_AdOH | Amount of adipic acid production | Excel workbook for calculation of nylon salt production, AA slurry production and dry AA production | ton | Monthly | Appendix 8 |
| Nitric acid consumption (HNO3_consumption) & physical losses in the adipic acid production process ($HNO_3$_physical) | All data required for calculation of $HNO_3$ chemical and the N2O emission factor N2O_AdOH | Excel workbook based on the raw material consumption, DCS data and Lab data | ton | Monthly | Appendix 9 |
| Q $N_2O$ reg | Per Brazilian regulation allowed $N_2O$ emissions | Brazilian regulation | kg/a | Date when relevant legislation is in place | Appendix 10 |
| $N_2O$ reg/AdOH | Per Brazilian regulation allowed $N_2O$ emissions per kg of adipic acid produced | Brazilian regulation | kg/kg | Date when relevant legislation is in place | Appendix 10 |
| $r_y$ | Per Brazilian regulation required share of $N_2O$ emissions to be destroyed | Brazilian regulation | % | Date when relevant legislation is in place | Appendix 10 |
| P $N_2O$ | Market price of $N_2O$ | Estimated | €/t | Yearly | Appendix 11 |
| Q_Steam_p | Amount of steam produced by the decomposition process | Steam meter | kg | Monthly | Appendix 12 |

| ID | Data variable | Source of data | Data unit | Recording frequency | Reference |
|---|---|---|---|---|---|
| Steam supplier data | All data required for calculation of E_Steam | Rhodia Industrial Platform of Paulínia | - | Yearly | Appendix 13 |
| Q_Power | Electric consumption of the decomposition facility | Electricity meter | kWh | Monthly | Appendix 14 |
| Electricity grid data | All data required for calculation of E_Power according to ACM0002 version 2 and the Monitoring Plan | Brazilian ONS (Operador Nacional do Sistema Elétrico) | - | Yearly | Appendix 15 |
| Q_Steam_c | Amount of steam consumed by the decomposition facility | Steam meter | kg | Monthly | Appendix 16 |
| Steam suppliers data | All data required for calculation of E_Steam_c | Rhodia Industrial Platform of Paulínia | - | Yearly | Appendix 17 |

## 8. Quality Control (QC) and Quality Assurance (QA)

### 8.1. Quality Management System

The thermal oxidation plant is operated by Rhodia operating personnel. Rhodia has assigned the responsibility for operating, monitoring and reporting to the Adipic Acid Plant Manager.

The operation, data transfer and reporting procedures are incorporated into the ISO 9001 procedures of the Paulínia Adipic Acid plant

The personnel have been trained by Rhodia engineers who have been trained by the technology supplier i.e. John Zink Company LLC, USA.

### 8.2. Quality control (QC) and quality assurance (QA) procedures that are being undertaken for data monitored

The Paulínia adipic acid plant is certified according to ISO9001 and applies appropriate QA & QC procedures.

The equipment and analytical methods given by the technology supplier John Zink Company LLC, USA as well as those supplied by Rhodia are done according to internationally accepted standards.

The QA & QC procedures are set and implemented in order to:

1. Secure a good consistency through planning to implementation of this CDM project and,
2. Stipulate who has responsibility for what and,
3. Avoid any misunderstanding between people and organization involved.

| Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)* | Uncertainty level of data (High/Medium/ Low) | Explain QA/QC procedures planned for these data, or why such procedures are not necessary. |
|---|---|---|
| *2a.1. (D.2.1.1) Q_GE* | *Low* | *This flow rate is measured with an Averaging Pitot tube. This instrument is a critical instrument in the QA/QC procedure.* |
| *2a.2. (D.2.1.1) $N_2O$_GE* | *Low* | *Measured using Laser Diode technology Specific procedures are applied to this analyzer for QA & QC following the manufacturer's recommendation.* |
| *2a.4. (D.2.1.1) Q_NG* | *Low* | *Is measured using natural gas meter from the supplier and as such is part of a regular procedure control between the Natural Gas supplier and Rhodia.* |
| *2b.1. (D.2.1.3) P_AdOH* | *Low* | *Is obtained from production records of the Paulínia Adipic Acid plant where the N2O waste originates. A QA/QC procedure is implemented. Production quantity is based on the packaged product plus slurry production used for the Nylon Salt production. Both dry adipic acid and nylon salt are weighed.* |
| *2a.5. (D.2.1.1) %_on-line* | *Low* | *Use high integrity performance by-pass valve to limit leaks. Procedures currently in place in Chalampé for monitoring $N_2O$ emissions have been implemented in Paulinia to periodically check their tightness and assure their good operation. They have been added to the QA/QC existing procedures.* |
| *2b.7. (D.2.1.3) Q_Steam_p* | *Low* | *Steam meter placed on the list of critical instrument data in the QA/QC procedures* |
| *3.1. (D.2.3.1) Q_Power* | *Low* | *Electricity meter. Standard procedures are used. No QA/QC procedures implemented as this flow represents less than 0.01% of the baseline emissions.* |
| *3.4. (D.2.3.1) Q_Steam_c* | *Low* | *Steam meter placed on the list of critical instrument data in the QA/QC procedures.* |

