FOURTH MONITORING REPORT

PROJECT: ACHEMA UKL-7 plant N_2O abatement project

Prepared by:

VERTIS

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April 20, 2012

Monitoring periods

Line 1
Project campaign 2
FROM: 13/09/2010
TO: 21/08/2011
ERUs 267,237

Line 2
Project campaign 5
FROM: 13/05/2011
TO: 08/12/2011
ERUs 150,047

Line 3
Project campaign 4
FROM: 19/11/2010
TO: 25/08/2011
ERUs 69,520

Line 4
Project campaign 4
FROM: 16/03/2011
TO: 05/10/2011
ERUs 105,340

Line 5
Project campaign 4
FROM: 17/03/2011
TO: 09/11/2011
ERUs 82,177

Line 6
Project campaign 4
FROM: 01/10/2010
TO: 10/08/2011
ERUs 214,833

Line 7
Project campaign 4
FROM: 10/12/2010
TO: 30/08/2011
ERUs 163,985

Line 8
Project campaign 4
FROM: 09/11/2010
TO: 01/09/2011
ERUs 111,857

Fourth monitoring period start and end: **September 13, 2010 – December 8, 2011**

Fourth monitoring period ERUs in total: 1,164,996

Emission Reductions (year 2010): 200,103 t CO2 equivalents
Emission Reductions (year 2011): 964,893 t CO2 equivalents
Emission Reductions (total): 1,164,996 t CO2 equivalents

MONITORING REPORT

PROJECT: ACHEMA UKL nitric acid plant N_2O abatement project
LINE: Line 1
MONITORING PERIOD:
FROM: 13/09/2010

TO: 21/08/2011

Prepared by:

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1. EXECUTIVE SUMMARY

This monitoring report determines baseline emission factor for the Line 1 of ACHEMA UKL nitric acid plant and quantity of emission reduction generated during the second project campaign on Line 1.

The first project campaign on Line 1 started on 11/11/2008. Secondary catalyst was installed on 30/10/2008. Total quantity of emission reductions generated during the second project period from 13/09/2010 through 21/08/2011 on Line 1 is **267 237 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	9.63	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	1.77	kgN2O/tHNO3
Nitric Acid Produced in the Baseline Campaign	NAP_BL	60 691	tHNO3
Nitric Acid Produced in the NCSG Baseline Campaign	NAP_BL_NCSG	60 691	tHNO3
Nitric Acid Produced in the Project Campaign	NAP_P	109 676	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**267 237**	**tCOe**
*ER=(EF_BL-EF_P)*NAP_P*GWP/1000*			
Abatement Ratio		**85.1%**	

EMISSION REDUCTION PER YEAR			
Year	2009	2010	2011
Date from		13 Sep 2010	01 Jan 2011
Date to		31 Dec 2010	21 Aug 2011
Nitric Acid Production		36 738	72 938
Emission Reduction		**89 516**	**177 721**
*ER_YR = ER * NAP_P_YR / NAP_P*			

Baseline emission factor established for the Line 1 during baseline measurement carried from 14/03/2008 through 21/10/2008 is 9.63 kgN_2O/tHNO_3.

Project emission factor during the second project campaign after installation of secondary catalysts on Line 1, which started on 13/09/2010 and went through 21/08/2011 with secondary catalyst installed and commissioned on 30/10/2008, is 1.77 kgN_2O/tHNO_3.

During the project campaign 109 676 tonnes of nitric acid was produced.

2. DESCRIPTION OF THE PROJECT ACTIVITY

Purpose of the Project (the “Project”) is the reduction of nitrous oxide (N_2O) emissions from nitric acid production Lines at the UKL-7 nitric acid plant of AB Achema (“Achema” or “the Company”). The Company is situated in Jonava, Lithuania.

Achema has installed and operates secondary N_2O reduction catalysts underneath the primary catalyst precious metal catching and catalytic gauzes package in the ammonium burners of the UKL-7 nitric acid plant.

This monitoring report contains information on Line 1 emission reductions including information on baseline emission factor setting for the Line 1.

The separate treatment of 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 requirements 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 1 has been established on the Line-specific basis. Campaign used for baseline measurements on the line 1 has been carried out from 14/03/2008 through 21/10/2008.

N_2O concentration and gas volume flow are monitored by monitoring system complying with requirements of the European Norm 14181.

