

JI Project

Nitrous Oxide Emission Reduction Project at GP Nitric Acid Plant in AB Achema Fertiliser Factory

MONITORING REPORT

FIRST PROJECT CAMPAIGN 16/08/2008 - 26/09/2009

Version 1.3

08 December 2009

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Introduction

The Joint Implementation project "Nitrous Oxide Emission Reduction Project at GP Nitric Acid Plant in AB Achema Fertiliser Factory" was successfully carried out by installing secondary catalyst in August 2008. The baseline campaign was launched from September 2007 to July 2008 during which emissions were monitored to determine the baseline emissions of the plant. After installing of the secondary catalyst, the first project campaign was launched and the project emissions monitored until the end of the campaign – 26 September 2009.

This report describes the monitoring measures implemented within the frame of JI project during a period of 16.08.2008 - 26.09.2009. It evaluates the achieved emission reductions for a given period and resumes steps, which were carried out in accordance with the Monitoring plan and the requirements of the CDM methodology AM0034 v.3.3.

1. JI project design

1.1 Engineering solution for N2O reduction

BASF technology was applied by introducing a new catalyst bed which was installed in a new basket, directly under the Platinum gauze in the nitric acid reactors. The technology is owned and patented by BASF (German patent BASF Catalysts 03-85), and has also been installed in several other plants.

The secondary catalyst (on Al_2O_3 basis with active metal oxides CuO and ZnO) was installed underneath the platinum gauze. In order to be able to install a secondary catalyst the reconstruction of a burner basket was performed to make required 20-100 mm additional free space under the Platinum gauze.

Everything was prepared for the basket reconstruction and the catalyst replacement in the middle of July 2008. The GP plant was stopped on 28th July 2008 and after the cooling of the production line the old basket was dismantled. The installation of the new basket was successful as well as the installation of the secondary catalyst. The new catalyst's 03-85 shape is a extrudated Stars 3 mm. The free space in the basket was filled with ceramic Raschig rings and the test of GP plant operation was performed on 16th August 2009. The plant started fully operating at 1am on 17th August 2009.

The lifetime of the secondary catalyst is about 3 campaigns (lifetime of the platinum gauze), i.e. length of a campaign about 330 days in the high-pressure nitric acid reactors and about 1000 days in the medium-pressure nitric acid reactors. The guaranteed efficiency of the BASF secondary catalyst was about 80%. The average efficiency has reached up to 88 % during first project campaign.

1.2 Monitoring system

The N_2O monitoring system is designed according to the requirements set in the approved CDM baseline methodology AM0034 v3.3.

Baseline emissions were monitored and calculated by continuous multi-component measuring system Advance Cemas-NDIR manufactured by ABB, prior to installation of secondary catalysts. The monitoring system allows to measure N_2O concentration in the tail gas flow continuously during the entire lifespan of the primary catalysts in the oxidation reactor i.e. for approximately 11 months.

The monitoring system was installed, adjusted and launched on 30^{th} June 2007 at the end of the campaign IV. Campaign V (baseline campaign) was launched on 5^{th} September 2007. Emissions were monitored during the entire baseline campaign after which, a secondary catalyst was installed and the first project campaign (VI) was launched.

Monitoring results of the baseline campaign give an average value of N_2O emissions released to the atmosphere while producing 1 t of HNO_3 without abatement technique. After the installation of the secondary catalyst, the baseline emissions were compared to the actual emissions that were also continuously measured. The difference between baseline emissions and actual emissions after the installation of the secondary catalyst give emission reduction values.

Location of sampling probes for on-line measurement of tail gas volume flow, temperature, pressure and N_2O concentration with ABB multi-component measuring system at GP nitric acid plant are shown in a figure below.



Figure 1 Sampling points for N₂O monitoring at GP plant

As it can be seen on the process scheme above, the volume flow, temperature and pressure measuring probe is installed after expander unit and N_2O sampling probe directly after DeNOx reactor.