8.3. Calibration/Maintenance of Measuring and Analytical Instruments

All measuring and analytical instruments are being calibrated as per the methodology AM0021/version 1 and the PDD using either existing or specifically created protocols in Paulínia's Quality Management System procedures.

The maintenance methods and procedures have been incorporated as part of the ISO 9001 procedures and form an integral part of the systems and procedures for the organization.

8.4. Environmental Impact

After commissioning the thermal oxidation plant, online analysis of the NOx content in the gaseous effluents is carried out to verify such discharge from the plant. Monitoring of the NOx content in the waste gas is required by local environmental legislation stated in the Commitment Agreement (TAC) signed with the Public Attorney of the State of São Paulo. NOx in the gaseous effluent can be randomly checked by the environmental agency Cetesb through sampling and analysis by an external laboratory. Analytical data show that the plant complies with the established environmental standard.

Table showing analysis of Gaseous Emission for Thermal Oxidation plant

| Parameter | Unit | Limit as per applicable standard | Analytical results in this period |
|---|---|---|---|
| NOx | vppm | 300 max<br>at least 95% of time | Average of 44<br>and less than 300 for 99.2% of time |

## 9. GHG Calculations

Statement of GHG emission reduction in this monitoring period.

As suggested by the methodology (AM0021/version 1), the GHG emission reduction, (ERy), achieved by the project activity for the period is
ERy = BEy - PEy - Ly

9.1. Calculation of Q_N2Oy

It has been checked that there are no Brazilian regulation into place that would limit the quantity of $N_2O$ emitted that can be taken into account for the calculation of the baseline emissions (see D.2.1.4. in the PDD).

The quantity Q_N2Oy of N2O emitted over the period can then be calculated by:

Q_N2Oy = P_AdOH x N2O_/AdOH

Over the period of reference the emission factor from the adipic acid plant was above the capped value of 0.27 kg N2O/kg AdOH (see Appendix 9). So the capped value is being used according to AM 0021/version 1.

| Parameter | Value | Reference |
|---|---|---|
| Q_N2Oy | 1 506 427 kg | Calculated |
| P_AdOH | 5 579 t | Appendix 8 |
| N2O_/AdOH | 0.27 kg N2O/kg AdOH | Appendix 9 |
| Q_$N_2O$ reg | No limit | Appendix 10 |
| $N_2O$_reg / AdOH | No limit | Appendix 10 |
| $r_y$ | NA | Appendix 10 |

The Executive Board has confirmed on EB36 the application of a yearly Adipic acid production cap as required by the methodology. The current year period started on November 19, 2008 and will end on November 18, 2009. The accumulated production of adipic acid in the period starting on November 19, 2008 and ending in the last day of this period is lower than the yearly capped value defined in the PDD, 94 900 t. Therefore the total production of this period can be used as such. This approach is consistent with the definitions and requirements of the "Guidance on accounting eligible HFC-23" AM0001 (EB39 Annex 8): the year of the crediting period is defined on the basis of the starting date of the crediting period of a project activity (in the present case November 19th).

9.2. Calculation of baseline emissions

The amount of baseline emissions in the given period y (measured in t CO2 eq.) is calculated by

$$BEy = Q\_N2O_y \times GWP\_N2O + Q\_Steam\_p_y \times E\_Steam_y$$

and rounded down in t CO2 eq. to get conservative consistency of final calculation of emission reductions formula.

| Parameter | Value | Reference |
|---|---|---|
| **BEy** | **467 871 t CO2 eq.** | Calculated |
| Q_N2$O_y$ | 1 506 427 kg | Calculated in 9.1 |
| GWP_N2O | 310 kg CO2 eq./ kg $N_2O$ | Kyoto Protocol Rule. Decision 2/CP.3 |
| Q_Steam_$p_y$ | 6 062 700 kg of steam | Appendix 12 |
| E_$Steam_y$ | 0.145 kg-$CO_2$/kg of steam | Appendix 13 |

9.3. Calculation of (Q_N2O x (1-%_on-line))y

The quantity of N2O that has by-passed the decomposition facility is calculated from the adipic acid production made while by-passing the decomposition facility.

