

MONITORING REPORT

First periodic verification
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PROJECT: Project aimed at N₂O emissions reduction by installation of secondary catalyst inside ammonia oxidation reactors at 3 nitric acid production plants NA2, NA3 and NA4 of Azomures SA, company situated in Targu Mures, Romania

Prepared by:



VERTIS FINANCE

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PROJECT: Project aimed at N₂O emissions reduction by installation of secondary catalyst inside ammonia oxidation reactors at 3 nitric acid production plants NA2, NA3 and NA4 of Azomures SA, company situated in Targu Mures, Romania

LINE: Line 2

MONITORING PERIOD:

FROM: 28/10/2008

TO: 19/07/2010

Prepared by:



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1. EXECUTIVE SUMMARY

This monitoring report determines baseline emission factor for the Line 2 of Azomures nitric acid plant and quantity of emission reduction generated during the first project campaign on the line.

Total quantity of emission reductions generated during the period from 28/10/2008 through 19/07/2010 on Line 2 is **775 624 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION		
Baseline Emission Factor	EF_BL	13.32 kgN ₂ O/tHNO ₃
Project Campaign Emission Factor	EF_P	0.93 kgN ₂ O/tHNO ₃
Nitric Acid Produced in the Baseline Campaign	NAP_BL	207 983 tHNO ₃
Nitric Acid Produced in the NCSG Baseline Campaign	NAP_BL_NCSG	201 829 tHNO ₃
Nitric Acid Produced in the Project Campaign	NAP_P	202 023 tHNO ₃
GWP	GWP	310 tCO ₂ e/tN ₂ O
Emission Reduction	ER	775 624 tCOe
<i>ER=(EF_BL-EF_P)*NAP_P*GWP/1000</i>		
Abatement Ratio	93.0%	

EMISSION REDUCTION PER YEAR			
Year	2008	2009	2010
Date From	28 Oct 2008	01 Jan 2009	01 Jan 2010
Date To	31 Dec 2008	31 Dec 2009	19 Jul 2010
Nitric Acid Production	9 433	123 606	68984
Emission Reduction	36 217	474 559	264848
<i>ER_YR = ER * NAP_P_YR / NAP_P</i>			

Baseline emission factor established for the Line 2 is 13.32 kgN₂O/tHNO₃. The baseline was carried out from 13/07/2007 through 20/10/2008.

The secondary catalyst on Line 2 was installed on 27/10/2008. Project emission factor during the first project campaign, which started on 28/10/2008 and went through 19/07/2010, is 0.93 kgN₂O/tHNO₃.

During the project campaign 202 023 tonnes of nitric acid was produced.

2. DESCRIPTION OF THE PROJECT ACTIVITY

Purpose of the Project (the “Project”) is the reduction of nitrous oxide (N₂O) emissions from Joint Implementation project aimed at N₂O emissions reduction by installation of secondary catalyst inside ammonia oxidation reactors at 3 nitric acid production plants NA2, NA3 and NA4 of Azomures SA company, situated at Târgu Mures, Romania.

Azomures has installed and operates secondary N₂O reduction catalysts underneath the primary catalyst precious metal catching and catalytic gauzes package in the ammonium burners of all 3 nitric acid plants.

This monitoring report contains information on Line 2 emission reductions including information on baseline emission factor setting for the Line 2.

The separate treatment of the three nitric acid lines and overlapping of the monitoring periods are allowed by the clarification issued Joint Implementation Supervisory Committee: “CLARIFICATION REGARDING OVERLAPPING MONITORING PERIODS UNDER THE VERIFICATION PROCEDURE UNDER THE JOINT IMPLEMENTATION SUPERVISORY COMMITTEE”. The Project meets all the requirement set out by the clarification:

1. The Project is composed of clearly identifiable components for which emission reductions or enhancements of removals are calculated independently; and
2. Monitoring is performed independently for each of these components, i.e. the data/parameters monitored for one component are not dependent on/effect data/parameters (to be) monitored for another component; and
3. The monitoring plan ensures that monitoring is performed for all components and that in these cases all the requirements of the JI guidelines and further guidance by the JISC regarding monitoring are met.

3. BASELINE SETTING

Baseline emission factor for Line 2 has been established on a line-specific basis. Campaign used for baseline measurements on the Line 2 has been carried out from 13/07/2007 through 20/10/2008. Nitric acid production during this campaign did not exceed the historic nitric acid production established as an average production during previous historic campaigns.

N₂O concentration and gas volume flow are monitored by monitoring system complying with requirements of the European Norm 14181.

Monitoring system provides separate readings for N₂O concentration and gas flow volume for every hour of operation as an average of the measured values for the previous 60 minutes.

Measurement results can be distorted before and after periods of downtime or malfunction of the monitoring system and can lead to mavericks. To eliminate such extremes and to ensure a conservative approach, the following statistical evaluation is applied to the complete data series of N₂O concentration as well as to the data series for gas volume flow. The statistical procedure is applied to data obtained after eliminating data measured for periods where the plant operated outside the permitted ranges:

- a) Calculate the sample mean (x)
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values (volume of stack gas (VSG) and N₂O concentration of stack gas (NCSG))

The average mass of N₂O emissions per hour is estimated as product of the NCSG and VSG. The N₂O emissions per campaign are estimates product of N₂O emission per hour and the total number of complete hours of operation of the campaign using the following equation:

$$BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC} (tN_2O)$$

The line specific baseline emissions factor representing the average N₂O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N₂O emissions by the total output of 100% concentrated nitric acid during baseline campaign.

The overall uncertainty of the monitoring system has been determined by the QAL2 report and the measurement error is expressed as a percentage (UNC). The N₂O emission factor per tonne of nitric acid produced in the baseline period (EF_{BL}) has been then be reduced by the percentage error as follows:

$$EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100) (tN_2O/tHNO_3)$$

where:

Variable	Definition
EF_{BL}	Baseline N_2O emissions factor ($tN_2O/tHNO_3$)
BE_{BC}	Total N_2O emissions during the baseline campaign (tN_2O)
$NCSG_{BC}$	Mean concentration of N_2O in the stack gas during the baseline campaign (mgN_2O/m^3)
OH_{BC}	Operating hours of the baseline campaign (h)
VSG_{BC}	Mean gas volume flow rate at the stack in the baseline measurement period (m^3/h)
NAP_{BC}	Nitric acid production during the baseline campaign ($tHNO_3$)
UNC	Overall uncertainty of the monitoring system (%), calculated as the combined uncertainty of the applied monitoring equipment.

3.1 Measurement procedure for N_2O concentration and tail gas volume flow

3.1.1 Tail gas N_2O concentration

- the impulse line is the same as the NO_x outlet line
- the circuit is the same as for measuring NO_x outlet concentration, including up to the pressure reducing valve outlet.
- the gas for the N_2O analyzer is taken from here through a water discharge cooler. The analyzer is produced by Environement S.A., France and is based on non-dispersive infrared absorption principle; it is placed in the same cabinet as the NO_x analyzer. The N_2O concentration measurement range is between 0 – 2000 ppm.
- the outlet analyzer signal is of 4 – 20 mA, proportional to the value of the concentration. This signal is transmitted through an electric cable at the plant's central control panel. The electric cable is approx. 100 m long.
- the device that converts the 4 – 20 mA signal in nitrogen oxides concentration is a ISU – MMC- 24C digital indicator produced by Infostar Pascani. The device has 16 inlet circuits of 4 – 20 mA. The readings are digitally displayed and are recorded every 2 seconds. Data recorded into the "data logger" are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer's hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.
- as described in the QAL2 report and in the Determination Report Azomures was supplied with incorrectly prepared calibration gas where declared concentration of N_2O varied from its actual concentration. This was figured out by the Airtec laboratory conducting the QAL2 test and Airtec also calculated the correction factor to be used for N_2O concentration data from beginning of baseline measurements until date of calibration and start of using new properly prepared calibration gas in February 2008.

3.1.2 Tail gas flow, temperature and pressure

- the measuring point is located on the expansion turbine outlet pipe towards the discharge nozzle; Pytot type sensor with multiple holes; operating conditions: absolute $p = 2.5$ bar, $t = 80^{\circ}\text{C}$

- pneumatic connection line (12 mm diameter and approx. 1 m long hoses) between the sensor and the electric switch box where the Dp cell is located; pneumatic connection line (6 mm diameter and approx. 2 m long hose) between the sensor and the electric switch box where the absolute pressure measuring cell is located

- measuring device: Dp differential transducer, produced by ABB, measuring range between 0 – 30 mbar; absolute pressure transducer produced by Endress&Hauser,

measuring range between 0 – 0.3 bar; Pt100 thermal resistance with built-in adapter, measuring range between 0 - 200°C ; analogue output signal 4 – 20 mA

- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA

- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.

- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

3.2 Permitted range of operating conditions of the nitric acid plant

Under certain circumstances, the operating conditions during the measurement period used to determine baseline N_2O emission factor may be outside the permitted range or limit corresponding to normal operating conditions. N_2O baseline data measured during hours where the operating conditions were outside the permitted range have been eliminated from the calculation of the baseline emissions factor.

Normal ranges for operating conditions have been determined for the following parameters:

- oxidation temperature;
- oxidation pressure;
- ammonia gas flow rate,
- air input flow rate.

The permitted range for these parameters has been established using the plant operation manual, as described in the PDD.

3.3 Composition of the ammonia oxidation catalyst

It is business-as-usual in Azomures to change composition of oxidation catalysts installed between campaigns, so the composition during historic and the baseline campaigns is varying.

3.4 Historic Campaign Length

The average historic campaign length (CL_{normal}) defined as the average campaign length for the historic campaigns used to define operating condition (the previous 4 campaigns), has been used as a cap on the length of the baseline campaign.

4. PROJECT EMISSIONS

During the first project campaign on Line 2 the tail gas volume flow in the stack of the nitric acid plant as well as N₂O concentration have been measured on a continuous basis.

4.1.1 Estimation of campaign-specific project emissions factor

The monitoring system was installed using the guidance document EN 14181 and provides separate readings for N₂O concentration and gas flow volume for every hour of operation. Same statistical evaluation that was applied to the baseline data series has been applied to the project data series:

- a) Calculate the sample mean (x)
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values

$$PE_n = VSG * NCSG * 10^{-9} * OH \text{ (tN}_2\text{O)}$$

where:

Variable	Definition
VSG	Mean stack gas volume flow rate for the project campaign (m ³ /h)
NCSG	Mean concentration of N ₂ O in the stack gas for the project campaign (mgN ₂ O/m ³)
PE _n	Total N ₂ O emissions of the n th project campaign (tN ₂ O)
OH	Is the number of hours of operation in the specific monitoring period (h)

4.1.2 Derivation of a moving average emission factor

Because this campaign was first project campaign on Line 2 there has been no moving average emission factor established yet for this campaign.

4.2 Minimum project emission factor

Because this campaign was first project campaign on Line 2 there has been no minimum average emission factor established yet for this campaign. This factor will be established after 10th project campaign.

4.3 Project Campaign Length

Project campaign production of nitric acid has been lower than defined nameplate capacity of 725 tHNO₃/day, and thus NAP value for the project campaign emission reductions calculation has been used in its entirety.

4.4 Leakage

No leakage calculation is required.