Flow volume, temperature and pressure of the tail gas are measured separately from N_2O because length of straight duct at the N_2O sampling point is not long enough according to requirements for such measurements.

The N₂O monitoring system at GP plant consists of the following components:

- ✓ N₂O analyzer AO-2000-URAS-26 (ABB)
- ✓ Flow meter DELTAFLOW (Systec)
- ✓ Data Server EMI 3000
- ✓ Distributed control system (DCS)

A simplified scheme of the monitoring system is presented below:



Figure 2 Automated monitoring system at GP plant

A flow meter measures volume flow (m^3/h) , temperature and pressure in the tail gas and sends signals to the server. The server stores data and forwards signal to the Distributed Control System (DCS). The N₂O analyzer continuously measures concentration of N₂O in the tail gas and also sends signal to the data server which forwards it to DCS.

The AM0034 methodology requires monitoring scheme to be installed according to the European Norm 14181 (2004). The Norm requires evaluation of the automated measuring system (AMS) against three Quality Assurance Levels (QAL1, QAL2 and QAL3) and an Annual Surveillance Test (AST). Besides that, it must be ensured that the automated measuring system (AMS) is installed in accordance with the relevant European/ international standards and manufacturer requirements and functional test is performed at the commissioning of the AMS.

QAL1 procedure requires compliance of the equipment with EN ISO 14956. AO-2000-URAS-26 and DELTAFLOW are ISO 14956 certified by the manufacturers.

QAL2 procedure requires determination of the calibration function and a test of the measured values of the AMS compared with the uncertainty given by legislation. During the maintenance period of the GP plant (July 2008) the openings required for QAL2 tests were made in the duct.

QAL2 procedure was performed by an accredited independent entity. QAL2 test results were then integrated into the calculations performed by the monitoring software - CDMN2O.

QAL3 is a procedure to check drift and precision in order to demonstrate that the AMS is in control during its operation so that it continues to function within the required specifications for uncertainty. QAL3 is performed automatically as the system calibrates itself once a week. In addition, Achema's experts perform maintenance of the equipment such as fixing faults, changing filters, removing condensate from the system etc.

AST is a procedure to evaluate whether the measured values obtained from the AMS still meet the required uncertainty criteria – as demonstrated in the previous QAL2 test. AST is set to be performed annually by a selected validator.

The AM0034 requires determining the normal ranges for operating conditions for the following parameters: (i) oxidation temperature; (ii) oxidation pressure; (iii) ammonia gas flow rate, and (iv) air input flow rates. To calculate the "permitted range" for oxidation temperature and pressure, a historical data method was chosen and the permitted range then was entered into the AMS.

1.3 Data processing system

The data processing system consists of the following components:

- Data logger CX1000
- Data server EMI3000
- External Backup harddrive
- Software CDMN2O



Figure 3 Data processing system

The Data logger CX1000 continuously reads and stores digital data of the monitoring system while EMI3000 handles the communication with the datalogger and evaluates continuously physical second values with status information. Based on this second values 60-minutes averages with status information are calculated.

All data are stored in a MySql-database and thus available for further evaluation. It is also backed up in the external hard drive disc.

Emission calculations are performed by CDMN2O (Version 1.0) software of AFRISO which allows to evaluate data according to the requirements of the approved CDM baseline methodology AM0034. Software is installed on the same PC running EMI3000 and is accessing its database.

The software's compliance with AM0034 requirements has been verified and approved. EMI3000 and CDMN2O are operated by a responsible engineer of AB Achema subsidiary "Sistematika" weekly maintenance and additional services related to the software are provided by AFRISO.

Data processing system follows the methodology of the AM0034 and the monitoring plan, therefore only the final results as output of the system are presented in this report.