Monitoring system provides separate readings for N_2O 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 N_2O 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 N_2O concentration of stack gas (NCSG))

The average mass of N_2O emissions per hour is estimated as product of the NCSG and VSG. The N_2O emissions per campaign are estimates product of N_2O 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 N_2O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N_2O 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 N_2O emission factor per tonne of nitric acid produced in the baseline period (EFBL) 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

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from the Line 1 tail gas duct at sampling point located after expansion turbine and transported by sample Line to the Monitoring room A, where the analyzer is located.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis.

N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production lines. N_2O concentration is measured by 3 concentration meters on a switched basis.

N_2O concentration measured data are sent from the analyzer on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

3.1.2 Tail gas flow rate, pressure and temperature

Tail gas flow, pressure and temperature is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section. Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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 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 5 campaigns), has been used as a cap on the length of the baseline campaign.

4. PROJECT EMISSIONS

During the first project campaign on line 1 the tail gas volume flow in the stack of the nitric acid plant as well as N_2O concentration have been measured on the 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 N_2O 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

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

where:

Variable	**Definition**
VSG	Mean stack gas volume flow rate for the project campaign (m^3/h)
NCSG	Mean concentration of N_2O in the stack gas for the project campaign (mgN_2O/m^3)
PE_n	Total N_2O emissions of the n^{th} project campaign (tN_2O)
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 the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this campaign.

4.2 Minimum project emission factor

The minimum average emission factor established factor will be established after 10th project campaign.

4.3 Project Campaign Length

Project campaign production of nitric acid has been below defined nameplate capacity and thus all NAP produced from date of installation of secondary catalysts has been used for calculation of emission reductions.

Because the nitric acid production during the project was higher than the baseline, all of the baseline NCSG values were used to determine the baseline emission factor.

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 N_2O:

$$ER = (EFBL - EFP) * NAP * GWPN_2O \ (tCO_2e)$$

Where:

Variable	**Definition**
ER	Emission reductions of the project for the specific campaign (tCO_2e)
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 ($tN_2O/tHNO_3$)
EFP	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of $EF_{ma,n}$ and EF_n)

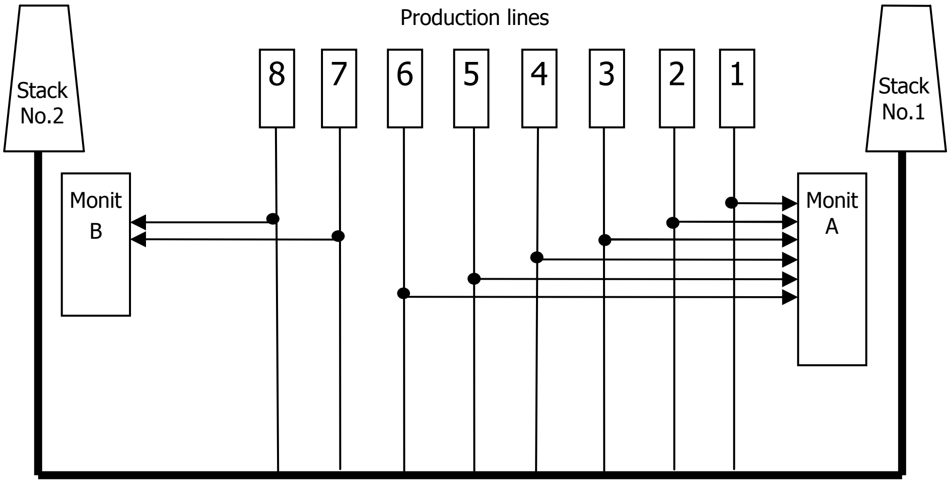
5. MONITORING PLAN

Purpose of the monitoring plan

The purpose of the monitoring plan is to describe the system used to monitor emissions of N_2O from the plant in such a way that is compliant with the prescriptions of the AM0034/Version 02.

Plant description

The UKL-7 nitric acid plant comprises 8 production Lines numbered from 1 through 8, each with its own burner, absorption column and expansion turbine. Each production Line represents a separate nitric acid production unit independent from each other. The tail gasses from each Line are after expansion turbines led to a common stack bus and vented through two interconnected stacks.