4.5 Emission reductions

The emission reductions for the project activity during this campaign have been determined by deducting the campaign-specific emission factor from the baseline emission factor and multiplying the result by the production output of 100% concentrated nitric acid over the campaign period and the GWP of N₂O:

$$ER = (EFBL - EFP) * NAP * GWPN_2O \text{ (tCO}_2\text{e)}$$

Where:

Variable	Definition
ER	Emission reductions of the project for the specific campaign (tCO ₂ e)
NAP	Nitric acid production for the project campaign (tHNO ₃). The maximum value of NAP shall not exceed the design capacity.
EFBL	Baseline emissions factor (tN ₂ O/tHNO ₃)
EFP	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of EF _{ma,n} and EF _n)

5. MONITORING PLAN

5.1 Main air flow

- the measuring point is located on the compressor air discharge pipe
- diaphragm type sensor with ring-like chambers
- operating conditions: $p = 2.5 - 3$ bars, $t = 150^{\circ}\text{C}$
- pneumatic signal transmission between the sensor and the transducer through 2 impulse pipes, approx. 10 m long
- measuring device: Fischer Roesmount differential electronic transducer, having a measuring range between 0 – 45.24 mbar; output signal: analogue 4 – 20 mA
- signal transmission: electric wires, approx. 30 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.2 Secondary air flow

- the measuring point is located on the air compressor discharge pipe
- diaphragm type sensor with ring-like chambers
- operating conditions: $p = 2.5 - 3$ bars, $t = 150^{\circ}\text{C}$
- pneumatic signal transmission between the sensor and the transducer through 2 impulse pipes, approx. 15 m long

- measuring device: Fischer Roesmount differential electronic transducer, having a measuring range between 0 – 500 mm H₂O; output signal: analogue 4 – 20 mA
- signal transmission: electric wires, approx. 50 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.3 Casing protection air flow

- the measuring point is located on the air duct to the reactors casing, ramifications from the compressor discharge pipe
- diaphragm type sensor with ring-like chambers
- operating conditions: $p = 2.5 - 3$ bars, $t = 150^{\circ}\text{C}$
- pneumatic signal transmission between the sensor and the transducer through 2 impulse pipes, approx. 10 m long
- measuring device: FEPA Birlad differential electronic transducer, having a measuring range between 0 – 1500 mm H₂O; output signal: analogue 4 – 20 mA
- signal transmission: electric wires, approx. 60 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.4 Reactor sieves temperature

- the measuring point is located on the oxidation reactor; sensor; PtRh-Pt thermocouple, operating conditions: $t = 800 - 1000^{\circ}\text{C}$
- electric signal transmission between the sensor and the transducer: PtRh-Pt correction cable, approx. 50 m long
- digital indicator measuring device; measuring range between $0 - 1000^{\circ}\text{C}$; analogue output signal $4 - 20 \text{ mA}$
- signal transmission: electric wires, approx. 10 m long, analogue signal $4 - 20 \text{ mA}$
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.5 Consumed liquid ammonia flow

- the measuring point is located on the column 4 outlet pipe towards the nitric acid storehouse; electromagnetic sensor; operating conditions: $p = 2.5 \text{ bar}$, $t = 40^{\circ}\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 90 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between $0 - 20 \text{ t/h}$; analogue output signal $4 - 20 \text{ mA}$
- signal transmission: electric wires, approx. 10 m long, analogue signal $4 - 20 \text{ mA}$
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this

database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.6 Flow of produced nitric acid

- the measuring point is located on the column 4 outlet pipe towards the nitric acid storehouse; electromagnetic sensor; operating conditions: $p = 2.5 \text{ bar}$, $t = 40^\circ\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 100 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between 0 – 100 t/h; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.7 Temperature of produced nitric acid

- the measuring point is located on the column 4 outlet pipe towards the nitric acid storehouse; Coriolis type sensor; operating conditions: $p = 2.5 \text{ bar}$, $t = 40^\circ\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 100 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between $-50 - 200^\circ\text{C}$; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.

- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.8 Density of produced nitric acid

- the measuring point is located on the column 4 outlet pipe towards the nitric acid storehouse; Coriolis type sensor; operating conditions: $p = 2.5 \text{ bar}$, $t = 40^\circ\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 100 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between 1.2 – 1.4 kg/l; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.9 Tail gases flow, tail gases pressure, tail gases temperature

- the measuring point is located on the expansion turbine outlet pipe towards the discharge nozzle; Pytot type sensor with multiple holes; operating conditions: absolute $p = 2.5 \text{ bar}$, $t = 80^\circ\text{C}$
- pneumatic connection line (12 mm diameter and approx. 1 m long hoses) between the sensor and the electric switch box where the Dp cell is located; pneumatic connection line (6 mm diameter and approx. 2 m long hose) between the sensor and the electric switch box where the absolute pressure measuring cell is located
- measuring device: Dp differential transducer, produced by ABB, measuring range between 0 – 30 mbar; absolute pressure transducer produced by Endress&Hauser, measuring range between 0 – 0.3 bar; Pt100 thermal resistance with built-in adapter, measuring range between 0 - 200°C; analogue output signal 4 – 20 mA

- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.10 Oxidation reactor pressure

- the measuring point is located on the air compressor discharge pipe; sensor type: capsule for electronic transducer; operating conditions: absolute $p = 3.5$ bar, $t = 200^{\circ}\text{C}$
- pneumatic connection line between the sensor and the transducer; pneumatic connection line of 8 mm diameter and approx. 10 m long
- measuring device: Foxboro transducer, measuring range between 0 – 5 bar; absolute pressure transducer produced by Endress&Hauser, measuring range between 0 – 0.3 bar; Pt100 thermal resistance with built-in adapter, measuring range between 0 - 200°C ; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 50 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.11 N₂O concentration

- the impulse line is the same as the NO_x outlet line
- the circuit is the same as for measuring NO_x outlet concentration, including up to the pressure reducing valve outlet.

- the gas for the N₂O analyzer is taken from here through a water discharge cooler. The analyzer is produced by Environement S.A., France and is based on non-dispersive infrared absorption principle; it is placed in the same cabinet as the NO_x analyzer. The N₂O concentration measurement range is between 0 – 2000 ppm.
- the outlet analyzer signal is of 4 – 20 mA, proportional to the value of the concentration. This signal is transmitted through an electric cable at the plant's central control panel. The electric cable is approx. 100 m long.
- the device that converts the 4 – 20 mA signal in nitrogen oxides concentration is a ISU – MMC- 24C digital indicator produced by Infostar Pascani. The device has 16 inlet circuits of 4 – 20 mA. The readings are digitally displayed and are recorded every 2 seconds. Data recorded into the "data logger" are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer's hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

6. QAL 2 CALIBRATION ADJUSTMENTS

6.1 Applied principle

As required in the applicable norm EN14181: "The relation between the instrument readings of the recording measuring procedure and the quantity of the measuring objects has to be described by using a suitable convention method. The results have to be expressed by a regression analysis."

As it is described in the Calibration Report issued by Airtec laboratory, the measurement results derived from the analog signals (4 mA to 20 mA) provided the installed instruments have been compared to the comparative measurements.

Linearity check of the instruments characteristics is stated in the QAL2 Calibration Report issued by the laboratory. The valid ranges of linearity are determined by statistical analysis according to the guideline and the linearity assumptions are further used in the Calibration Report establishing linear regression lines.

The general formula of the regression line, established in the EN14181 and used in the Calibration Report is:

$$Y = a + bX$$

where:

X is the measured value of the instrument in mA
Y is the value of the parameter being objective of the measurement
a is a constant of the regression line
b is the slope of the regression line

After a comparative test the laboratory issued the old and new regression lines properties, namely "a" and "b" applying for all of the measured parameters that are subject to calibration as stated in the Calibration Report.

The QAL2 corrections are based on the fact that the actual analog current outputs (in mA) of the measurement instruments are relevant for both, the old and new regression lines:

$$X_o = X_n = X$$

where :

X_n: X new
Y_o: Y old

This allows us to derive a calibrating formula that gives us the corrected value of the measured physical parameters. The applied calibrating equation is:

$$Y_n = A_n + (B_n/B_o) * (Y_o - A_o)$$

In order to take into account the properties of the AMS and their implication to the QAL 2 implementation in the model, we will further introduce several remarks to the conversion and normalization of the data.

The units returned by the AMS in “Nm³/h” stand for normalized cubic meters of the gas volume at normal gas conditions (0° C, 1 atm.).

6.2 Stack gas volume flow

The measurement system captures and logs normalized stack volume flow in an integrated manner, calculating the final figure from the mA signal of the endpoints by itself, as opposing to storing just temperature and pressure and deriving the volume flow later. Therefore, the volume flow values can be used as input for QAL2 recalibration transformation without de-normalization and the need for temperature, pressure, and duct cross-section area. The normalized calibrated stack gas flow rates are further fed into the emission calculation model for processing as set out by the Approved Baseline and Monitoring Methodology AM_0034.

6.3 Nitric acid concentration in stack gas

The nitric acid concentration in the raw data set from the AMS is in ppm (parts per million). After QAL2 re-calibration, the values are converted to mgN₂O/Nm³ (mg N₂O per normalized cubic meter) to make it fit into the formulas set out in the methodology.

7. EMISSION REDUCTION CALCULATIONS

Table T 2 illustrates the establishment of historic campaign length based on 4 previous campaigns. Average production in campaigns preceding the baseline campaign was 260 782 tHNO₃ and time duration was on average 401 days. Table contains also information on suppliers of primary catalysts for Line 2 (4 burners). As shown in the table, it is usual practice in Azomures to use primary catalysts from two suppliers.

T 2 Historic campaigns

Line	AzoMures-2	Production	Start	End	Days	Production per day	Primary Catalyst	Composition
Historic Campaigns	1 t HNO ₃	-	-	-	-	n/a	N/A	-
	2 t HNO ₃	241 277	11 Sep 2001	15 Jun 2003	642	376	Engelhart-Cal	Pt95/Rh5
	3 t HNO ₃	250 030	19 Jun 2003	01 Aug 2004	409	611	OMG AG	Pt95/Rh5
	4 t HNO ₃	319 467	20 Aug 2004	14 Feb 2006	543	588	Umicore Degussa	Pt95/Rh5
	5 t HNO ₃	232 352	03 Apr 2006	21 May 2007	413	563	Umicore Degussa	Pt95/Rh5
Average HNO ₃ production	t HNO ₃	260 782			401	650		
Project Campaigns	BL t HNO ₃	207 983	13 Jul 2007	20 Oct 2008	465	447	Heraous	Pt57.99/Rh3.85/Pd38.16
	PL t HNO ₃	202 023	28 Oct 2008	19 Jul 2010	629	321	Johnson Matthey	Pt76.65/Rh4.35/Pd19

Table T 3 and Chart C 1 define the length of the baseline campaign set according to the historic campaign length. Baseline campaign measurements was carried out from 13/07/2007 through 20/10/2008. During baseline campaign, a total of 207 983 tHNO₃ was produced, NCSG measurements are taken into account until the production of 201 829 tHNO₃ was reached.

The project campaign production value is 202 023 tHNO₃ lower than historic nitric acid production set at level of 260 782 tHNO₃.

T 3 Baseline campaign length

AzoMures-2	Historic Campaigns End	Start of Baseline Measurement	End of Baseline Measurement NCSG	End of Baseline Measurement	End of Baseline Campaign
Dates	2007 May 21	2007 Jul 13	2008 Oct 07	2008 Oct 20	2008 Oct 21
Baseline Factor kgN ₂ O/tHNO ₃	-	-	13.32	13.32	13.32
Production tHNO ₃	-	-	201 829	207 983	-
Per Day Production tHNO ₃	649.7				
Baseline less Historic Production	(52 799.0)				
Baseline less Historic Days	(81.3)				

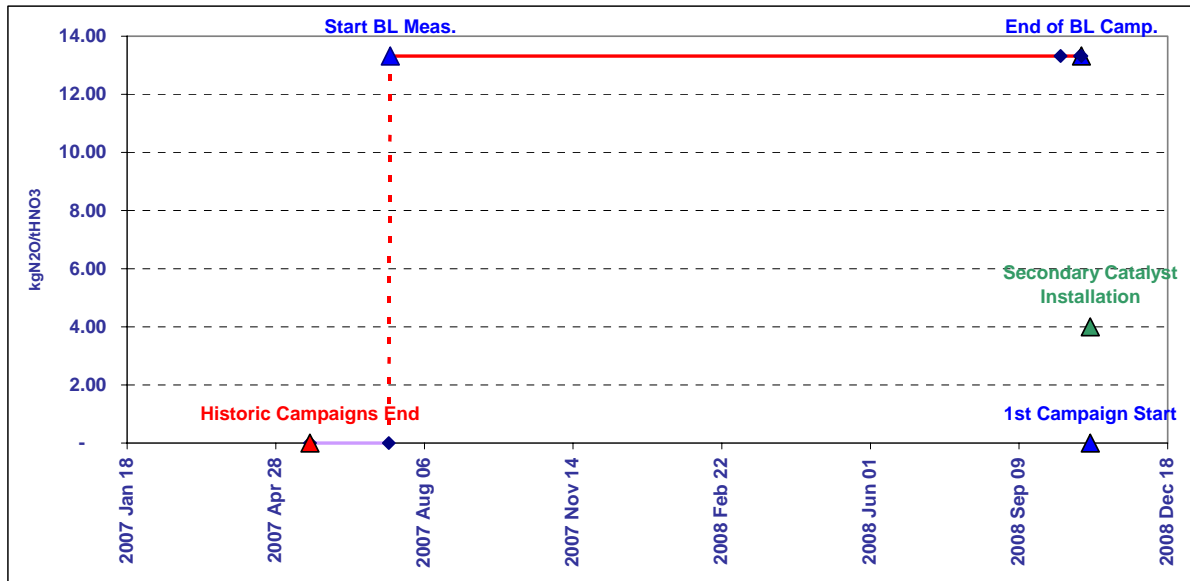
C 1 Baseline campaign length


Table T 4 illustrates the calculation of the baseline emission factor on Line 2 using the method as defined in the CDM methodology AM0034 and in the PDD. Baseline measurement was carried out from 13/07/2007 through 20/10/2008.