2. Evaluation of the monitoring data

2.1 Monitoring data acquired

According to the Monitoring plan these parameters have been monitored and archived by EMI3000:

OH [h] Operating Hours - derived from Digital Input "In Operation" OT [°C] Oxidation Temperature **OP** [kPa] Oxidation Pressure AFR [kg/h] Ammonia Flow AIFR [%] Ammonia/Air-Ratio PSG [hPa] absolute Pressure TSG [°C] Stack Flow Temperature VSG.opcond [m³/h] Stack Flow insitu VSG [Nm³/h] Stack Flow [$^{\circ}$ C, 1013hPa] = VSG.oc * (273 / (273 + TSG) * (1013 / PSG) NCSG[L].lR [mg/m³] N20 Low Range NCSG[L].IR.v [mg/m³] N20 Low Range: Valid Counter = incremented if in Low Range and valid NCSG[L].hR [mg/m³] N20 High Range NCSG[L].hR.v [mg/m³] N20 High Range: Valid Counter = incremented if in high Range and valid NCSG[L] [mg/m³] N20 C(HNO3) [%] Concentration of HNO3 NAP.input [kg/h] HNO3-Production NAP [kg/h] HNO3-Production at 100%-conc. = C(NAP) * NAP.input

Mass rate of the N_2O flow is automatically calculated from the data of N_2O concentration in the tail gas and from its flow rate. The calculation is executed automatically in the EMI3000, where the calculated data is stored and archived.

2.2 Methodology



Figure 4 Data evaluation process

General evaluation rules are as follows:

• values for VSG, NSCG when OT, OP, AFR, AIFR inside permitted range:

 $\begin{array}{l} OT_{min} < OT_h < OT_{max} \\ OP_{min} < OP_h < OP_{max} \\ AFR < AFR_{max} \\ AIFR < AIFR_{max} \end{array}$

• values for VSG, NSCG are inside 95%-confidence interval

The basic formula used to calculate emission reductions by CDMN2O software is the following:

$\mathbf{ER} = (\mathbf{EF}_{B1} - \mathbf{EF}_{P}) * \mathbf{NAP}_{P} * \mathbf{GWP}_{N2O}$

 $ERP = \text{campaign specific emission reduction [t CO_2]}$ $EF_{B1} = N_2O \text{ Baseline Emission Factor [t N_2O / t HNO_3]}$ $EFP = N_2O \text{ Production Emission Factor [t N_2O / t HNO_3]}$ $NAPP = HNO_3 \text{ production during Production campaign [t HNO_3]}$ $GWP_{N2O} = \text{constant 310.0 [t CO_2 / t N_2O]}$ The intermediate calculation is as follows:

1. Calculation of Baseline Emissions

BEBC = VSGBC,95% * NSCGBC,95% * 10⁻⁹ *** OHBC** [t N2O] BEBC = N2O Baseline Emissions [t N2O] VSGBC,95% = average stack flow inside 95%-confidence interval [Nm3/h] NSCGBC,95% = average N2O-concentration inside 95%-confidence interval [mg/Nm3] OHBC = operating hours [h]

2. Calculation of Baseline Emission Factor

EFBL = **BEBC** / **NAPBC** * (1 - **UNC** / 100%) [t N₂O / t HNO₃] EFBI = N₂O Baseline Emission Factor [t N₂O / t HNO₃] **BEBC** = N₂O Baseline Emissions [t N₂O] **NAPBC** = HNO₃ Production during campaign [t HNO₃] **UNC** = total uncertainty of system [%]

3. Calculation of Campaign Emissions

PEn = VSGn,95% * NSCGn,95% * 10⁻⁹ * OHn [t N2O] PEn = N₂O Campaign Emissions [t N₂O] VSGn,95% = average stack flow inside 95%-confidence interval [Nm₃/h] NSCGn,95% = average N₂O-concentration inside 95%-confidence interval [mg/Nm₃] OHn = operating hours [h]