Primary catalyst is changed at different times thus it is necessary to measure the emissions from each Line individually. This means that eight separate sets of monitoring equipment are installed to measure tail gas flow, nitric acid production, nitric acid concentration, and the operating conditions. N_2O concentration in the tail gas is measured by 3 switched concentration meters.

Monitoring System architecture

Methodology AM0034/Version 02 requires installation of an N_2O monitoring system that includes both a gas volume flow meter to determine the tail gas mass volume flow and an infrared gas analyser to determine the concentration of N_2O.

But tail gas N_2O concentration meter and tail gas volume flow meter alone are not sufficient for a JI project purposes. In order of being able to calculate the baseline emission factor expressed as tonnage of N_2O in t CO_2e per 1 tonne of HNO_3 (100%), it is necessary to include also HNO_3 measurement, and in order of being able to document normal operating conditions it is necessary to include also operating conditions measurement.

Because of this we use the term Monitoring System (MS) to describe entire monitoring system directly and indirectly used for the JI purposes, while Automated Measurement System (AMS) covers only N_2O emissions and tail gas mass volume part of the MS.

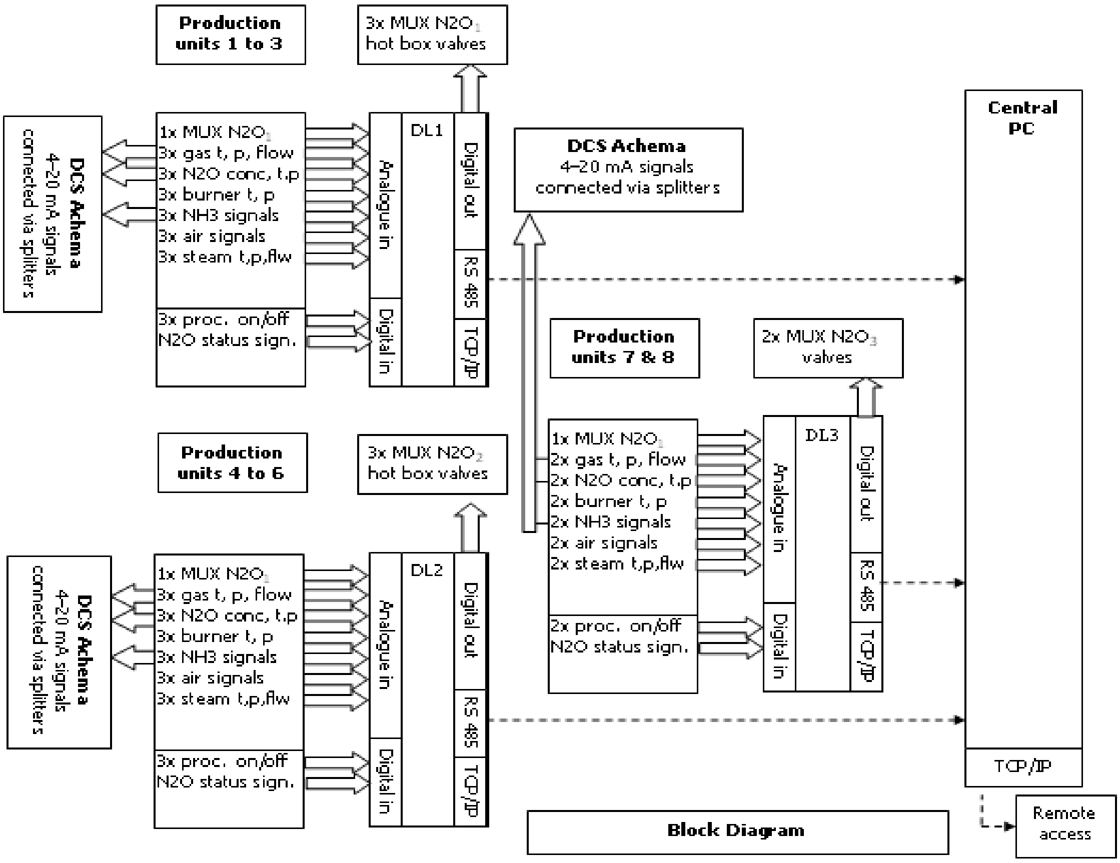
Monitoring System (MS) for purpose of this monitoring plan means:

monitoring system measuring operational conditions;
Ammonia volume flow
Ammonia temperature
Ammonia pressure
Primary air volume flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

nitric acid 100% concentrate production;
Nitric acid concentration
Nitric acid flow
Nitric acid temperature

and newly installed measurement devices for measurement of N2O concentration and tail gas flow, temperature and pressure (AMS)
N_2O concentration in the stack
Stack volume flow rate
Stack gas temperature
Stack gas pressure

Incorporation of the AMS into the MS by interfacing already existing and newly installed measurement devices is documented by the diagram below.