Extreme values and data measured during hours when one or more of operating conditions were outside of the permitted range have been eliminated from the calculations. As a next step we have eliminated data beyond 95% confidence interval and calculated new mean values of N₂O concentration and stack gas volume flow using following method:

- a) Calculate the sample mean (x)
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values (volume of stack gas (VSG) and N₂O concentration of stack gas (NCSG))

Using the means values we have calculated the baseline emissions as set out in the PDD.

$$BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC} (tN_2O)$$

Operating hours defined as hours, when nitric acid production at least 0.1 tHNO₃ and oxidation temperature at least 600°C occurred. Calculated baseline N₂O emissions were 1,194 tN₂O.

$$EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100) (tN_2O/tHNO_3)$$

The UNC factor defined by the QAL2 report is 3.460%. As a result we have arrived to the baseline emission factor of 13.32 kgN₂O/tHNO₃.

Table shows the calculation of the project emission factor on Line 2 during the project campaign. Project campaign started on 28/10/2008 and went through 19/07/2010.

We have eliminated extreme values and data beyond the 95% confidence interval as prescribed by the PDD.

- a) Calculate the sample mean (\bar{x})
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values

Using the mean values we have calculated total mass of N₂O emissions (PE_n) as follows:

$$PE_n = VSG * NCSG * 10^{-9} * OH (tN_2O)$$

Operating hours (OH) defined as hours, when nitric acid production at least 0.1 tHNO₃ and oxidation temperature at least 600°C occurred.

By dividing total mass of N₂O emissions by the nitric acid production (capped by nameplate capacity 725 tHNO₃/day) we have determined the project campaign specific emission factor at value of 0.93 kgN₂O/tHNO₃.

$$EF_n = PE_n / NAP_n (tN_2O/tHNO_3)$$

This emission factor has been used in further calculation of emission reductions. Neither moving average emission factor nor minimum emission factor was established, since it was the first project campaign.

T 4 Baseline emission factor

BASELINE EMISSION FACTOR								
Parameter	Operating Hours	Nitric Acid Production	N2O Concentration	Gas Volume Flow	Ammonia Flow Rate	Ammonia to Air Ratio	Oxidation Temperature	Oxidation Pressure
Code Unit	OH h	NAP t/h	NCSG mg N2O/Nm3	VSG Nm3/h	AFR Nm3/h	AIFR %	OT °C	OP kPa
Elimination of extreme values								
Lower limit		0	0	0	0	0	-	0
Upper Limit		60.00	5 000	200 000	18 000	20.00	1 200	1 000
Raw Data Measured Range								
Count	8 132	10 112	9 595	10 109	10 100	10 108	10 107	9 299
as % of Dataset	80%	100%	95%	100%	100%	100%	100%	92%
Minimum		-	3	576	-	0	(26)	-
Maximum		40.70	4 917	130 424	16 424	1.37	876	403
Mean		20.57	2 734	102 619	9 743	0.16	735	309
Standard Deviation		9.36	1 320	31 897	3 817	0.15	280	140
Total		207 983						
N2O Emissions (VSG * NCSG * OH)		2 282 t N2O						
Emission Factor		10.59 kgN2O / tHNO3						
Permitted Range								
Minimum					7 800	0	800	0
Maximum					12 000	0.12	880	400
Data within the permitted range								
Count	5 737		5 411	5 737				
as % of Operating Hours	71%		67%	71%				
Minimum			6	-				
Maximum			4 917	130 424				
Mean			3 020	113 924				
Standard Deviation			979	8 075				
N2O Emissions (VSG * NCSG * OH)		2 798 t N2O						
Emission Factor		12.99 kgN2O / tHNO3						
Data within the confidence interval								
95% Confidence interval								
Lower bound			1 101	98 097				
Upper bound			4 938	129 751				
Count			5 283	5 713				
as % of Operating Hours			65%	70%				
Minimum			1 176	99 844				
Maximum			4 917	129 653				
Mean			3 087	114 286				
Standard Deviation			886	4 903				
N2O Emissions (VSG * NCSG * OH)		2 869 t N2O						
Emission Factor (EF_BL)		13.32 kgN2O / tHNO3						

T 5 Project emission factor

PROJECT EMISSION FACTOR															
Parameter	Operating Hours	Nitric Acid Production	N2O Concentration	Gas Volume Flow	Ammonia Flow Rate	Ammonia to Air Ratio	Oxidation Temperature	Oxidation Pressure							
Code Unit	OH h	NAP t/h	NCSG mg N2O/Nm3	VSG Nm3/h	AFR Nm3/h	AIFR %	OT °C	OP kPa							
Elimination of extreme values															
Lower limit		0	0	0	0	0	-	50	0						
Upper Limit		60.00	5 000	200 000	18 000	20.00		1 200	1 000						
Raw Data Measured Range															
Count	8 389	14 285	12 005	14 009	5 853	14 166		14 286	8 644						
as % of Dataset	59%	100%	84%	98%	41%	99%		100%	61%						
Minimum		-	0	48	-	0		(31)	-						
Maximum		50.17	1 615	127 349	17 989	1.39		868	401						
Mean		14.14	166	71 788	161	0.31		354	367						
Standard Deviation		12.16	140	41 490	790	0.26		429	53						
Total		202 023													
<table border="1" style="width:100%"> <tr> <td>N2O Emissions (VSG * NCSG * OH)</td> <td>100 t N2O</td> </tr> <tr> <td>Emission Factor</td> <td>0.49 kgN2O / tHNO3</td> </tr> </table>										N2O Emissions (VSG * NCSG * OH)	100 t N2O	Emission Factor	0.49 kgN2O / tHNO3		
N2O Emissions (VSG * NCSG * OH)	100 t N2O														
Emission Factor	0.49 kgN2O / tHNO3														
Data within the confidence interval															
95% Confidence interval															
Lower bound			-	109	-	9 532									
Upper bound				440		153 108									
Count				7 927		8 387									
as % of Operating Hours				94%		100%									
Minimum				0		3 284									
Maximum				437		127 349									
Mean				215		104 569									
Standard Deviation				85		8 448									
<table border="1" style="width:100%"> <tr> <td>N2O Emissions (VSG * NCSG * OH)</td> <td>189 t N2O</td> </tr> <tr> <td>Actual Project Emission Factor (EF_PActual)</td> <td>0.93 kgN2O / tHNO3</td> </tr> <tr> <td>Abatement Ratio</td> <td>93.0%</td> </tr> </table>										N2O Emissions (VSG * NCSG * OH)	189 t N2O	Actual Project Emission Factor (EF_PActual)	0.93 kgN2O / tHNO3	Abatement Ratio	93.0%
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Abatement Ratio	93.0%														
Moving Average Emission Factor Correction															
		Actual Factors		Moving Average Rule											
	1	0.93		0.93											
	2	-													
<table border="1" style="width:100%"> <tr> <td>Project Emission Factor (EF_P)</td> <td>0.93 kgN2O / tHNO3</td> </tr> <tr> <td>Abatement Ratio</td> <td>93.0%</td> </tr> </table>										Project Emission Factor (EF_P)	0.93 kgN2O / tHNO3	Abatement Ratio	93.0%		
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Abatement Ratio	93.0%														

MONITORING REPORT

PROJECT: Project aimed at N₂O emissions reduction by installation of secondary catalyst inside ammonia oxidation reactors at 3 nitric acid production plants NA2, NA3 and NA4 of Azomures SA, company situated in Targu Mures, Romania

LINE: Line 3

MONITORING PERIOD:

FROM: 24/07/2008

TO: 05/04/2010

Prepared by:



VERTIS FINANCE

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1. EXECUTIVE SUMMARY

This monitoring report determines baseline emission factor for the Line 3 of Azomures nitric acid plant and quantity of emission reduction generated during the first project campaign on the line 3.

Total quantity of emission reductions generated during the period from 24/07/2008 through 05/04/2010 on Line 3 is **966 565 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	12.46	kgN ₂ O/tHNO ₃
Project Campaign Emission Factor	EF_P	1.45	kgN ₂ O/tHNO ₃
Nitric Acid Produced in the Baseline Campaign	NAP_BL	215 669	tHNO ₃
Nitric Acid Produced in the NCSG Baseline Campaign	NAP_BL_NCSG	215 669	tHNO ₃
Nitric Acid Produced in the Project Campaign	NAP_P	283 044	tHNO ₃
GWP	GWP	310	tCO ₂ e/tN ₂ O
Emission Reduction	ER	966 565	tCOe
<i>ER=(EF_BL-EF_P)*NAP_P*GWP/1000</i>			
Abatement Ratio			88.4%

EMISSION REDUCTION PER YEAR			
Year	2008	2009	2010
Date From	24 Jul 2008	01 Jan 2009	01 Jan 2010
Date To	31 Dec 2008	31 Dec 2009	05 Apr 2010
Nitric Acid Production	83 282	142 747	57 015
Emission Reduction	284 398	487 466	194 701
<i>ER_YR = ER * NAP_P_YR / NAP_P</i>			

Baseline emission factor established for the Line 3 is 12.46 kgN₂O/tHNO₃. The baseline was carried out from 02/03/2007 through 14/07/2008.

The secondary catalyst on Line 3 was installed on 24/07/2008. Project emission factor during the first project campaign, which started on 24/07/2008 and went through 05/04/2010, is 1.45 kgN₂O/tHNO₃.

During the project campaign 283 044 tonnes of nitric acid was produced.

2. DESCRIPTION OF THE PROJECT ACTIVITY

Purpose of the Project (the “Project”) is the reduction of nitrous oxide (N₂O) emissions from Joint Implementation project aimed at N₂O emissions reduction by installation of secondary catalyst inside ammonia oxidation reactors at 3 nitric acid production plants NA2, NA3 and NA4 of Azomures SA company, situated at Târgu Mures, Romania.

Azomures has installed and operates secondary N₂O reduction catalysts underneath the primary catalyst precious metal catching and catalytic gauzes package in the ammonium burners of all 3 nitric acid plants.

This monitoring report contains information on Line 3 emission reductions including information on baseline emission factor setting for the Line 3.

The separate treatment of the three nitric acid lines and overlapping of the monitoring periods are allowed by the clarification issued Joint Implementation Supervisory Committee: “CLARIFICATION REGARDING OVERLAPPING MONITORING PERIODS UNDER THE VERIFICATION PROCEDURE UNDER THE JOINT IMPLEMENTATION SUPERVISORY COMMITTEE”. The Project meets all the requirement set out by the clarification:

1. The Project is composed of clearly identifiable components for which emission reductions or enhancements of removals are calculated independently; and
2. Monitoring is performed independently for each of these components, i.e. the data/parameters monitored for one component are not dependent on/effect data/parameters (to be) monitored for another component; and
3. The monitoring plan ensures that monitoring is performed for all components and that in these cases all the requirements of the JI guidelines and further guidance by the JISC regarding monitoring are met.