The quantity of adipic acid produced while by-passing the destruction facility is monitored and the quantity of N2O that by-pass the decomposition facility is registered daily:

Q_N2O_by-pass = P_AdOH x (1-%_on-line) x N2O_/AdOH

This value is a value by excess as during each connection/ disconnection phases the production is counted as completely by-passed.

The quantity of N2O that by-passed the decomposition facility over the period is:
(Q_N2O x (1-%_on-line))y = $Q\_N2O\_by\text{-}pass_y$

The $\%\_on\text{-}line_y$ equivalent over the period is calculated as:
$\%\_on\text{-}line_y = 1 - (Q\_N2O\_by\text{-}pass_y / Q\_N2O_y)$

| Parameter | Value | Reference |
|---|---|---|
| $Q\_N2O\_by\text{-}pass_y$ | 59 099 kg | Appendix 7 |
| P_AdOH | 5 579 t | Appendix 8 |
| N2O_/AdOH | 0.27 kg N2O/kg AdOH | Appendix 9 |
| $\%\_on\text{-}line_y$ | 96.077 % | Appendix 6 |

9.4. Calculation of project emissions

The emissions due to the decomposition process PEy are the emissions due to the N2O that has not been sent to the decomposition process, the N2O non destroyed by the decomposition process and the emissions due to the use of natural gas.

PEy = ((Q_ $N_2O$ x (1-%_on-line))y + (Q_GE x $N_2O$ _GE x Specific_gravity_of_N2O)y) x GWP_ $N_2O$ + Q_NGy x E_NGy

PEy = ($Q\_N2O\_by\text{-}pass_y$ + (Q_GE x $N_2O$ _GE x Specific_gravity_of_N2O)y) x GWP_ $N_2O$ + Q_NGy x E_NGy

The non-destroyed $N_2O$ (ND_ $N_2O$ y) is constantly monitored and obtained from the constant monitoring of the flow (Q_GE) and the concentration of $N_2O$ ($N_2O$ _GE) of the effluent gas:
ND_ $N_2O$ = Q_GE x $N_2O$ _GE x Specific_gravity_of_N2O

PEy = ($Q\_N2O\_by\text{-}pass_y$ + ND_ $N_2O_y$) x GWP_ $N_2O$ + Q_NGy x E_NGy
PEy is rounded up in t CO2 eq. to get conservative consistency in final calculation of emission reductions formula.

| Parameter | Value | Reference |
|---|---|---|
| **PEy** | **19 372 t CO2 eq.** | Calculated |
| $Q\_N2O\_by\text{-}pass_y$ | 59 099 kg | Appendix 7 |
| Q_GE | 7 185 592 $Nm^3$ | Appendix 1 |
| $N_2O$_GE | 5.0 vppm | Appendix 2 |
| Specific gravity of_N2O | 1.963 x 10^-6 | Appendix 2 and 3 |
| ND_ $N_2O$ $_y$ | 71 kg N2O | Appendix 3 |
| GWP_ $N_2O$ | 310 kg CO2 eq./ kg $N_2O$ | Kyoto Protocol Rule. Decision 2/CP.3 |

| | | |
|---|---|---|
| $Q\_NG_y$ | 465 356 $Nm^3$ | Appendix 4 |
| $E\_NG_y$ | 2.212 kg CO2 eq./ $Nm^3$ | Appendix 5 |

Note:

1) The value of E_NGy shown above is the yearly moving average of E_NG as required by the PDD for calculation of E_Steam. The project emissions are more accurately calculated using the monthly values of E_NG shown in Appendix 5, following methodology AM0021/version 1 and the Monitoring Plan.

2) The value of ND_N2Oy is calculated by the DCS using every 10 second data of Q_GE and N2O_GE (see Appendix 2 and 3) and is more accurate than the value calculated using total average values.

9.5. Calculation of leakage

Leak emissions comprise the emissions associated with the energy sources used to generate any steam and electricity used by the decomposition plant.

Leakage amounts to:

$L_y = Q\_Power \times E\_Power + Q\_steam\_c_y \times E\_steam\_c_y$

Ly is rounded up in tCO2 eq. to get conservative consistency in final calculation of emission reductions formula.

| Parameter | Value | Reference |
|---|---|---|
| **Ly** | **37 t CO2 eq.** | Calculated |
| Q_Power | 28 977 kWh | Appendix 14 |
| E_Power | 1.095 kg $CO_2$/kWh | Appendix 15 |
| $Q\_Steam\_\ c_y$ | 22 100 kg | Appendix 16 |
| $E\_Steam\_c_y$ | 0.215 kg $CO_2$ / kg of steam | Appendix 17 |

9.6. Calculation of emission reduction

The total emission reduction achieved by this project activity during this monitoring period is therefore,

ERy = BEy – PEy – Ly

Or,

ERy = **467 871 t CO2 eq. – 19 372 t CO2 eq. – 37 t CO2 eq.**

Or,

**ERy = 448 462 t CO2 eq.**

The above emission reduction covers the generation of N2O during this monitoring period.