N_2O automated measurement system

Main purpose of the N_2O automated measurement system (AMS) is to measure total mass of N_2O emitted during particular campaigns (both baseline and project). In order of calculation of total mass of N_2O emitted during particular campaign it is necessary to measure on an extractive basis the N_2O concentration in a tail gas and on a non-extractive basis tail gas flow, pressure and temperature.

N_2O concentration

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from respective tail gas ducts at sampling points located after expansion turbines and transported by heated sample lines to the Monitoring room A located next to the main production hall. This applies to 2 concentration meters measuring lines 1-3 and lines 4-6. lines 7-8 are measured by third concentration meter located at the other side of the production hall (Monitoring room B) physically closer to respective production lines 7 and 8.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis. Correction of dry basis ppmV value to real wet tail

gas conditions based on steam flow injected into the system is part of both - the project emissions calculations and baseline emission factor calculations.

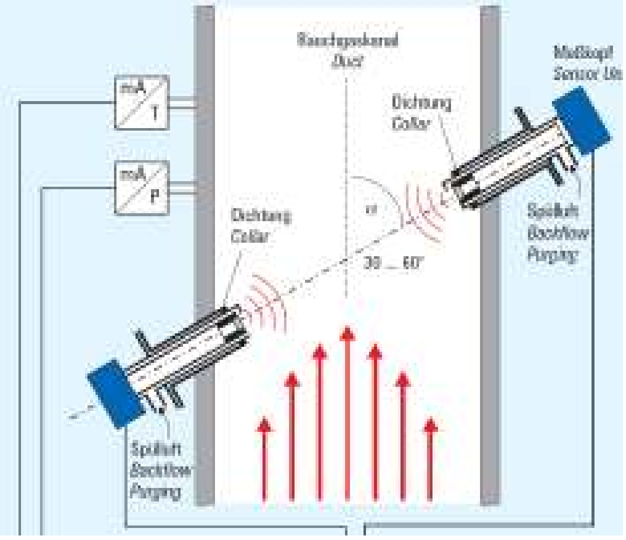
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production Lines. N_2O concentration is measured by 3 concentration meters on a switched basis. Tail gas samples are automatically switched. Under-sampling uncertainty is part of both - the project emissions calculations and baseline emission factor calculations.

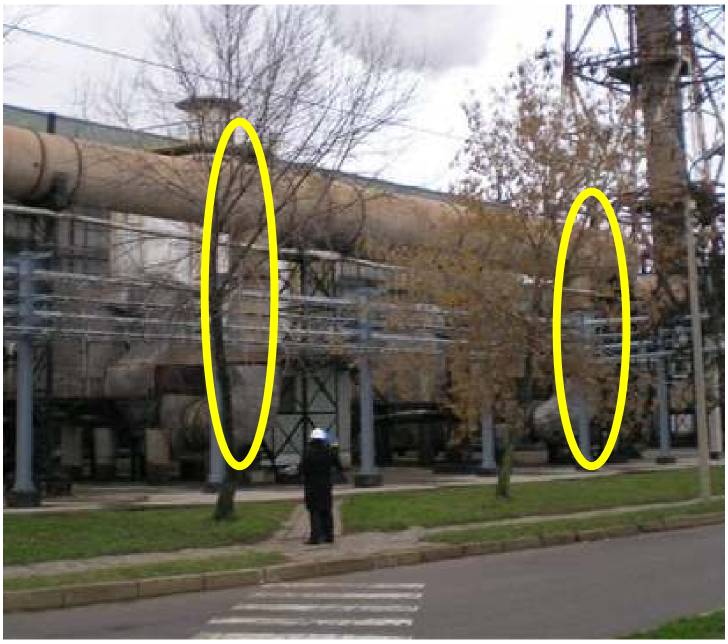
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas flow, pressure and temperature

Tail gas flow is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section.



The tail gas ducts do not allow any optimum location to perform the flow monitoring. The only possible location is the quite short vertical tube behind the 90° “knee”.