3. BASELINE SETTING

Baseline emission factor for Line 3 has been established on a line-specific basis. Campaign used for baseline measurements on the Line 3 has been carried out from 02/03/2007 through 14/07/2008. Nitric acid production during this campaign did not exceed the historic nitric acid production established as an average production during previous historic campaigns.

N₂O concentration and gas volume flow are monitored by monitoring system complying with requirements of the European Norm 14181.

Monitoring system provides separate readings for N₂O concentration and gas flow volume for every hour of operation as an average of the measured values for the previous 60 minutes.

Measurement results can be distorted before and after periods of downtime or malfunction of the monitoring system and can lead to mavericks. To eliminate such extremes and to ensure a conservative approach, the following statistical evaluation is applied to the complete data series of N₂O concentration as well as to the data series for gas volume flow. The statistical procedure is applied to data obtained after eliminating data measured for periods where the plant operated outside the permitted ranges:

- a) Calculate the sample mean (x)
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values (volume of stack gas (VSG) and N₂O concentration of stack gas (NCSG))

The average mass of N₂O emissions per hour is estimated as product of the NCSG and VSG. The N₂O emissions per campaign are estimates product of N₂O emission per hour and the total number of complete hours of operation of the campaign using the following equation:

$$BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC} (tN_2O)$$

The line specific baseline emissions factor representing the average N₂O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N₂O emissions by the total output of 100% concentrated nitric acid during baseline campaign.

The overall uncertainty of the monitoring system has been determined by the QAL2 report and the measurement error is expressed as a percentage (UNC). The N₂O emission factor per tonne of nitric acid produced in the baseline period (EF_{BL}) has been then be reduced by the percentage error as follows:

$$EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100) (tN_2O/tHNO_3)$$

where:

Variable	Definition
EF_{BL}	Baseline N_2O emissions factor ($tN_2O/tHNO_3$)
BE_{BC}	Total N_2O emissions during the baseline campaign (tN_2O)
$NCSG_{BC}$	Mean concentration of N_2O in the stack gas during the baseline campaign (mgN_2O/m^3)
OH_{BC}	Operating hours of the baseline campaign (h)
VSG_{BC}	Mean gas volume flow rate at the stack in the baseline measurement period (m^3/h)
NAP_{BC}	Nitric acid production during the baseline campaign ($tHNO_3$)
UNC	Overall uncertainty of the monitoring system (%), calculated as the combined uncertainty of the applied monitoring equipment.

3.1 Measurement procedure for N_2O concentration and tail gas volume flow

3.1.1 Tail gas N_2O concentration

- the impulse line is the same as the NO_x outlet line
- the circuit is the same as for measuring NO_x outlet concentration, including up to the pressure reducing valve outlet.
- the gas for the N_2O analyzer is taken from here through a water discharge cooler. The analyzer is produced by Environement S.A., France and is based on non-dispersive infrared absorption principle; it is placed in the same cabinet as the NO_x analyzer. The N_2O concentration measurement range is between 0 – 2000 ppm.
- the outlet analyzer signal is of 4 – 20 mA, proportional to the value of the concentration. This signal is transmitted through an electric cable at the plant's central control panel. The electric cable is approx. 100 m long.
- the device that converts the 4 – 20 mA signal in nitrogen oxides concentration is a ISU – MMC- 24C digital indicator produced by Infostar Pascani. The device has 16 inlet circuits of 4 – 20 mA. The readings are digitally displayed and are recorded every 2 seconds. Data recorded into the "data logger" are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer's hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

3.1.2 Tail gas flow, temperature and pressure

- the measuring point is located on the expansion turbine outlet pipe towards the discharge nozzle; Pytot type sensor with multiple holes; operating conditions: absolute $p = 2.5$ bar, $t = 80^\circ C$

- pneumatic connection line (12 mm diameter and approx. 1 m long hoses) between the sensor and the electric switch box where the Dp cell is located; pneumatic connection line (6 mm diameter and approx. 2 m long hose) between the sensor and the electric switch box where the absolute pressure measuring cell is located

- measuring device: Dp differential transducer, produced by ABB, measuring range between 0 – 30 mbar; absolute pressure transducer produced by Endress&Hauser,

measuring range between 0 – 0.3 bar; Pt100 thermal resistance with built-in adapter, measuring range between 0 - 200°C; analogue output signal 4 – 20 mA

- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA

- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.

- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

3.2 Permitted range of operating conditions of the nitric acid plant

Under certain circumstances, the operating conditions during the measurement period used to determine baseline N₂O emission factor may be outside the permitted range or limit corresponding to normal operating conditions. N₂O baseline data measured during hours where the operating conditions were outside the permitted range have been eliminated from the calculation of the baseline emissions factor.

Normal ranges for operating conditions have been determined for the following parameters:

- oxidation temperature;
- oxidation pressure;
- ammonia gas flow rate,
- air input flow rate.

The permitted range for these parameters has been established using the plant operation manual, as described in the PDD.

3.3 Composition of the ammonia oxidation catalyst

It is business-as-usual in Azomures to change composition of oxidation catalysts installed between campaigns, so the composition during historic and the baseline campaigns is varying.

3.4 Historic Campaign Length

The average historic campaign length (CL_{normal}) defined as the average campaign length for the historic campaigns used to define operating condition (the previous 4 campaigns), has been used as a cap on the length of the baseline campaign.

4. PROJECT EMISSIONS

During the first project campaign on Line 3 the tail gas volume flow in the stack of the nitric acid plant as well as N₂O concentration have been measured on a continuous basis.

4.1.1 Estimation of campaign-specific project emissions factor

The monitoring system was installed using the guidance document EN 14181 and provides separate readings for N₂O concentration and gas flow volume for every hour of operation. Same statistical evaluation that was applied to the baseline data series has been applied to the project data series:

- a) Calculate the sample mean (x)
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values

$$PE_n = VSG * NCSG * 10^{-9} * OH \text{ (tN}_2\text{O)}$$

where:

Variable	Definition
VSG	Mean stack gas volume flow rate for the project campaign (m ³ /h)
NCSG	Mean concentration of N ₂ O in the stack gas for the project campaign (mgN ₂ O/m ³)
PE _n	Total N ₂ O emissions of the n th project campaign (tN ₂ O)
OH	Is the number of hours of operation in the specific monitoring period (h)

4.1.2 Derivation of a moving average emission factor

Because this campaign was first project campaign on Line 3 there has been no moving average emission factor established yet for this campaign.

4.2 Minimum project emission factor

Because this campaign was first project campaign on Line 3 there has been no minimum average emission factor established yet for this campaign. This factor will be established after 10th project campaign.

4.3 Project Campaign Length

Project campaign production of nitric acid has been lower than defined nameplate capacity of 725 tHNO₃/day, and thus NAP value for the project campaign emission reductions calculation has been used in its entirety.

4.4 Leakage

No leakage calculation is required.

4.5 Emission reductions

The emission reductions for the project activity during this campaign have been determined by deducting the campaign-specific emission factor from the baseline emission factor and multiplying the result by the production output of 100% concentrated nitric acid over the campaign period and the GWP of N₂O:

$$ER = (EFBL - EFP) * NAP * GWPN_2O \text{ (tCO}_2\text{e)}$$

Where:

Variable	Definition
ER	Emission reductions of the project for the specific campaign (tCO ₂ e)
NAP	Nitric acid production for the project campaign (tHNO ₃). The maximum value of NAP shall not exceed the design capacity.
EFBL	Baseline emissions factor (tN ₂ O/tHNO ₃)
EFP	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of EF _{ma,n} and EF _n)

5. MONITORING PLAN

5.1 Main air flow

- the measuring point is located on the compressor air discharge pipe
- diaphragm type sensor with ring-like chambers
- operating conditions: $p = 2.5 - 3$ bars, $t = 150^{\circ}\text{C}$
- pneumatic signal transmission between the sensor and the transducer through 2 impulse pipes, approx. 10 m long
- measuring device: Fischer Roesmount differential electronic transducer, having a measuring range between 0 – 45.24 mbar; output signal: analogue 4 – 20 mA
- signal transmission: electric wires, approx. 30 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.2 Secondary air flow

- the measuring point is located on the air compressor discharge pipe
- diaphragm type sensor with ring-like chambers
- operating conditions: $p = 2.5 - 3$ bars, $t = 150^{\circ}\text{C}$
- pneumatic signal transmission between the sensor and the transducer through 2 impulse pipes, approx. 15 m long

- measuring device: Fischer Roesmount differential electronic transducer, having a measuring range between 0 – 500 mm H₂O; output signal: analogue 4 – 20 mA
- signal transmission: electric wires, approx. 50 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.3 Casing protection air flow

- the measuring point is located on the air duct to the reactors casing, ramifications from the compressor discharge pipe
- diaphragm type sensor with ring-like chambers
- operating conditions: $p = 2.5 - 3$ bars, $t = 150^{\circ}\text{C}$
- pneumatic signal transmission between the sensor and the transducer through 2 impulse pipes, approx. 10 m long
- measuring device: FEPA Birlad differential electronic transducer, having a measuring range between 0 – 1500 mm H₂O; output signal: analogue 4 – 20 mA
- signal transmission: electric wires, approx. 60 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.4 Reactor sieves temperature

- the measuring point is located on the oxidation reactor; sensor; PtRh-Pt thermocouple, operating conditions: $t = 800 - 1000^{\circ}\text{C}$
- electric signal transmission between the sensor and the transducer: PtRh-Pt correction cable, approx. 50 m long
- digital indicator measuring device; measuring range between $0 - 1000^{\circ}\text{C}$; analogue output signal $4 - 20 \text{ mA}$
- signal transmission: electric wires, approx. 6 m long, analogue signal $4 - 20 \text{ mA}$
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.5 Consumed liquid ammonia flow

- the measuring point is located on the ammonia evaporator inlet pipe; Coriolis type sensor; operating conditions: $p = 12 \text{ bar}$, $t = 8 - 10^{\circ}\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 90 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between $0 - 20 \text{ t/h}$; analogue output signal $4 - 20 \text{ mA}$
- signal transmission: electric wires, approx. 10 m long, analogue signal $4 - 20 \text{ mA}$
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.6 Flow of produced nitric acid

- the measuring point is located on the column 4 outlet pipe towards the nitric acid storehouse; electromagnetic sensor; operating conditions: $p = 2.5 \text{ bar}$, $t = 40^\circ\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 100 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between 0 – 100 t/h; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.7 Temperature of produced nitric acid

- the measuring point is located on the column 4 outlet pipe towards the nitric acid storehouse; Coriolis type sensor; operating conditions: $p = 2.5 \text{ bar}$, $t = 40^\circ\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 100 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between $-50 - 200^\circ\text{C}$; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this

database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.8 Density of produced nitric acid

- the measuring point is located on the column 4 outlet pipe towards the nitric acid storehouse; Coriolis type sensor; operating conditions: $p = 2.5 \text{ bar}$, $t = 40^\circ\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 100 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between 1.2 – 1.4 kg/l; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.9 Tail gases flow, tail gases pressure, tail gases temperature

- the measuring point is located on the expansion turbine outlet pipe towards the discharge nozzle; Pytot type sensor with multiple holes; operating conditions: absolute $p = 2.5 \text{ bar}$, $t = 80^\circ\text{C}$
- pneumatic connection line (12 mm diameter and approx. 1 m long hoses) between the sensor and the electric switch box where the Dp cell is located; pneumatic connection line (6 mm diameter and approx. 2 m long hose) between the sensor and the electric switch box where the absolute pressure measuring cell is located
- measuring device: Dp differential transducer, produced by ABB, measuring range between 0 – 30 mbar; absolute pressure transducer produced by Endress&Hauser, measuring range between 0 – 0.3 bar; Pt100 thermal resistance with built-in adapter, measuring range between 0 - 200°C; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA

- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.10 Oxidation reactor pressure

- the measuring point is located on the air compressor discharge pipe; sensor type: capsule for electronic transducer; operating conditions: absolute $p = 3.5$ bar, $t = 200^{\circ}\text{C}$
- pneumatic connection line between the sensor and the transducer; pneumatic connection line of 8 mm diameter and approx. 10 m long
- measuring device: Foxboro transducer, measuring range between 0 – 5 bar; absolute pressure transducer produced by Endress&Hauser, measuring range between 0 – 0.3 bar; Pt100 thermal resistance with built-in adapter, measuring range between 0 - 200°C ; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 50 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.11 N₂O concentration

- the impulse line is the same as the NO_x outlet line
- the circuit is the same as for measuring NO_x outlet concentration, including up to the pressure reducing valve outlet.
- the gas for the N₂O analyzer is taken from here through a water discharge cooler. The analyzer is produced by Environement S.A., France and is based on non-dispersive infrared absorption principle; it is placed in the same cabinet as the NO_x analyzer. The N₂O concentration measurement range is between 0 – 2000 ppm.