**Appendix 1**

| | |
|---|---|
| Name of item | Q_GE |
| Description | Volume of effluent gas leaving the stack |
| Value in period | 7 185 592 $Nm^3$ |
| Method of monitoring | Annubar flow meter |
| Recording frequency | Monthly |
| Background data | Log sheet record / flowmeter |

| Period | Quantity of gaseous effluent $Nm^3$ |
|---|---|
| Apr 1st – Apr 26th, 2009 | 7 185 592 |

**Appendix 2**

| | |
|---|---|
| Name of item | N2O_GE |
| Description | Concentration of $N_2O$ in the effluent gas |
| Value in period | 5.0 vppm |
| Method of monitoring | Laser diode online analyzer |
| Recording frequency | Monthly |
| Background data | Log sheet record |
| Calculation method | The instant values of the on-line analyzer are used to calculate the quantity of ND_N2O every 10 sec:<br>ND_N2O = Q_GE * N2O_GE * Specific_gravity_of_N2O<br>The specific_gravity_of_N2O = 44/22.414 x 10^-6 |

The analyzer has a range of 0-500 ppm with a detection limit of 5 ppm (1% of range). We use 5 ppm as a default value when the measured value is below the detection limit.
Cumulated value for ND_N2O is recorded (see appendix 3).

At the end of the month/period based upon the flow Q_GE, and ND_N2O the concentration of N2O equivalent for the month/period is calculated.

This value is for information as the constant calculation of ND_N2O is more accurate.

| Period | ND_N2O<br>Kg | Quantity of gaseous effluent<br>$Nm^3$ | Average concentration of $N_2O$_GE<br>vppm |
|---|---|---|---|
| Apr 1st – Apr 26th, 2009 | 71 | 7 185 592 | 5.0 |

## Appendix 3

| | |
|---|---|
| Name of item | ND_N2O |
| Description | Quantity of non-destroyed N2O emitted by the decomposition facility |
| Value in period | 71 kg $N_2O$ |
| Method of monitoring | On-line DCS calculation |
| Recording frequency | Monthly |
| Background data | Log sheet record |
| Calculation method | Actual quantity of non destroyed N2O is calculated on-line in the DCS from the concentration of N2O and the flow rate of the gaseous effluent:<br>ND_N2O = Q_GE * N2O_GE * Specific_gravity_of_N2O<br>The specific_gravity_of_N2O = 44/22.414 x 10^-6 |

| Period | ND_N2O<br>kg |
|---|---|
| Apr 1st – Apr 26th, 2009 | 71 |

**Appendix 4**

| | |
|---|---|
| Name of item | Q_NG |
| Description | Amount of natural gas used by the decomposition process |
| Value in period | 465 356 $Nm^3$ |
| Method of monitoring | Natural gas consumption data |
| Recording frequency | Monthly |
| Background data | Log sheet record / flowmeter |

| Period | Q_NG $Nm^3$ |
|---|---|
| Apr 1st – Apr 26th, 2009 | 465 356 |

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**Appendix 5**

| | |
|---|---|
| Name of item | E_NGy with NGC |
| Description | Emissions coefficient for natural gas combustion<br>Natural gas composition (NGC) is informed by the natural gas supplier |
| Value in period for $E\_NG_y$ | 2.212 kg $CO_2/Nm^3$ |
| Method of monitoring | Natural Gas Composition (NGC) |
| Recording frequency | Monthly |
| Background data | Composition data received from COMGAS, the natural gas supplier |
| Calculation method | The average number of C in a mole of NG is calculated from the composition = ∑ (number of C in each mole) x (volume ratio)<br>Following monthly data are used to calculate monthly project emissions due to the consumption of Natural Gas.<br>For this monitoring period was applied March data, because April data has not been available yet.<br><br>The yearly value (E_NGy) is calculated with the data available for the year prior to the beginning of the period and is used for the calculation of E_Steam. |

| Component | **March** Natural Gas Composition | Number of C |
|---|---|---|
| CH4 (Methane) | 88.64 | 1 |
| C2H6 (Ethane) | 6.32 | 2 |
| C3H8 (Propane) | 1.80 | 3 |
| I-C4H10 (I-Butane) | 0.27 | 4 |
| N-C4H10 (N-Butane) | 0.38 | 4 |
| I-C5H12 (I-Pentane) | 0.11 | 5 |
| N-C5H12 (N-Pentane) | 0.07 | 5 |
| C6H14+ (Hexane) | 0.09 | 6 |
| N2 (Nitrogen) | 0.60 | 0 |
| CO2 (Carbon dioxide) | 1.71 | 1 |
| Average number of C | 1.124 | |
| E_NG (month) | **2.210** | |