Since the flow is not really laminar, a classical Pitot tube one point solution wouldn't allow good results. The ultrasonic system is under these conditions superior to differential pressure. Cross duct monitoring is more accurate than a couple of discrete point averaged pressure.

Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas steam injection elimination

Steam injected into the Achema UKL-7 tail gas for purpose of increasing the turbine output is eliminated from the tail gas mass flow calculation by following formulae:

flow - STVF= Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325)*((100-Humi)/100)

where Humi (water content)=

(Flow_steam*1.2436)/(Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325))*100+0.6

where 1.2436 is the conversion factor from kg/h to Nm3/h and 0.6% is a value of humidity present in a flue gas permanently without steam injection

The Flow_steam parameter necessary for calculation of the water content in the dataloggers is provided in the kg/h unit.

Achema measures steam flow in kg/h using formula Q=C*sqrt(dp) , where C is flow constant which is already integrated using an orifice plate sizing program. The orifice plate calculation for injection steam has been done for temperature 250˚C and pressure 6 bar.

Flow steam in kg/h measured by using the constant steam T and P values is then recalculated to actual steam T and P values valid for relevant hours and as result the STVF value cleaned of the steam injected is used for further emission reductions calculations.

EN14181 compliance

As required by the AM0034/Version 02 methodology the N_2O automated measurement system (AMS) complies with requirements of the technical norm EN14181. N_2O AMS consists from the N_2O concentration meter and integrated flowmeter (F, T, P). Both measurement devices are QAL1 certified (concentration meter for the N_2O measurand specifically) and after full commissioning of the monitoring system there was the QAL2 test carried out by an independent laboratory certified according to ISO17025.

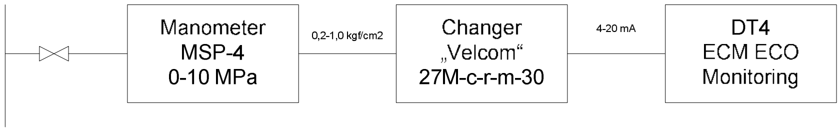
Operating conditions

For purpose of the baseline emissions factor setting it is necessary to monitor and report operating conditions in all 8 burners. Namely:

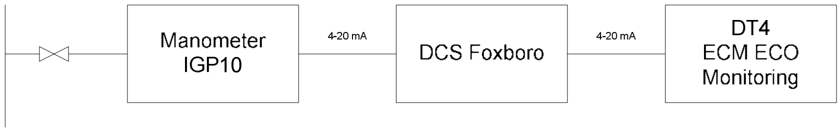
Ammonia flow
Ammonia temperature
Ammonia pressure
Primary air flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

All these parameters are measured by the plant monitoring system as presented on diagrams below:

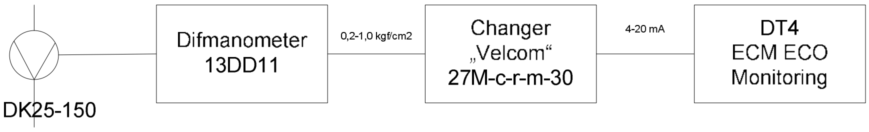
P in mixer 1-6 line



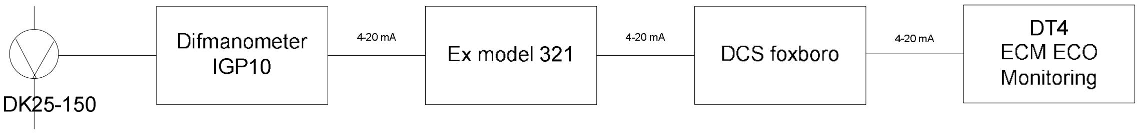
P in mixer 7-8 line



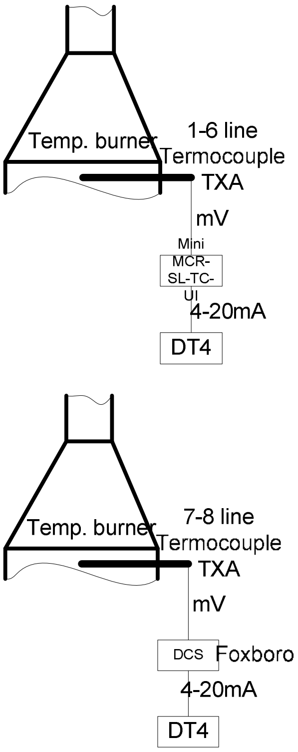
NH3 to mixer 1-6 line



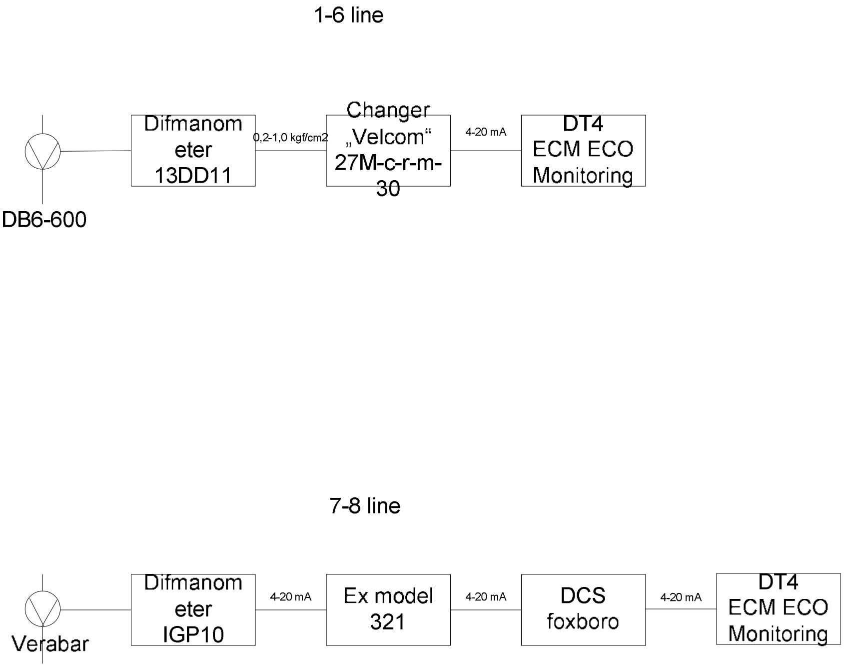
NH3 to mixer 7-8 line



T in burner



Air to mixer



Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further. Maintenance procedures for the ammonia oxidation parameters follow the existing procedures for the operation of the nitric acid plant.

Nitric acid production

Nitric acid concentration is based on two components: nitric acid and water. Standard monitoring method is on-Line refractometry. Measurement of nitric acid (100%) mass volume production per campaign is necessary for calculation of the baseline emissions factor. Nitric acid concentration on all 8 Lines is measured by K-Patents PR-23-GP refractometers.

This analyzer is applying a prism to “return” a generated optical beam back to an LCD detector.

The detector is measuring refraction of monitored liquid based on known refraction of water and nitric acid. The instrument is calibrated for percent concentration of nitric acid. The analyzer is mounted on DIN-flange 2656, PN25 DN80. The optical prism does not require cleaning.

PR-23-GP characteristics:

Measuring RI is a direct concentration measurement principle. No need to rely or convert magnitudes.
Digital instrument – no calibration drift
As it is a robust instrument it is maintenance free
Dual connectivity if the installation positions allow.
On-Line data logging, through Ethernet, on whichever web browser.
No influence by bubbles or particles. It is very common that air enters the process pipeline and still the refractometer measures accurately.

Nitric acid concentration data are in an analog 4-20mA format provided to dataloggers which process these signals further.

In order of being able to calculate total mass volume of nitric acid 100% concentrate produced during the baseline campaign it is necessary to monitor also nitric acid flow and temperature. Measurement of pressure is not necessary for determination of the nitric acid mass volume flow, because nitric acid is in form of liquid and as such it has stabile pressure characteristic.

Signals obtained from the nitric acid flow and temperature measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Nitric acid flow and temperature measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further.

After installation of refractometers there have been occurrences of their failure and following repair service by the manufacturer. For this period starting from 27/11/2007 and ending on 29/07/2008 project uses HNO_3 concentration data provided by the laboratory measurements.