- the outlet analyzer signal is of 4 – 20 mA, proportional to the value of the concentration. This signal is transmitted through an electric cable at the plant's central control panel. The electric cable is approx. 100 m long.
- the device that converts the 4 – 20 mA signal in nitrogen oxides concentration is a ISU – MMC- 24C digital indicator produced by Infostar Pascani. The device has 16 inlet circuits of 4 – 20 mA. The readings are digitally displayed and are recorded every 2 seconds. Data recorded into the "data logger" are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer's hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

6. QAL 2 CALIBRATION ADJUSTMENTS

6.1 Applied principle

As required in the applicable norm EN14181: "The relation between the instrument readings of the recording measuring procedure and the quantity of the measuring objects has to be described by using a suitable convention method. The results have to be expressed by a regression analysis."

As it is described in the Calibration Report issued by Airtec laboratory, the measurement results derived from the analog signals (4 mA to 20 mA) provided the installed instruments have been compared to the comparative measurements.

Linearity check of the instruments characteristics is stated in the QAL2 Calibration Report issued by the laboratory. The valid ranges of linearity are determined by statistical analysis according to the guideline and the linearity assumptions are further used in the Calibration Report establishing linear regression lines.

The general formula of the regression line, established in the EN14181 and used in the Calibration Report is:

$$Y = a + bX$$

where:

X is the measured value of the instrument in mA
Y is the value of the parameter being objective of the measurement
a is a constant of the regression line
b is the slope of the regression line

After a comparative test the laboratory issued the old and new regression lines properties, namely "a" and "b" applying for all of the measured parameters that are subject to calibration as stated in the Calibration Report.

The QAL2 corrections are based on the fact that the actual analog current outputs (in mA) of the measurement instruments are relevant for both, the old and new regression lines:

$$X_o = X_n = X$$

where :

X_n: X new
Y_o: Y old

This allows us to derive a calibrating formula that gives us the corrected value of the measured physical parameters. The applied calibrating equation is:

$$Y_n = A_n + (B_n/B_o) * (Y_o - A_o)$$

In order to take into account the properties of the AMS and their implication to the QAL 2 implementation in the model, we will further introduce several remarks to the conversion and normalization of the data.

The units returned by the AMS in “Nm³/h” stand for normalized cubic meters of the gas volume at normal gas conditions (0° C, 1 atm.).

6.2 Stack gas volume flow

The measurement system captures and logs normalized stack volume flow in an integrated manner, calculating the final figure from the mA signal of the endpoints by itself, as opposing to storing just temperature and pressure and deriving the volume flow later. Therefore, the volume flow values can be used as input for QAL2 recalibration transformation without de-normalization and the need for temperature, pressure, and duct cross-section area. The normalized calibrated stack gas flow rates are further fed into the emission calculation model for processing as set out by the Approved Baseline and Monitoring Methodology AM_0034.

6.3 Nitric acid concentration in stack gas

The nitric acid concentration in the raw data set from the AMS is in ppm (parts per million). After QAL2 re-calibration, the values are converted to mgN₂O/Nm³ (mg N₂O per normalized cubic meter) to make it fit into the formulas set out in the methodology.

7. EMISSION REDUCTION CALCULATIONS

Table T 2 illustrates the establishment of historic campaign length based on 4 previous campaigns. Average production in campaigns preceding the baseline campaign was 286 940 tHNO₃ and time duration was on average 383 days. Table contains also information on suppliers of primary catalysts for Line 3 (4 burners). As shown in the table, it is usual practice in Azomures to use primary catalysts from two suppliers.

T 2 Historic campaigns

Line	AzoMures-3	Production	Start	End	Days	Production per day	Primary Catalyst	Composition
Historic Campaigns	1 t HNO ₃	-	-	-	-	n/a	-	-
	2 t HNO ₃	210 275	12 Oct 2001	27 Oct 2002	380	553	Engelhart-Cal	Pt95/Rh5
	3 t HNO ₃	325 002	08 Nov 2002	13 Apr 2004	522	623	Engelhart-Cal	Pt95/Rh5
	4 t HNO ₃	349 459	20 Apr 2004	02 Oct 2005	530	659	Engelhart-Cal	Pt95/Rh5
	5 t HNO ₃	263 025	19 Oct 2005	16 Feb 2007	485	542	Johnson Matthey	Pt84.16/Rh4.62/Pd11.22
Average HNO ₃ production	t HNO ₃	286 940			383	748		
Project Campaigns	BL t HNO ₃	215 669	02 Mar 2007	14 Jul 2008	500	432	Johnson Matthey	Pt83.66/Rh4.61/Pd11.73
	PL t HNO ₃	283 044	24 Jul 2008	05 Apr 2010	620	457	Johnson Matthey	Pt56.20/Rh3.10/Pd39.07

Table T 3 and Chart C 1 define the length of the baseline campaign set according to the historic campaign length. Baseline campaign measurements was carried out from 02/03/2007 through 14/07/2008. During baseline campaign, a total of 215 669 tHNO₃ was produced, NCSG measurements are taken into account until the production of 215 669 tHNO₃ was reached.

The project campaign production value is 283 044 tHNO₃ lower than historic nitric acid production set at level of 286 940 tHNO₃.

T 3 Baseline campaign length

AzoMures-3	Historic Campaigns End	Start of Baseline Measurement	End of Baseline Measurement NCSG	End of Baseline Measurement	End of Baseline Campaign
Dates	2007 Feb 16	2007 Mar 02	2008 Jul 14	2008 Jul 14	2008 Jul 15
Baseline Factor kgN ₂ O/tHNO ₃	-	-	12.46	12.46	12.46
Production tHNO ₃	-	-	215 669	215 669	-
Per Day Production tHNO ₃	748.4				
Baseline less Historic Production	(71 271.0)				
Baseline less Historic Days	(95.2)				

C 1 Baseline campaign length

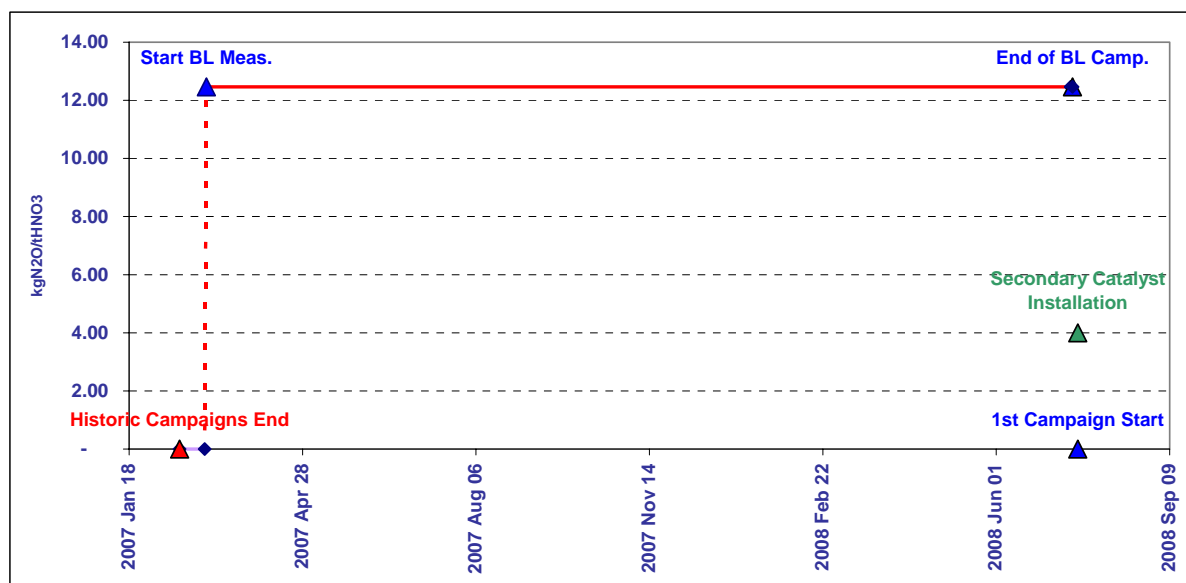


Table T 4 illustrates the calculation of the baseline emission factor on Line 3 using the method as defined in the CDM methodology AM0034 and in the PDD. Baseline measurement was carried out from 02/03/2007 through 14/07/2008.

Extreme values and data measured during hours when one or more of operating conditions were outside of the permitted range have been eliminated from the calculations. As a next step we have eliminated data beyond 95% confidence interval and calculated new mean values of N₂O concentration and stack gas volume flow using following method:

- Calculate the sample mean (x)
- Calculate the sample standard deviation (s)
- Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- Eliminate all data that lie outside the 95% confidence interval
- Calculate the new sample mean from the remaining values (volume of stack gas (VSG) and N₂O concentration of stack gas (NCSG))

Using the means values we have calculated the baseline emissions as set out in the PDD.

$$BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC} (tN_2O)$$

Operating hours defined as hours, when nitric acid production at least 0.1 tHNO₃ and oxidation temperature at least 600°C occurred. Calculated baseline N₂O emissions were 1,194 tN₂O.

$$EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100) (tN_2O/tHNO_3)$$

The UNC factor defined by the QAL2 report is 3.185%. As a result we have arrived to the baseline emission factor of 12.46 kgN₂O/tHNO₃.

Table T5 shows the calculation of the project emission factor on Line 3 during the project campaign. Project campaign started on 24/07/2008 and went through 05/04/2010.

We have eliminated extreme values and data beyond the 95% confidence interval as prescribed by the PDD.

- a) Calculate the sample mean (\bar{x})
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values

Using the mean values we have calculated total mass of N_2O emissions (PE_n) as follows:

$$PE_n = VSG * NCSG * 10^{-9} * OH (tN_2O)$$

Operating hours (OH) defined as hours, when nitric acid production at least 0.1 tHNO₃ and oxidation temperature at least 600°C occurred.

By dividing total mass of N_2O emissions by the nitric acid production (capped by nameplate capacity 725 tHNO₃/day) we have determined the project campaign specific emission factor at value of 1.45 kgN₂O/tHNO₃.

$$EF_n = PE_n / NAP_n (tN_2O/tHNO_3)$$

This emission factor has been used in further calculation of emission reductions. Neither moving average emission factor nor minimum emission factor was established, since it was the first project campaign.