The CO2 specific gravity in standard state is 1.965
E_NG = 1.965 x (average number of C in a mole of NG)

**Appendix 6**

| | |
|---|---|
| Name of item | %_on-line |
| Description | % of production time that the N2O is sent to the decomposition facility |
| Value in period | 96.077 % |
| Method of monitoring | Position of limit switch on the valve allowing to by-pass the decomposition facility |
| Recording frequency | Monthly |
| Background data | Log sheet record |
| Calculation method | Based upon the position of the limit switch on the valve by-passing the decomposition facility, the % of time that the production is connected to the facility is continuously counted and used to calculate Q_ N2O_by-pass (See Appendix 7). |

At the end of the period, %_on-line for the period is calculated as:

$$\%\_on\text{-}line_y = 1 - (Q\_N2O\_by\text{-}pass_y / ( P\_AdOH_y \times N2O\_/AdOH))$$

| Period | Q_N2O_by-pass$_y$ kg | P_AdOH$_y$ t | %_on-line$_y$ % |
|---|---|---|---|
| Apr 1st – Apr 26th, 2009 | 59 099 | 5 579 | 96.077 |

**Appendix 7**

| | |
|---|---|
| Name of item | Q_N2O_by-pass |
| Description | N2O by-passing the decomposition facility |
| Value in period | **59 099 kg** |
| Method of monitoring | Production record and %_on-line DCS monitoring |
| Recording frequency | Monthly |
| Background data | Production & %_on-line log sheet record |
| Calculation method | The quantity of adipic acid produced while by-passing the destruction facility is first calculated:<br>AdOH_by-pass = P_AdOH x (1 - %_on-line)<br>The quantity of N2O that by-pass the facility is then recorded daily.<br>$Q\_N2O\_by\text{-}pass_d = P\_AdOH_d \times N2O\_/AdOH \times (1 - \%\_on\text{-}line)$<br>At the end of the period the quantity of N2O that by-passed the facility is :<br>$Q\_N2O\_by\text{-}pass_y = \Sigma\ (Q\_N2O\_by\text{-}pass_d)$ |

| Period | $Q\_N2O\_by\text{-}pass_y$ kg |
|---|---|
| Apr 1st – Apr 26th, 2009 | 59 099 |

**Appendix 8**

| | |
|---|---|
| Name of item | P_AdOH |
| Description | Adipic acid production |
| Value in period | 5 579 t |
| Method of monitoring | Packaged production and slurry used to nylon salt production |
| Recording frequency | Monthly |
| Background data | Log sheet record |

The production of adipic acid over the year ending with the last day of this period (from November 19th, 2008 to November, 18th 2009) is P_AdOH_cur_year = 34 581 t lower than the yearly capped value defined in the PDD, 94 900 t (detailed information is available in the Excel file "Workbook ER Paulinia", sheet BE, line 22, submitted to UNFCCC). Therefore, the total production of this period can be used as such. The Executive Board has confirmed on EB36 the application of a yearly Adipic acid production cap as required by the methodology. This approach is consistent with the definitions and requirements of the "Guidance on accounting eligible HFC-23" AM0001 (EB39 Annex 8): the year of the crediting period is defined on the basis of the starting date of the crediting period of a project activity (November 19th); the current period ends on November 18th, which is the end date of the year of the crediting period.

| Month - year | Adipic acid production<br>t |
|---|---|
| Apr 1st – Apr 26th, 2009 | 5 579 |

As described in the PDD (Section A.2, Section B.2 Table 3 and annex4 Monitoring plan), the adipic acid production is measured by adding the dry adipic acid production, the slurry adipic acid production contained in the Nylon salt, and the in-process product inventory variations. In this case:

- Dry adipic acid: is the product which was packaged (determined by weigh scales).
- Slurry adipic Acid: is the product used to be mixed in fixed proportions with Hexamethyldiamine and make Nylon salt on Paulinia site. Nylon salt quality is very accurately analyzed and controlled. Daily Nylon salt production is obtained by the sum of the weight of the truckloads plus the variation of Nylon salt storage tank levels. Both

the concentration of Nylon salt as well as adipic acid content are controlled in the Nylon salt production process: the Nylon salt concentration is monitored online by refractive index measurement and the adipic acid slurry content is monitored through precise pH measurement. Furthermore, following the Quality Control procedure to guarantee the Nylon salt specification, the content of the storage tank F5300 is analyzed every 2 hours for pH and concentration using very accurate instruments in the laboratory, according to the Quality Document "ISAL-HMD-SAL-QA-006" as stated in the PDD, section D3 line 2b.1. Should a parameter show a deviation, the Nylon salt unit operator would immediately correct the concentrations in the process to correct Nylon salt concentration and/or adipic acid content. The Nylon salt specification is very narrow (± 0.02 for pH and ± 0.2% for concentration) and the analysis of the storage tank present a very low variability within those limits. This accuracy was checked by the auditor during the Initial Verification. Rhodia follows the PDD annex 3 and the monitoring plan and utilizes the Excel file "SAP-HMD.xls" to determine the nylon salt produced and automatically the corresponding adipic acid slurry. The calculation of the quantity of adipic acid in nylon salt on dry basis is based on a constant ratio of adipic acid in Nylon salt which is constant as fixed by the very precise value of the pH of the Nylon salt. The analytical results of pH and concentration of the Nylon salt solution for each period of one month are kept in an Excel file named "Qualidade SALN_month.xls" which is shown to the DOE for verification along with the file "SAP-HMD.xls". The ratio of Adipic Acid in Nylon Salt is 0.55748 in the Excel file "SAP-HMD.xls" in compliance with the guidance issued by the Executive Board in its 45$^{th}$ meeting of February 2009.

The details of the calculation of the production amount are as follows.

The total daily adipic acid made by the nitric oxidation reaction is the sum of two terms (Equation (1)):

| | |
|---|---|
| Total Production [P_AdOH] = [Finished Product] + [Variation of the In-Process Product] | (1) |

The finished adipic acid production is obtained by adding the production of dry and slurry adipic acid, according to Equation (2).

| | |
|---|---|
| [Finished Product] = [Dry Adipic Acid] + [Slurry Adipic Acid] | (2) |

The in-process adipic acid is obtained by adding the amount of adipic acid contained in all process equipment where adipic acid is present at different concentrations.

The variation of the In-Process Product inventory of day N is obtained by subtracting the total In-Process Product of day N minus In-Process Product of day (N-1) as in Equation (3):

| | |
|---|---|
| [Variation of the In-Process Product] = [In-process Product of day N] – [In-process Product of day (N-1)] | (3) |

Therefore, according to described in the sections above, the total production of adipic acid is the sum of the following terms described in Equation (4), after rewriting Equation (1) using Equation (2):

| | |
|---|---|
| Total Production [P_AdOH] = [Dry Adipic Acid] + [Slurry Adipic Acid] + [Variation of the In-Process Product] | (4) |

The total production is normally different from the finished product on a daily basis since the in-process product is always varying. The total production can be higher or lower than the finished product. On a long term basis however those differences compensate each other and the accumulated total production will of course approach the sum of dry + slurry.

For the purpose of determining the daily amount of $N_2O$ generated by the nitric oxidation of the raw materials, it must be used the total production, not the finished adipic acid production, since $N_2O$ is generated by the reaction and is independent of the finished production for a limited time (up to 1 or 2 days). In fact during such limited time the adipic acid made at the reaction can be accumulated in the process equipments awaiting to be processed through purification and drying.

**Appendix 9**

| | |
|---|---|
| Name of item | HNO3_consumption & HNO3_physical |
| Description | Nitric acid consumption and losses in the adipic acid process |
| Value in period | (see table below) |
| Method of monitoring | Excel workbook based on monitoring data and analysis |
| Recording frequency | Monthly |
| Background data | Log sheet records |
| Calculation method | Nitric acid physical losses (HNO3_physical) in the aqueous wastes, the off gases, the adipic acid and the by-product are monitored.<br>Those losses are deducted from the nitric acid consumption, (HNO3_consumption) to get the chemical consumption, (HNO3_chemical). |

| Period | HNO3_consumption t | HNO3_physical t | HNO3_chemical t |
|---|---|---|---|
| Apr 1st – Apr 26th, 2009 | 5 094 | 279 | 4 815 |
| Rolling year Apr 26th, 2009 | 77 026 | 3 908 | 73 118 |

| | |
|---|---|
| Name of item | N2O_AdOH |
| Description | N2O emission factor for adipic acid production |
| Value in period | 0.270 kg $N_2O$/kg AdOH |
| Method of monitoring | Adipic acid production, nitric acid consumption and physical losses |
| Recording frequency | Yearly |
| Calculation method | The N2O emission factor is then calculated over the period on one year using the last rolling year data: |