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:

$$Xo=Xn=X$$

where:

Xn: X new
Xo: X 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:

$$Yn=An + (Bn/Bo)*(Yo-Ao)$$

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 “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

Based on the real conditions measured and applied by the AMS for normalization (TSG in °C and PSG in hPa), the stack gas volume flow values are converted to real conditions before the regression analysis using the ideal gas law. The actual gas volume flow rates are derived from gas velocity measurements, therefore, before applying the regression analysis the gas speed is calculated from the volume flow and the duct cross-section and is fed into the calibrating equation. The calibrated values derived from the calibrating equation then converted back to normalized units using the calibrated real conditions (calibrated TSG and PSG). The normalized calibrated stack gas flow rates are further fed into the emission calculation model for further 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 mgN_2O/m_3. The concentration was converted to ppmv to make it compatible with the regression Lines parameters. The nitrous gas concentration values are then calibrated using the provided regression Lines parameters and are input in the model.

6.4 Stack gas Temperature

The stack gas temperature was calibrated by the regression conversion formula

6.5 Stack gas Pressure

The calibration report provides us with a regression Line for the stack gas pressure. We calibrate the readings of the measurements system using the regression formula and applying the values (in kPa).

7. EMISSION REDUCTION CALCULATIONS

Table T 2 illustrates the establishment of historic campaign length based on 5 previous campaigns. Average production in 5 campaigns preceding the baseline campaign was 65 461 $tHNO_3$ and time duration was on average 261 days. Table contains also information on suppliers of primary catalysts for the line 1.

T 2 Historic campaigns

Line	ACHEMA UKL-1	Production	Start	End	Days	Production per day	Primary Catalyst	Composition
Historic Campaigns	**1** t HNO3	61 581	29 Jul 2004	26 Apr 2005	271	227	Johnson Matthey	N/A *
	2 t HNO3	-	29 Apr 2005	24 Oct 2005	178	-	Heraeus	N/A *
	3 t HNO3	58 648	24 Oct 2005	20 Sep 2006	331	177	Johnson Matthey	N/A *
	4 t HNO3	65 266	21 Sep 2006	24 Jul 2007	306	213	Umicore	N/A *
	5 t HNO3	76 351	07 Aug 2007	13 Mar 2008	219	349	Johnson Matthey	N/A *
Average HNO3 production	t HNO3	**65 461**			**261**	**251**	* Confidential but available for the verification	
Project Campaigns	**BL** t HNO3	60 691	14 Mar 2008	21 Oct 2008	221	275	Johnson Matthey	N/A *
	PL t HNO3	109 676	13 Sep 2010	21 Aug 2011	343	320	Johnson Matthey	N/A *

The project campaign production value of 109 676 tHNO3 was higher than historic nitric acid production set at level of 65 461 tHNO3.

It is business as usual scenario in Achema UKL-7 plant to keep using primary catalysts from several suppliers and with several compositions. Selection of primary catalysts is determined by technical parameters of their use and price levels offered by suppliers in specific time. Primary catalysts used during the baseline campaign, if other than used in previous campaign/s, did not increase emissions of N2O as confirmed by relevant statements provided to the verifier.

T 3 and Chart C 1 define the length of the baseline campaign. Baseline campaign measurements for this project campaign started on 14/03/2008 and continued through 21/10/2008 when the 60 691 $tHNO_3$ nitric acid production was reached. The measurement of baseline Nitrous Acid Concentration (NCSG) was carried out until production reached - $tHNO_3$.

T 3 Baseline campaign length

ACHEMA UKL-1	Historic Campaings End	Start of Baseline Measurement	End of Baseline Measurement NCSG	End of Baseline Measurement	End of Baseline Campaign
Dates	2008 Mar 13	2008 Mar 14	2008 Oct 21	2008 Oct 21	2008 Oct 22
Baseline Factor kgN2O/tHNO3	-	-	9.63	9.63	9.63
Production tHNO3		-	60 691	60 691	-
Per Day Production tHNO3	250.8				
Baseline less Historic Production	**(4 770.2)**				
Baseline less Historic Days	**(19.0)**				