T 4 Baseline emission factor

BASELINE EMISSION FACTOR									
Parameter	Operating Hours	Nitric Acid Production	N2O Concentration	Gas Volume Flow	Ammonia Flow Rate	Ammonia to Air Ratio	Oxidation Temperature	Oxidation Pressure	
Code Unit	OH h	NAP t/h	NCSG mg N2O/Nm3	VSG Nm3/h	AFR Nm3/h	AIFR %	OT °C	OP kPa	
Elimination of extreme values									
Lower limit		0	100	20 000	0	0	-	50	0
Upper Limit		60.00	5 000	200 000	18 000	20.00		1 200	1 000
Raw Data Measured Range									
Count	8 624	7 388	6 243	6 482	11 915	11 174		11 989	11 431
as % of Dataset	72%	62%	52%	54%	99%	93%		100%	95%
Minimum		0.10	161	20 263	-	-		(31)	-
Maximum		40.54	4 999	136 304	15 445	19.94		864	400
Mean		29.19	3 997	95 572	7 882	8.53		623	104
Standard Deviation		4.80	575	15 376	4 881	4.22		356	117
Total		215 669							
N2O Emissions (VSG * NCSG * OH)									
Emission Factor		3 294 t N2O							
		14.79 kgN2O / tHNO3							
Permitted Range									
Minimum					8 000	9		800	0
Maximum					12 500	11.50		860	260
Data within the permitted range									
Count	8 291		6 877	6 924					
as % of Operating Hours	96%		80%	80%					
Minimum			271	-					
Maximum			4 999	415 934					
Mean			3 340	93 138					
Standard Deviation			1 220	21 931					
N2O Emissions (VSG * NCSG * OH)									
Emission Factor		2 683 t N2O							
		12.04 kgN2O / tHNO3							
Data within the confidence interval									
95% Confidence interval									
Lower bound			948	50 153					
Upper bound			5 732	136 122					
Count			6 683	6 468					
as % of Operating Hours			77%	75%					
Minimum			952	50 192					
Maximum			4 999	135 386					
Mean			3 413	94 322					
Standard Deviation			1 160	14 628					
N2O Emissions (VSG * NCSG * OH)									
Emission Factor (EF_BL)		2 776 t N2O							
		12.46 kgN2O / tHNO3							

T 5 Project emission factor

PROJECT EMISSION FACTOR									
Parameter	Operating Hours	Nitric Acid Production	N2O Concentration	Gas Volume Flow	Ammonia Flow Rate	Ammonia to Air Ratio	Oxidation Temperature	Oxidation Pressure	
Code Unit	OH h	NAP t/h	NCSG mg N2O/Nm3	VSG Nm3/h	AFR Nm3/h	AIFR %	OT °C	OP kPa	
Elimination of extreme values									
Lower limit		0	100	20 000	0	0	-	50	0
Upper Limit		60.00	5 000	200 000	18 000	20.00		1 200	1 000
Raw Data Measured Range									
Count	8 795	8 927	8 777	8 992	14 881	13 469	14 881	10 682	
as % of Dataset	59%	60%	59%	60%	100%	91%	100%	72%	
Minimum		0.10	106	20 162	-	-	(31)	-	
Maximum		43.49	2 979	122 260	12 837	19.93	868	272	
Mean		31.71	731	93 987	6 545	7.56	491	204	
Standard Deviation		4.69	710	15 820	5 433	4.61	407	94	
Total		283 044							
N2O Emissions (VSG * NCSG * OH)									
Emission Factor	604	t N2O							
	2.13	kgN2O / tHNO3							
Data within the confidence interval									
95% Confidence interval									
Lower bound			661	62 980					
Upper bound			2 122	124 995					
Count			7 630	8 733					
as % of Operating Hours			87%	99%					
Minimum			119	64 223					
Maximum			2 120	122 260					
Mean			491	94 949					
Standard Deviation			310	14 783					
N2O Emissions (VSG * NCSG * OH)									
Actual Project Emission Factor (EF_PActual)	410	t N2O							
	1.45	kgN2O / tHNO3							
Abatement Ratio	88.4%								
Moving Average Emission Factor Correction									
		Actual Factors	Moving Average Rule						
	1	1.45	1.45						
	2	-							
Project Emission Factor (EF_P)									
Abatement Ratio	1.45	kgN2O / tHNO3							
	88.4%								

MONITORING REPORT

PROJECT: Project aimed at N₂O emissions reduction by installation of secondary catalyst inside ammonia oxidation reactors at 3 nitric acid production plants NA2, NA3 and NA4 of Azomures SA, company situated in Targu Mures, Romania

LINE: Line 4

MONITORING PERIOD:

FROM: 11/08/2008

TO: 11/12/2009

Prepared by:



VERTIS FINANCE

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1. EXECUTIVE SUMMARY

This monitoring report determines baseline emission factor for the Line 4 of Azomures nitric acid plant and quantity of emission reduction generated during the first project campaign on the line.

Total quantity of emission reductions generated during the period from 11/08/2008 through 11/12/2009 on Line 4 is **455 195 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	8.91	kgN ₂ O/tHNO ₃
Project Campaign Emission Factor	EF_P	1.48	kgN ₂ O/tHNO ₃
Nitric Acid Produced in the Baseline Campaign	NAP_BL	213 874	tHNO ₃
Nitric Acid Produced in the NCSG Baseline Campaign	NAP_BL_NCSG	197 731	tHNO ₃
Nitric Acid Produced in the Project Campaign	NAP_P	197 733	tHNO ₃
GWP	GWP	310	tCO ₂ e/tN ₂ O
Emission Reduction	ER	455 195	tCOe
<i>ER=(EF_BL-EF_P)*NAP_P*GWP/1000</i>			
Abatement Ratio	83.4%		

EMISSION REDUCTION PER YEAR			
Year	2008	2009	2010
Date From	11 Aug 2008	01 Jan 2009	
Date To	31 Dec 2008	11 Dec 2009	
Nitric Acid Production	65 277	132 456	
Emission Reduction	150 273	304 922	
<i>ER_YR = ER * NAP_P_YR / NAP_P</i>			

Baseline emission factor established for the Line 4 is 8.91 kgN₂O/tHNO₃. The baseline was carried out using overlapping technique. The first part of the baseline is the interval from 10/03/2008 to 10/08/2008, and it is completed by the second part from 06/04/2007 to 10/03/2008, thus adding up to a comparable campaign.

The secondary catalyst on Line 4 was installed on 11/08/2008. Project emission factor during the first project campaign, which started on 11/08/2008 and went through 11/12/2009, is 1.48 kgN₂O/tHNO₃.

During the project campaign 197 733 tonnes of nitric acid was produced.

2. DESCRIPTION OF THE PROJECT ACTIVITY

Purpose of the Project (the “Project”) is the reduction of nitrous oxide (N₂O) emissions from Joint Implementation project aimed at N₂O emissions reduction by installation of secondary catalyst inside ammonia oxidation reactors at 3 nitric acid production plants NA2, NA3 and NA4 of Azomures SA company, situated at Târgu Mures, Romania.

Azomures has installed and operates secondary N₂O reduction catalysts underneath the primary catalyst precious metal catching and catalytic gauzes package in the ammonium burners of all 3 nitric acid plants.

This monitoring report contains information on Line 4 emission reductions including information on baseline emission factor setting for the Line 4.

The separate treatment of the three nitric acid lines and overlapping of the monitoring periods are allowed by the clarification issued Joint Implementation Supervisory Committee: “CLARIFICATION REGARDING OVERLAPPING MONITORING PERIODS UNDER THE VERIFICATION PROCEDURE UNDER THE JOINT IMPLEMENTATION SUPERVISORY COMMITTEE”. The Project meets all the requirement set out by the clarification:

1. The Project is composed of clearly identifiable components for which emission reductions or enhancements of removals are calculated independently; and
2. Monitoring is performed independently for each of these components, i.e. the data/parameters monitored for one component are not dependent on/effect data/parameters (to be) monitored for another component; and
3. The monitoring plan ensures that monitoring is performed for all components and that in these cases all the requirements of the JI guidelines and further guidance by the JISC regarding monitoring are met.

3. BASELINE SETTING

Baseline emission factor for Line 4 has been established on a line-specific basis. Campaign used for baseline measurements on the Line 4 has been carried out using overlapping technique. The first part of the baseline is the interval from 10/03/2008 to 10/08/2008, and it is completed by the second part from 06/04/2007 to 10/03/2008, thus adding up to a comparable campaign. Nitric acid production during this campaign did not exceed the historic nitric acid production established as an average production during previous historic campaigns.

N₂O concentration and gas volume flow are monitored by monitoring system complying with requirements of the European Norm 14181.

Monitoring system provides separate readings for N₂O concentration and gas flow volume for every hour of operation as an average of the measured values for the previous 60 minutes.

Measurement results can be distorted before and after periods of downtime or malfunction of the monitoring system and can lead to mavericks. To eliminate such extremes and to ensure a conservative approach, the following statistical evaluation is applied to the complete data series of N₂O concentration as well as to the data series for gas volume flow. The statistical procedure is applied to data obtained after eliminating data measured for periods where the plant operated outside the permitted ranges:

- a) Calculate the sample mean (x)
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values (volume of stack gas (VSG) and N₂O concentration of stack gas (NCSG))

The average mass of N₂O emissions per hour is estimated as product of the NCSG and VSG. The N₂O emissions per campaign are estimates product of N₂O emission per hour and the total number of complete hours of operation of the campaign using the following equation:

$$BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC} (tN_2O)$$

The line specific baseline emissions factor representing the average N₂O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N₂O emissions by the total output of 100% concentrated nitric acid during baseline campaign.

The overall uncertainty of the monitoring system has been determined by the QAL2 report and the measurement error is expressed as a percentage (UNC). The N₂O emission factor per tonne of nitric acid produced in the baseline period (EF_{BL}) has been then be reduced by the percentage error as follows:

$$EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100) (tN_2O/tHNO_3)$$

where:

Variable	Definition
EF_{BL}	Baseline N_2O emissions factor ($tN_2O/tHNO_3$)
BE_{BC}	Total N_2O emissions during the baseline campaign (tN_2O)
$NCSG_{BC}$	Mean concentration of N_2O in the stack gas during the baseline campaign (mgN_2O/m^3)
OH_{BC}	Operating hours of the baseline campaign (h)
VSG_{BC}	Mean gas volume flow rate at the stack in the baseline measurement period (m^3/h)
NAP_{BC}	Nitric acid production during the baseline campaign ($tHNO_3$)
UNC	Overall uncertainty of the monitoring system (%), calculated as the combined uncertainty of the applied monitoring equipment.

3.1 Measurement procedure for N_2O concentration and tail gas volume flow

3.1.1 Tail gas N_2O concentration

- the impulse line is the same as the NO_x outlet line
- the circuit is the same as for measuring NO_x outlet concentration, including up to the pressure reducing valve outlet.
- the gas for the N_2O analyzer is taken from here through a water discharge cooler. The analyzer is produced by Environement S.A., France and is based on non-dispersive infrared absorption principle; it is placed in the same cabinet as the NO_x analyzer. The N_2O concentration measurement range is between 0 – 2000 ppm.
- the outlet analyzer signal is of 4 – 20 mA, proportional to the value of the concentration. This signal is transmitted through an electric cable at the plant's central control panel. The electric cable is approx. 100 m long.
- the device that converts the 4 – 20 mA signal in nitrogen oxides concentration is a ISU – MMC- 24C digital indicator produced by Infostar Pascani. The device has 16 inlet circuits of 4 – 20 mA. The readings are digitally displayed and are recorded every 2 seconds. Data recorded into the "data logger" are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer's hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.
- as described in the QAL2 report and in the Determination Report Azomures was supplied with incorrectly prepared calibration gas where declared concentration of N_2O varied from its actual concentration. This was figured out by the Airtec laboratory conducting the QAL2 test and Airtec also calculated the correction factor to be used for N_2O concentration data from beginning of baseline measurements until date of calibration and start of using new properly prepared calibration gas in February 2008.

3.1.2 Tail gas flow, temperature and pressure

- the measuring point is located on the expansion turbine outlet pipe towards the discharge nozzle; Pytot type sensor with multiple holes; operating conditions: absolute $p = 2.5$ bar, $t = 80^{\circ}\text{C}$

- pneumatic connection line (12 mm diameter and approx. 1 m long hoses) between the sensor and the electric switch box where the Dp cell is located; pneumatic connection line (6 mm diameter and approx. 2 m long hose) between the sensor and the electric switch box where the absolute pressure measuring cell is located

- measuring device: Dp differential transducer, produced by ABB, measuring range between 0 – 30 mbar; absolute pressure transducer produced by Endress&Hauser,

measuring range between 0 – 0.3 bar; Pt100 thermal resistance with built-in adapter, measuring range between 0 - 200°C ; analogue output signal 4 – 20 mA

- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA

- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.

- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

3.2 Permitted range of operating conditions of the nitric acid plant

Under certain circumstances, the operating conditions during the measurement period used to determine baseline N_2O emission factor may be outside the permitted range or limit corresponding to normal operating conditions. N_2O baseline data measured during hours where the operating conditions were outside the permitted range have been eliminated from the calculation of the baseline emissions factor.

Normal ranges for operating conditions have been determined for the following parameters:

- oxidation temperature;
- oxidation pressure;
- ammonia gas flow rate,
- air input flow rate.

The permitted range for these parameters has been established using the plant operation manual, as described in the PDD.

3.3 Composition of the ammonia oxidation catalyst

It is business-as-usual in Azomures to change composition of oxidation catalysts installed between campaigns, so the composition during historic and the baseline campaigns is varying.

3.4 Historic Campaign Length

The average historic campaign length (CL_{normal}) defined as the average campaign length for the historic campaigns used to define operating condition (the previous 4 campaigns), has been used as a cap on the length of the baseline campaign.

4. PROJECT EMISSIONS

During the first project campaign on Line 4 the tail gas volume flow in the stack of the nitric acid plant as well as N₂O concentration have been measured on a continuous basis.

4.1.1 Estimation of campaign-specific project emissions factor

The monitoring system was installed using the guidance document EN 14181 and provides separate readings for N₂O concentration and gas flow volume for every hour of operation. Same statistical evaluation that was applied to the baseline data series has been applied to the project data series:

- a) Calculate the sample mean (x)
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values

$$PE_n = VSG * NCSG * 10^{-9} * OH \text{ (tN}_2\text{O)}$$

where:

Variable	Definition
VSG	Mean stack gas volume flow rate for the project campaign (m ³ /h)
NCSG	Mean concentration of N ₂ O in the stack gas for the project campaign (mgN ₂ O/m ³)
PE _n	Total N ₂ O emissions of the n th project campaign (tN ₂ O)
OH	Is the number of hours of operation in the specific monitoring period (h)

4.1.2 Derivation of a moving average emission factor

Because this campaign was first project campaign on Line 4 there has been no moving average emission factor established yet for this campaign.

4.2 Minimum project emission factor

Because this campaign was first project campaign on Line 4 there has been no minimum average emission factor established yet for this campaign. This factor will be established after 10th project campaign.

4.3 Project Campaign Length

Project campaign production of nitric acid has been lower than defined nameplate capacity of 750 tHNO₃/day, and thus NAP value for the project campaign emission reductions calculation has been used in its entirety.

4.4 Leakage

No leakage calculation is required.

4.5 Emission reductions

The emission reductions for the project activity during this campaign have been determined by deducting the campaign-specific emission factor from the baseline emission factor and multiplying the result by the production output of 100% concentrated nitric acid over the campaign period and the GWP of N₂O:

$$ER = (EFBL - EFP) * NAP * GWPN_2O \text{ (tCO}_2\text{e)}$$

Where:

Variable	Definition
ER	Emission reductions of the project for the specific campaign (tCO ₂ e)
NAP	Nitric acid production for the project campaign (tHNO ₃). The maximum value of NAP shall not exceed the design capacity.
EFBL	Baseline emissions factor (tN ₂ O/tHNO ₃)
EFP	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of EF _{ma,n} and EF _n)

5. MONITORING PLAN

5.1 Main air flow

- the measuring point is located on the compressor air discharge pipe
- diaphragm type sensor with ring-like chambers
- operating conditions: $p = 2.5 - 3$ bars, $t = 150^{\circ}\text{C}$
- pneumatic signal transmission between the sensor and the transducer through 2 impulse pipes, approx. 10 m long
- measuring device: Fischer Roesmount differential electronic transducer, having a measuring range between 0 – 45.24 mbar; output signal: analogue 4 – 20 mA
- signal transmission: electric wires, approx. 30 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.2 Secondary air flow

- the measuring point is located on the air compressor discharge pipe
- diaphragm type sensor with ring-like chambers
- operating conditions: $p = 2.5 - 3$ bars, $t = 150^{\circ}\text{C}$
- pneumatic signal transmission between the sensor and the transducer through 2 impulse pipes, approx. 15 m long

- measuring device: Fischer Roesmount differential electronic transducer, having a measuring range between 0 – 500 mm H₂O; output signal: analogue 4 – 20 mA
- signal transmission: electric wires, approx. 50 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.3 Casing protection air flow

- the measuring point is located on the air duct to the reactors casing, ramifications from the compressor discharge pipe
- diaphragm type sensor with ring-like chambers
- operating conditions: $p = 2.5 - 3$ bars, $t = 150^{\circ}\text{C}$
- pneumatic signal transmission between the sensor and the transducer through 2 impulse pipes, approx. 10 m long
- measuring device: FEPA Birlad differential electronic transducer, having a measuring range between 0 – 1500 mm H₂O; output signal: analogue 4 – 20 mA
- signal transmission: electric wires, approx. 60 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.4 Reactor sieves temperature

- the measuring point is located on the oxidation reactor; sensor; PtRh-Pt thermocouple, operating conditions: $t = 800 - 1000^{\circ}\text{C}$
- electric signal transmission between the sensor and the transducer: PtRh-Pt correction cable, approx. 50 m long
- digital indicator measuring device; measuring range between $0 - 1000^{\circ}\text{C}$; analogue output signal $4 - 20 \text{ mA}$
- signal transmission: electric wires, approx. 6 m long, analogue signal $4 - 20 \text{ mA}$
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.5 Consumed liquid ammonia flow

- the measuring point is located on the ammonia evaporator inlet pipe; Coriolis type sensor; operating conditions: $p = 12 \text{ bar}$, $t = 8 - 10^{\circ}\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 90 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between $0 - 20 \text{ t/h}$; analogue output signal $4 - 20 \text{ mA}$
- signal transmission: electric wires, approx. 10 m long, analogue signal $4 - 20 \text{ mA}$
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.6 Flow of produced nitric acid

- the measuring point is located on the column 4 outlet pipe towards the nitric acid storehouse; electromagnetic sensor; operating conditions: $p = 2.5 \text{ bar}$, $t = 40^\circ\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 100 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between 0 – 100 t/h; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.7 Temperature of produced nitric acid

- the measuring point is located on the column 4 outlet pipe towards the nitric acid storehouse; Coriolis type sensor; operating conditions: $p = 2.5 \text{ bar}$, $t = 40^\circ\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 100 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between $-50 - 200^\circ\text{C}$; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this

database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.8 Density of produced nitric acid

- the measuring point is located on the column 4 outlet pipe towards the nitric acid storehouse; Coriolis type sensor; operating conditions: $p = 2.5 \text{ bar}$, $t = 40^\circ\text{C}$
- electric signal transmission between the sensor and the transducer: 2-wire cable, approx. 100 m long
- measuring device: DZL363 flowmeter adapter produced by Endress&Hauser; measuring range between 1.2 – 1.4 kg/l; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.9 Tail gases flow, tail gases pressure, tail gases temperature

- the measuring point is located on the expansion turbine outlet pipe towards the discharge nozzle; Pytot type sensor with multiple holes; operating conditions: absolute $p = 2.5 \text{ bar}$, $t = 80^\circ\text{C}$
- pneumatic connection line (12 mm diameter and approx. 1 m long hoses) between the sensor and the electric switch box where the Dp cell is located; pneumatic connection line (6 mm diameter and approx. 2 m long hose) between the sensor and the electric switch box where the absolute pressure measuring cell is located
- measuring device: Dp differential transducer, produced by ABB, measuring range between 0 – 30 mbar; absolute pressure transducer produced by Endress&Hauser, measuring range between 0 – 0.3 bar; Pt100 thermal resistance with built-in adapter, measuring range between 0 - 200°C; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 5 m long, analogue signal 4 – 20 mA

- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.10 Oxidation reactor pressure

- the measuring point is located on the air compressor discharge pipe; sensor type: capsule for electronic transducer; operating conditions: absolute $p = 3.5$ bar, $t = 200^{\circ}\text{C}$
- pneumatic connection line between the sensor and the transducer; pneumatic connection line of 8 mm diameter and approx. 10 m long
- measuring device: Foxboro transducer, measuring range between 0 – 5 bar; absolute pressure transducer produced by Endress&Hauser, measuring range between 0 – 0.3 bar; Pt100 thermal resistance with built-in adapter, measuring range between 0 - 200°C ; analogue output signal 4 – 20 mA
- signal transmission: electric wires, approx. 50 m long, analogue signal 4 – 20 mA
- signal conversion device: ISU 24M digital indicator; placed inside the control panel; converts the analogue signal into digital signal; recording period: 2 seconds.
- data recorded into the “data logger” are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer’s hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

5.11 N₂O concentration

- the impulse line is the same as the NO_x outlet line
- the circuit is the same as for measuring NO_x outlet concentration, including up to the pressure reducing valve outlet.
- the gas for the N₂O analyzer is taken from here through a water discharge cooler. The analyzer is produced by Environement S.A., France and is based on non-dispersive infrared absorption principle; it is placed in the same cabinet as the NO_x analyzer. The N₂O concentration measurement range is between 0 – 2000 ppm.

- the outlet analyzer signal is of 4 – 20 mA, proportional to the value of the concentration. This signal is transmitted through an electric cable at the plant's central control panel. The electric cable is approx. 100 m long.
- the device that converts the 4 – 20 mA signal in nitrogen oxides concentration is a ISU – MMC- 24C digital indicator produced by Infostar Pascani. The device has 16 inlet circuits of 4 – 20 mA. The readings are digitally displayed and are recorded every 2 seconds. Data recorded into the "data logger" are transmitted through an optic fiber network to a computer designated particularly for this type of monitoring. This computer is located in the Instrumentation Plant. Data are stored in a database on the computer's hard disk. From this database data are afterwards processed in order to obtain all data necessary for the project. The entire database is periodically saved on graphic and magnetic support as an Excel file.

6. QAL 2 CALIBRATION ADJUSTMENTS

6.1 Applied principle

As required in the applicable norm EN14181: "The relation between the instrument readings of the recording measuring procedure and the quantity of the measuring objects has to be described by using a suitable convention method. The results have to be expressed by a regression analysis."

As it is described in the Calibration Report issued by Airtec laboratory, the measurement results derived from the analog signals (4 mA to 20 mA) provided the installed instruments have been compared to the comparative measurements.

Linearity check of the instruments characteristics is stated in the QAL2 Calibration Report issued by the laboratory. The valid ranges of linearity are determined by statistical analysis according to the guideline and the linearity assumptions are further used in the Calibration Report establishing linear regression lines.

The general formula of the regression line, established in the EN14181 and used in the Calibration Report is:

$$Y = a + bX$$

where:

X is the measured value of the instrument in mA

Y is the value of the parameter being objective of the measurement

a is a constant of the regression line

b is the slope of the regression line

After a comparative test the laboratory issued the old and new regression lines properties, namely "a" and "b" applying for all of the measured parameters that are subject to calibration as stated in the Calibration Report.

The QAL2 corrections are based on the fact that the actual analog current outputs (in mA) of the measurement instruments are relevant for both, the old and new regression lines:

$$X_o = X_n = X$$

where :

X_n: X new

Y_o: Y old

This allows us to derive a calibrating formula that gives us the corrected value of the measured physical parameters. The applied calibrating equation is:

$$Y_n = A_n + (B_n/B_o) * (Y_o - A_o)$$

In order to take into account the properties of the AMS and their implication to the QAL 2 implementation in the model, we will further introduce several remarks to the conversion and normalization of the data.

The units returned by the AMS in “Nm³/h” stand for normalized cubic meters of the gas volume at normal gas conditions (0° C, 1 atm.).

6.2 Stack gas volume flow

The measurement system captures and logs normalized stack volume flow in an integrated manner, calculating the final figure from the mA signal of the endpoints by itself, as opposing to storing just temperature and pressure and deriving the volume flow later. Therefore, the volume flow values can be used as input for QAL2 recalibration transformation without de-normalization and the need for temperature, pressure, and duct cross-section area. The normalized calibrated stack gas flow rates are further fed into the emission calculation model for processing as set out by the Approved Baseline and Monitoring Methodology AM_0034.