4. Calculation of Campaign Emission Factor

2.3 Illustration of Calculations

BE_{BC} = $138946.53 * 2759.54 * 10^{-9} * 7328 = 2809.764 \text{ t } \text{N}_2\text{O}$

EF_{BL} = $2809.764 / 290000.7 * (1-5.12/100) = 0.009193 t N_2O/t HNO_3$

PEn = $133840.30 * 304.17 * 10^{-9} * 7630 = 310.618 t N_2O$

 $EFn = 310.618 / 290004.17 = 0.001071 t N_2O/t HNO_3$

 $\mathbf{ER} = (0.009193 - 0.001071) * 290004.17 * 310 = 730148.56 \text{ t CO}_2$

2.4 Data correction

The data obtained during the downtime of the monitoring system was handled according to AM0034 (v.3.3) methodology by using CDMN2O software. In the events of the monitoring system disorders, the lowest between the conservative IPCC ($4.5 \text{ kg N2O} / t \text{ HNO}_3$) or the last measured value was automatically selected by CDMN2O for the downtime period for the baseline emission factor, and the highest measured value in the campaign was selected for the downtime period for the campaign emission factor.

2.5 Campaign length

According to the AM0034 methodology (v.3.3), EF_{BL} has to be recalculated in two cases:

1. if $CL_{BL} > CL_{normal}$ 2. if $CL_n < CL_{normal}$

where:

 CL_{BL} – length of the baseline campaign CL_{normal} – average historic campaign length CL_n – length of a project campaign

According to the monitoring results:

$$\begin{split} CL_{BL} &= 299800.8 \ t \ HNO_3 \\ CL_{normal} &= 303129.33 \ t \ HNO_3 \\ CL_n &= 290004.17 \ t \ HNO_3 \end{split}$$

 $\begin{array}{l} CL_{BL} < \ CL_{normal} \\ CL_n < CL_{normal} \end{array}$

Therefore EF_{BL} was recalculated in the CDMN2O software according to the AM0034 (v.3.3) methodology requirements by eliminating all N₂O values from the baseline campaign that are resulting from HNO₃ production which exceeds amount equal to CL_n . The end point of the baseline data selected for calculation of EF_{BL} was 18.07.2008. 3:00 with the NAP equal to 290000,7 t HNO₃.

2.6 Impact of regulations

Regulations have no impact on the current campaign's monitoring data. AB Achema operates according the IPPC permit No.2/15 which was updated on April 30 2008. The IPPC permit issued to AB Achema imposes N₂O limits starting from 2011, which will affect corresponding campaigns. This impact will be reflected in the related monitoring reports.

3. Monitoring results

3.1. Configuration of baseline's campaign calculation

ACHEMA Jonova, Line 1

Date 11/5/2009 Page: 1 001 Baseline (05.09.07 10:00 - 28.07.08 24:00) Configuration 01 Campaigne Data Minimum Maximum Туре baseline OT 756 00 °C 778 70 °C Status calculated 0P 243.00 kPa 283.00 kPa AFR Start 05.09.2007 10:00 11497 16 t NH3/h Stop 28.07.2008 24:00 AIFB 1010% UNC 5.12 % CI.Normal 303129.330 t GS.Normal Johnson Matthey GC.Normal : 95% Pt/5%Rh (Gauze 1-3), 37%Pt/60%Pd/3%Rh (Gauze 4) GS.Baseline Johnson Matthey 95% Pt/5%Rh (Gauze 1-3), 37%Pt/60%Pd/3%Rh (Gauze 4) GC.Baseline Zero-Offset low high
 Range [max]

 low
 high

 -0.010
 3920 150
 Range [min] Gradient Std.Deviation Factor low high high low .13 10W 61 2 high -244 8 ,~ (F1) NCSG[L] IR post calc NCSG 244 8 -979 (VSG oc [F1] VSG opcond post calc 0 000 218506 000 15026 9 0 000 1600 000 (F1) PSG post cale 99.07 396.3 PSG (F1) TSG 0.000 400.000 25 29 -101 1 TSG post calc 0 0 ٠, VSG 1 oc none _ none PSG 1 TSG.1 none VSG 2 oc none none PSG 2 TSG 2 none (F1) Op Time он direct от [F1] OT direct OP (F1) OP direct AFR [F1] AFR direct AIFR [F1] AIFR direct (INAP) [F1] C[HNO3] post calo direct 0.000 100.00