N2O_AdOH = HNO3_chemical / P_AdOH / 63 /2 x 0.96 x 44

The calculated value for this period is above 0.270 and is then capped by the value of KE_N2O = 0.27, as specified in the PDD table D.2.1.3 and required by the methodology AM0021/version 1.

| Period | Value N2O_AdOH calculated kg N2O/kg AdOH | KE_N20 kg N2O/kg AdOH | N2O_AdOH kg N2O/kg AdOH |
|---|---|---|---|
| Rolling year Apr 26th, 2009 | 0.282 | 0.270 | 0.270 |

**Appendix 10**

| | |
|---|---|
| Name of item | Q_$N_2O$ reg , $N_2O$_reg / AdOH and $r_y$ |
| Description | Evolution of Brazilian legislation that may require limitation of $N_2O$ emissions using one of the following criteria:<br>- Q_$N_2O$ reg : allowed $N_2O$ emissions<br>- $N_2O$_reg / AdOH: allowed $N_2O$ emissions per kg of adipic acid produced<br>- $r_y$ : share of $N_2O$ emissions required to be destroyed |
| Value in period | not applicable |
| Method of monitoring | Survey |
| Recording frequency | When relevant |
| Background data | Brazilian legislation<br>No evolution of legislation since PDD emission. |

| Period | Q_$N_2O$ reg<br>kg | $N_2O$_reg / AdOH<br>kg | $r_y$<br>% |
|---|---|---|---|
| Apr 1st – Apr 26th, 2009 | No limit | No limit | 0 |

Note: Rhodia follows the evolution of Brazilian legislation about N2O emissions that could affect the project Emission Reduction through the parameters N2O_reg / AdOH, Q_N2O reg, or $r_y$ as part of the ISO 14000 requirements.
Rhodia has hired an external company specialized in regulations. It sends to GSIMAP (Rhodia Industrial Platform) all the changes in regulations that may impact Rhodia. GSIMAP team evaluates the changes and discusses the applicability to the Rhodia operations in a steering committee. The conclusions from this steering committee are then presented to the Quality representatives of all plant units in a formal meeting that happens every three months.
Furthermore GSIMAP experts on environmental issues participate on meetings held on external organizations (such as ABIQUIM - Brazilian Association of Chemical Industries, CETESB - local environmental agency) that discuss draft regulations. Those experts know in advance what comes next in terms of environmental laws.

## Appendix 11

| | |
|---|---|
| Name of item | $P\_N_2O$ |
| Description | Market price of $N_2O$ in waste gas |
| Value in period | 0 €/t |
| Method of monitoring | Market survey |
| Recording frequency | Yearly |
| Background data | No market for this low level of N2O concentration |

Beside the very high investment cost in a purification-concentration-liquefaction unit to extract the $N_2O$ from the exhaust flow of the adipic acid plant, neither the process as the product will get the necessary certifications for the pharmaceutical and food markets.

As pharmaceutical and food markets are the largest of the $N_2O$ usages we can conclude that there is no $N_2O$ market for the $N_2O$ produced as by-product of adipic acid.

| Year | $P\_N_2O$ |
|---|---|
| 2009 | 0 |

**Appendix 12**

| | |
|---|---|
| Name of item | Q_Steam_p |
| Description | Amount of steam produced by the decomposition facility |
| Value in period | 6 062 700 kg |
| Method of monitoring | Flowmeter |
| Recording frequency | Monthly |
| Background data | Log sheet record |

| Period | Q_Steam_p<br>Kg |
|---|---|
| Apr 1st – Apr 26th, 2009 | 6 062 700 |

**Appendix 13**

| | |
|---|---|
| Name of item | E_Steam |
| Description | $CO_2$ emission factor for steam produced by the facility |
| Value in period | 0.145 kg $CO_2$/kg of steam |
| Method of monitoring | Supplier data |
| Recording frequency | Yearly |
| Background data | Data supplied by the Rhodia Paulínia Industrial Platform |
| Calculation method | The calculation is made according to the monitoring plan, section 6.3.<br>We first calculate the amount of natural gas required to generate steam in Nm3/t of steam in a very efficient boiler<br>QNG_steam = △H (kJ/t) / (LHV (kJ/Nm3) x ɳ (%))<br>The LHV data is the yearly average value for the gas supplied by COMGAS.<br>$E\_NG_y$ is the yearly average value for the gas supplied by COMGAS (see appendix 5).<br>The yearly value of E_Steam is calculated with the data available for the year prior to the beginning of the period in order to assure to have the data. |
| Comment | LHV data is supplied by COMGAS in kcal/m3 at 20 $^oC$. Data were converted to kJ/Nm3. |

| Year ending | LHV kJ/$Nm^3$ | △H kJ/t | ɳ % | QNG_tsteam Nm3/t of steam | $E\_NG_y$ kg-$CO_2$/Nm3 | E_Steam kg-$CO_2$/ kg of steam |
|---|---|---|---|---|---|---|
| Mar 31st, 2009 | 38 746 | 2624000 | 97 | 65.69 | 2.212 | 0.145 |