6.3 Nitric acid concentration in stack gas

The nitric acid concentration in the raw data set from the AMS is in ppm (parts per million). After QAL2 re-calibration, the values are converted to mgN₂O/Nm³ (mg N₂O per normalized cubic meter) to make it fit into the formulas set out in the methodology.

7. EMISSION REDUCTION CALCULATIONS

Table T 2 illustrates the establishment of historic campaign length based on 4 previous campaigns. Average production in campaigns preceding the baseline campaign was 275 871 tHNO₃ and time duration was on average 408 days. Table contains also information on suppliers of primary catalysts for Line 4 (4 burners). As shown in the table, it is usual practice in Azomures to use primary catalysts from two suppliers.

T 2 Historic campaigns

Line	AzoMures-4	Production	Start	End	Days	Production per day	Primary Catalyst	Composition
Historic Campaigns	1 t HNO ₃	-	-	-	-	n/a	N/A	-
	2 t HNO ₃	237 767	08 Dec 2000	16 Apr 2002	494	481	Engelhart-Cal	Pt95/Rh5
	3 t HNO ₃	271 545	21 May 2002	20 Nov 2003	548	496	Engelhart-Cal	Pt95/Rh5
	4 t HNO ₃	308 263	27 Nov 2003	06 Feb 2005	437	705	Engelhart-Cal	Pt95/Rh5
	5 t HNO ₃	285 908	23 Feb 2005	05 Sep 2006	559	511	Heraeus	Pt58.46/Rh3.89/Pd37.65
Average HNO ₃ production	t HNO ₃	275 871			408	677		
Project Campaigns	BL t HNO ₃	213 874	10 Mar 2008	10 Mar 2008	-	n/a	Heraeus	Pt57.56/Rd3.83/Pd38.61
	PL t HNO ₃	197 733	11 Aug 2008	11 Dec 2009	487	406	Heraeus	Pt57.55/Rh3.82/Pd38.63

Table T 3 and Chart C 1 define the length of the baseline campaign set according to the historic campaign length. Baseline campaign measurements was carried out using overlapping technique. The first part of the baseline is the interval from 10/03/2008 to 10/08/2008, and it is completed by the second part from 06/04/2007 to 10/03/2008, thus adding up to a comparable campaign. During baseline campaign, a total of 213 874 tHNO₃ was produced, NCSG measurements are taken into account until the production of 197 731 tHNO₃ was reached.

The project campaign production value is 197 733 tHNO₃ lower than historic nitric acid production set at level of 275 871 tHNO₃.

T 3 Baseline campaign length

AzoMures-4	Historic Campaigns End	Start of Baseline Measurement	End of Baseline Measurement NCSG	End of Baseline Measurement	End of Baseline Campaign
Dates	2006 Sep 05	2007 Apr 06	2008 Feb 16	2008 Aug 10	2008 Aug 11
Baseline Factor kgN ₂ O/tHNO ₃	-	-	8.91	8.91	8.91
Production tHNO ₃	-	-	197 731	213 874	-
Per Day Production tHNO ₃	676.8				
Baseline less Historic Production	(61 996.8)				
Baseline less Historic Days	(91.6)				

C 1 Baseline campaign length

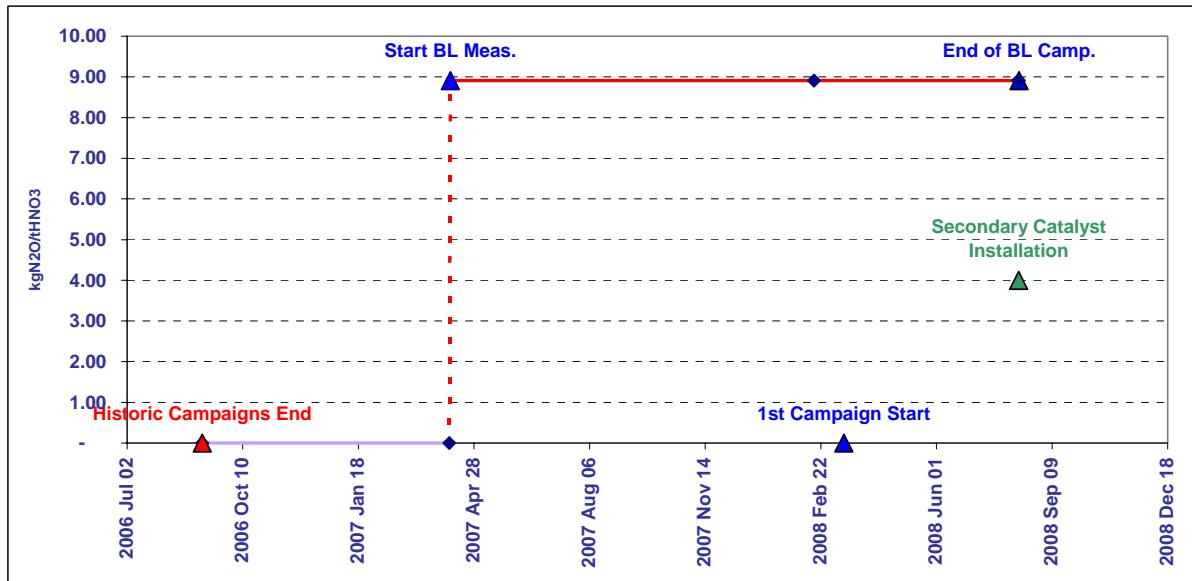


Table T 4 illustrates the calculation of the baseline emission factor on Line 4 using the method as defined in the CDM methodology AM0034 and in the PDD. Baseline measurement was carried out using overlapping technique. The first part of the baseline is the interval from 10/03/2008 to 10/08/2008, and it is completed by the second part from 06/04/2007 to 10/03/2008, thus adding up to a comparable campaign.

Extreme values and data measured during hours when one or more of operating conditions were outside of the permitted range have been eliminated from the calculations. As a next step we have eliminated data beyond 95% confidence interval and calculated new mean values of N₂O concentration and stack gas volume flow using following method:

- a) Calculate the sample mean (x)
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values (volume of stack gas (VSG) and N₂O concentration of stack gas (NCSG))

Using the means values we have calculated the baseline emissions as set out in the PDD.

$$BE_{BC} = VSG_{BC} * NCSG_{BC} * 10^{-9} * OH_{BC} (tN_2O)$$

Operating hours defined as hours, when nitric acid production at least 0.1 tHNO₃ and oxidation temperature at least 600°C occurred. Calculated baseline N₂O emissions were 1,194 tN₂O.

$$EF_{BL} = (BE_{BC} / NAP_{BC}) (1 - UNC/100) (tN_2O/tHNO_3)$$

The UNC factor defined by the QAL2 report is 3.412%. As a result we have arrived to the baseline emission factor of 8.91 kgN₂O/tHNO₃.

Table T5 shows the calculation of the project emission factor on Line 4 during the project campaign. Project campaign started on 11/08/2008 and went through 11/12/2009.

We have eliminated extreme values and data beyond the 95% confidence interval as prescribed by the PDD.

- a) Calculate the sample mean (\bar{x})
- b) Calculate the sample standard deviation (s)
- c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
- d) Eliminate all data that lie outside the 95% confidence interval
- e) Calculate the new sample mean from the remaining values

Using the mean values we have calculated total mass of N_2O emissions (PE_n) as follows:

$$PE_n = VSG * NCSG * 10^{-9} * OH (tN_2O)$$

Operating hours (OH) defined as hours, when nitric acid production at least 0.1 tHNO₃ and oxidation temperature at least 600°C occurred.

By dividing total mass of N_2O emissions by the nitric acid production (capped by nameplate capacity 725 tHNO₃/day) we have determined the project campaign specific emission factor at value of 1.48 kgN₂O/tHNO₃.

$$EF_n = PE_n / NAP_n (tN_2O/tHNO_3)$$

This emission factor has been used in further calculation of emission reductions. Neither moving average emission factor nor minimum emission factor was established, since it was the first project campaign.

T 4 Baseline emission factor

BASELINE EMISSION FACTOR									
Parameter	Operating Hours	Nitric Acid Production	N2O Concentration	Gas Volume Flow	Ammonia Flow Rate	Ammonia to Air Ratio	Oxidation Temperature	Oxidation Pressure	
Code Unit	OH h	NAP t/h	NCSG mg N2O/Nm3	VSG Nm3/h	AFR Nm3/h	AIFR %	OT °C	OP kPa	
Elimination of extreme values									
Lower limit		0	100	20 000	0	0	-	50	0
Upper Limit		60.00	5 000	200 000	18 000	20.00		1 200	1 000
Raw Data Measured Range									
Count	8 186	7 063	6 979	7 986	11 803	10 639		11 809	10 866
as % of Dataset	69%	60%	59%	68%	100%	90%		100%	92%
Minimum		0.19	101	22 057	-	-		(25)	-
Maximum		51.11	4 981	132 738	14 347	19.98		864	449
Mean		30.28	2 790	94 338	8 396	9.20		628	149
Standard Deviation		5.57	809	20 732	4 887	3.36		338	143
Total		213 874							
N2O Emissions (VSG * NCSG * OH)									
Emission Factor		2 154 t N2O							
		9.73 kgN2O / tHNO3							
Permitted Range									
Minimum					8 000	9		800	180
Maximum					13 800	11.50		860	300
Data within the permitted range									
Count	4 674		4 192	4 674					
as % of Operating Hours	57%		51%	57%					
Minimum			192	64 742					
Maximum			4 458	689 625					
Mean			2 484	98 642					
Standard Deviation			664	26 469					
N2O Emissions (VSG * NCSG * OH)									
Emission Factor		2 006 t N2O							
		9.06 kgN2O / tHNO3							
Data within the confidence interval									
95% Confidence interval									
Lower bound			1 183	46 763					
Upper bound			3 786	150 521					
Count			4 012	4 642					
as % of Operating Hours			49%	57%					
Minimum			1 200	64 742					
Maximum			3 784	150 376					
Mean			2 477	97 259					
Standard Deviation			582	12 181					
N2O Emissions (VSG * NCSG * OH)									
Emission Factor (EF_BL)		1 972 t N2O							
		8.91 kgN2O / tHNO3							

T 5 Project emission factor

PROJECT EMISSION FACTOR									
Parameter	Operating Hours	Nitric Acid Production	N2O Concentration	Gas Volume Flow	Ammonia Flow Rate	Ammonia to Air Ratio	Oxidation Temperature	Oxidation Pressure	
Code Unit	OH h	NAP t/h	NCSG mg N2O/Nm3	VSG Nm3/h	AFR Nm3/h	AIFR %	OT °C	OP kPa	
Elimination of extreme values									
Lower limit		0	100	20 000	0	0	-	50	0
Upper Limit		60.00	5 000	200 000	18 000	20.00		1 200	1 000
Raw Data Measured Range									
Count	5 991	6 085	6 047	9 269	11 612	8 652	11 689	8 938	
as % of Dataset	51%	52%	52%	79%	99%	74%	100%	76%	
Minimum		0.10	103	22 951	-	-	(31)	-	
Maximum		50.22	1 133	138 040	13 975	19.95	764	311	
Mean		32.50	481	91 701	5 836	8.22	289	187	
Standard Deviation		4.13	202	19 542	5 655	4.14	345	130	
Total		197 733							
N2O Emissions (VSG * NCSG * OH)									
Emission Factor	264	t N2O							
	1.34	kgN2O / tHNO3							
Data within the confidence interval									
95% Confidence interval									
Lower bound			85	53 399					
Upper bound			877	130 004					
Count			5 672	5 925					
as % of Operating Hours			95%	99%					
Minimum			124	71 974					
Maximum			876	127 481					
Mean			464	105 308					
Standard Deviation			180	6 888					
N2O Emissions (VSG * NCSG * OH)									
Actual Project Emission Factor (EF_PActual)	293	t N2O							
	1.48	kgN2O / tHNO3							
Abatement Ratio	83.4%								
Moving Average Emission Factor Correction									
		Actual Factors	Moving Average Rule						
	1	1.48	1.48						
	2	-							
Project Emission Factor (EF_P)									
Abatement Ratio	1.48	kgN2O / tHNO3							
	83.4%								