AM0034 - Configuration

NAP(op)

[F1] NAP input

3.2. Configuration of project's campaign calculation

| ACHEMA 002 Produc | A Jonova, Li stion (17.08.0) | ne 1 8 01:00 - 26 | 6.09.09 | 09.00) | | | | | | | | D. | ate 11757 Pa |
|--|--|--|---|--|---------------------------------------|-----------------------------|---|---|--|--|------------------------------------|--------------------------------------|---|
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| | | | | Con | figuration () | 1 | | | | | | | |
| Campaigne Data | a | | | | | | | | Мі | nmum | | Ma | simum |
| Туре | : project | | | | | | от | : | | 0.00 °C | | 1 | 000.00 °C |
| Status | calculated | | | | | | OP | : | | 0.00 kPa | | 11 | 000 00 kP |
| Start . | . 17.08.2008 | 01:00 | | | | | AFB | : | | | | 20 | 000.00 + N |
| Stop | : 26.09.2009 | 09:00 | | | | | AIFR | | | | | | 15.00 % |
| UNC | : 5.12 % | | | | | | | | | | | | |
| CI.Normal | : 303129.330 | Dt | | | | | | | | | | | |
| GS.Normal | : Johnson M | atthey | | | | | | | | | | | |
| GC Normal | . 95% Pt/5%(| Rh (Giauze 1-3), 3 | 7%Pt/60% | Pd/3%Rh (| Gauze 4) | | | | | | | | |
| | | | | | | | | | | | | | |
| GS Baseline | : Johnson Ma | althey | | | | | | | | | | | |
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| GS Baseline GC Baseline GS Project GC Project VSG ec PSG VSG ec PSG 1 VSG tec PSG 1 VSG tec PSG 1 VSG tec PSG 2 TSG 2 OH OT OP AED | Johnson M. 95% Pi/5% [F1]NcSqL is [F1]VSG opcond [F1]VSG opcond [F1]OS [F1]Op Time [F1]Op Time [F1]OP [F1]OP | Atthey Rh (Gauze 1-3), C post calc post calc post calc post calc post calc none none none none none deed deed deed | Rang low 0000 0000 0000 0000 | Pd/3%Rh (e [min] high sscoo 21856 000 400.000 | Gauze 4) | e (max) high 3920 160 | Gradi Jow 1505 9 99 07 25 29 | ent kigh 244 8 0 0 0 0 | Zero- low 244 8 -501076 -396 3 -101 1 | 3Hset high -9793 0 0 0 | Std De low 0 0 | viation high 13 0 0 0 | Factor 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| GS Baseline GC Baseline GS Project GC Project NCSG VSG ec PSG 15G 15G 15G 15G 1 VSC 2 ec PSG 2 TSG 2 OH 07 0P AFR AIEG | Johnson M. 95% Pi/5%1 [F1] NCSQLJ IR [F1] VSG opcond [F1] VSG opcond [F1] PSG [F1] TSG [F1] Op Time [F1] OP [F1] | Atthey Post calc post calc post calc post calc post calc post calc none none none none detect detect detect | Rang low 0000 0000 0000 0000 0000 0000 0000 | Ed/3%Bh (e [min] high secoo 21550000 40000 40000 | Gauze 4) | e (max) high 3920 160 | Grad low 612 15059 9907 2529 | ent hagh 0 0 0 | Zero-C low -244 8 -001076 -396 3 -101 1 | 3)//se/ hugh -9793 -0 | Sid De low 0 0 | viation high 13 0 0 | Factor |
| GS Baseline GC Baseline GS Project GC Project NCSG VSG ec PSG 1SG VSG ec PSG 1 TSG 1 VSG 2 ec PSG 2 TSG 7 OH OT OP AFR AIFE | Johnson M. 95% Pi/5%i 1 | Aithey Rh (Gauze 1-3), C post calc post calc post calc post calc none none none none decet decet decet decet decet | Rang low 0000 0000 0000 0000 0000 0000 0000 | Ed/3%Bh (e [min] high ss0000 150000 40000 | Gauze 4) low ootb | ≥ [max] high 3920 150 | Gradi low 612 15025 9 99.07 25 29 | tent high 244 8 0 0 0 - - - - - - - - - - - - - | Zeto-f low 244 8 -60107 6 -396 3 -101 1 | 31fset hugh 9793 0 0 0 0 | Sid De low 0 0 0 | viation high 0 0 | Factor 1 1 1 1 1 1 1 1 1 1 1 1 1 |