**Appendix 14**

| | |
|---|---|
| Name of item | Q_Power |
| Description | Electricity consumption by the decomposition facility |
| Value in period | 28 977 kWh |
| Method of monitoring | Power consumption data |
| Recording frequency | Monthly |
| Background data | Log sheet record / counter |

| Period | Q_Power kWh |
|---|---|
| Apr 1st – Apr 26th, 2009 | 28 977 |

**Appendix 15**

| | |
|---|---|
| Name of item | E_Power |
| Description | $CO_2$ intensity for electric generation |
| Value in period | 1.095 kg $CO_2$/kWh |
| Method of monitoring | Survey of data publication |
| Recording frequency | Yearly |
| Background data | Latest data made publicly available by the Brazilian Operador Nacional do Sistema Elétrico, ONS, are for 2007.<br>http://www.ons.com.br/biblioteca_virtual/publicacoes_operacao_sin.aspx<br>http://www.mme.gov.br/site/menu/select_main_menu_item.do?channelId=1432&pageId=4124 |
| Calculation method | Calculated according to the PDD monitoring plan based on ACM0002 version 2. E_Power is calculated by taking into account only the emission factors of the fossil-fuel electricity generation (simple OM). As explained in the PDD Monitoring Plan, ONS still does not supply the plant-specific data required for BM (build margin) calculation. This is a very conservative approach since only 4% of the total electricity supplied to the grid is generated using fossil fuels (96% of Hydro and Nuclear).<br>The detailed calculation is available in the Excel file "Workbook ER Paulínia" of this period (in the worksheet "E_Power") which is a confidential document communicated to the DOE and to the CDM Executive Board. The data and the calculations were verified by the DOE prior to their utilization. |

| Date (year) | E_Power<br>kg $CO_2$/kWh |
|---|---|
| 2009 | 1.095 |

**Appendix 16**

| | |
|---|---|
| Name of item | Q_Steam_c |
| Description | Amount of steam consumed by the decomposition facility |
| Value in period | 22 100 kg |
| Method of monitoring | Mass flowmeter |
| Recording frequency | Monthly |
| Background data | Log sheet record |

| Period | Q_Steam_c<br>Kg |
|---|---|
| Apr 1st – Apr 26th, 2009 | 22 100 |

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**Appendix 17**

| | |
|---|---|
| Name of item | E_Steam_c |
| Description | $CO_2$ intensity for steam consumed in the facility |
| Value in period | 0.215 kg $CO_2$/kg of steam |
| Method of monitoring | Calculated from steam supplier data |
| Recording frequency | Yearly |
| Background data | Data supplied by the Rhodia Paulínia Industrial Platform |
| Calculation method | This steam is supplied by existing boilers on site. Steam production, natural gas, fuel oil and by-products consumptions are monitored. From the monthly consumption of all fuels, the monthly value of E_NG and of the carbon content of each liquid fuel, monthly emissions of CO2 for steam production are calculated and cumulated over the year. E_Steam_c is obtained from the ratio of yearly CO2 emission over the yearly steam production. |

According to the PDD we calculate E_steam_c as a weighted average of the coefficients E_steam_c_NG (emission factor of steam produced by the boilers running on natural gas) and E_steam_c_chem&oil (emission factor of the steam produced by the boilers running on by-products and fuel oil) with the real share of the steam generated with each type of fuel.

E_steam_c = E_steam_c_NG x %_gen_NG +
+ E_steam_c_chem&oil x %_gen_chem&oil
where %_gen_chem&oil = 100% - %gen_NG

The yearly value of E_Steam_c is calculated with the data available for the year prior to the beginning of the period in order to assure to have the data.

| Year ending | E_Steam_c_NG kg $CO_2$/kg of steam | E_Steam_c_chem&oil kg $CO_2$/kg of steam | %_gen_NG Share of steam generated using natural gas | E_Steam_c kg $CO_2$/ kg of steam |
|---|---|---|---|---|
| Mar 31st, 2009 | 0.211 | 0.264 | 93.5 | 0.215 |