AM0034 - Configuration

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ACHEMA Jonova, Line 1

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Evaluation AM0034

| Begin End Type Status GS.Normal GC.Normal GS.Baseline GC.Baseline | : 17.08.2008 01:00:00 : 26.09.2009 09:00:00 : project : calculated : Johnson Matthey : 95% Pt/5%Rh (Gauz: : Johnson Matthey : 95% Pt/5%Rh (Gauz: | e 1-3), 37%Pt/60% e 1-3), 37%Pt/60% | 5Pd/3%Rh (Gauze 4) 5Pd/3%Rh (Gauze 4) | | | | | |
|--|---|---|--|--|--|--|--|--|
| GS.Project GC.Project | : Johnson Matthey : 95% Pt/5%Rh (Gauze 1-3), 37%Pt/60%Pd/3%Rh (Gauze 4) | | | | | | | |
| Baseline Extra Calculati | <u>on</u> | | | | | | | |
| BL.Start BL.Stopp BL.OH.total BL.OH.valid BL.VSG (mean) | : 05.09.2007 10:00:00 : 18.07.2008 03:00:00 : 7328 : 6983 : 138828 26 | h h Nm³/h | (95,29%) (6983 values) | | | | | |
| BL.VSG (Mean) BL.VSG (Std.Dev) BL.VSG (mean 95%) BL.NCSG (mean) | : 6973,23 : 138946,53 : 2750,63 | Nm³/h Nm³/n mg/Nm³ | (6646 values) (6983 values) | | | | | |
| BL.NCSG (Std.Dev) BL.NCSG (mean 95%) BL.NAP BL.UNC | : 284,51 : 2759,54 : 290000,700 : 5,12 | mg/Nm³ mg/Nm³ tHNO3 % | (6803 values) | | | | | |
| Project Calculation | | | | | | | | |
| OH.total OH.in op.cond. VSG (mean) VSG (Std.Dev) VSG (mean 95%) NCSG (mean) NCSG (Std.Dev) NCSG (mean 95%) NAP | : 7630 7630 133925,96 10819,34 133840,30 2326,60 203,55 304,17 290004,170 | h h Nm ³ /h Nm ³ /h mg/Nm ³ mg/Nm ³ mg/Nm ³ tHNO3 | (100,00 %) (7630 values) (7375 values) (7630 values) (7330 values) | | | | | |
| Baseline results | | | | | | | | |
| BE EF (BI) | : 2809,764 : 0,009193 | tN20 tN20 / tHNO3 | | | | | | |
| Project results | | | | | | | | |
| PE EF (n) EF (mean) EF (min) EF.p | : 310,618 : 0,001071 : 0,001071 : 0,001071 : 0,001071 : 730148.56 | tN20 tN20 / tHN03 tN20 / tHN03 tN20 / tHN03 tN20 / tHN03 | | | | | | |
| | . 730140,30 | | | | | | | |

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