C 1 Baseline campaign length

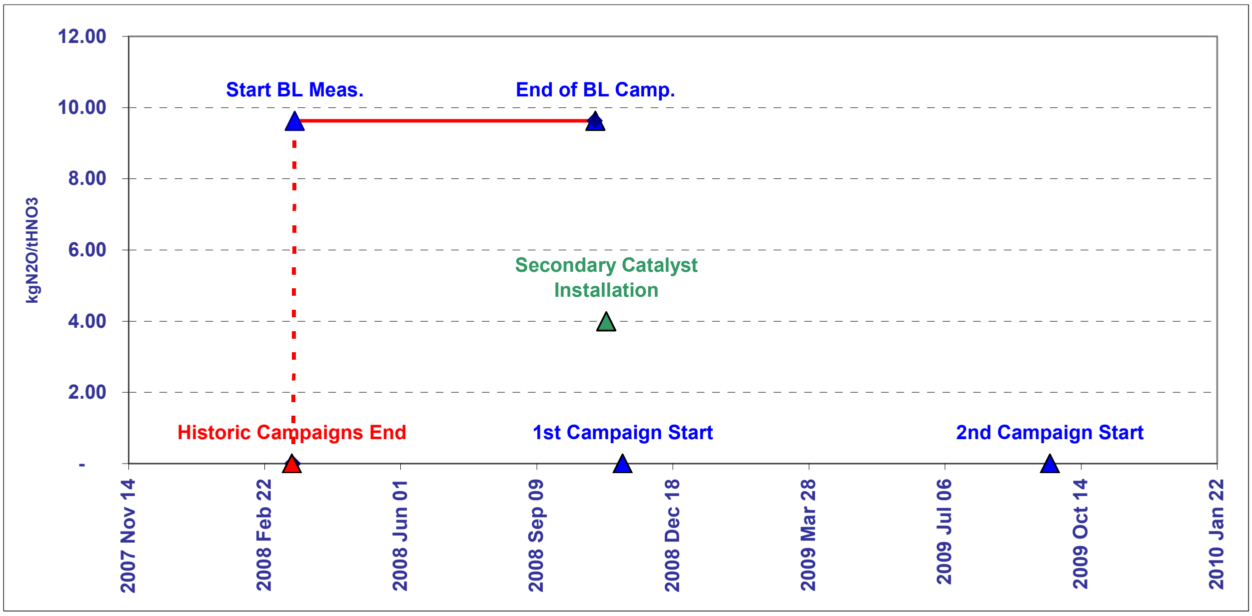


Table T 4 illustrates the calculation of the baseline emission factor on Line 1 using the method as defined in the CDM methodology AM0034 and in the PDD. We have not used overlapping approach allowed by the PDD. Baseline emission factor was determined based on raw data measured from 14/03/2008 through 21/10/2008.

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 N_2O 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 N_2O 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 620 tN_2O.

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

The UNC factor defined by the QAL2 report is 5.670%, which is further modified by an uncertainty of 0.089% due to under-sampling. As a result we have arrived to the baseline emission factor of 9.63 $kgN_2O/tHNO_3$.

Table T 5 shows the calculation of the project emission factor on Line 1 during the project campaign. Project campaign started on 13/09/2010 and went through 21/08/2011.

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

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

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

$$PE_n = VSG * NCSG * 10\text{-}9 * OH\ (tN2O)$$

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 350 tHNO3/day) we have determined the project campaign specific emission factor at value of 1.77 kgN2O/tHNO3.

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

Because the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this 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	AMS in Operation	Nitric Acid Production NCSG
Code	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP		NAP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa	h	t/h
Elimination of extreme values										
Lower limit		0	0	0	0	0	- 50	0		0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000		50
Raw Data Measured Range										
Count	**4 933**	4 999	4 989	4 921	5 054	5 028	5 275	5 275	4 483	4 999
as % of Dataset	*93%*	*94%*	*94%*	*93%*	*95%*	*95%*	*99%*	*99%*	*85%*	*94%*
Minimum		-	0	80	1 246	-	0	0		-
Maximum		15.28	2 401	82 164	6 281	17.17	902	605		15
Mean		12.14	1 806	67 547	5 825	10.28	857	554		12
Standard Deviation		3.42	261	11 066	194	1.04	162	46		3
Total		60 691								60 691
N2O Emissions (VSG * NCSG * OH)	602	t N2O								
Emission Factor	9.35	kgN2O / tHNO3								
Permitted Range										
Minimum					4 500	0	880	0		
Maximum					7 500	11.70	910	800		
Data within the permitted range										
Count	**4 926**		4 627	4 627					4 483	
as % of Operating Hours	***100%***		*94%*	*94%*					*91%*	
Minimum			219	3 822						
Maximum			2 401	227 671						
Mean			1 752	69 348						
Standard Deviation			318	3 984						
N2O Emissions (VSG * NCSG * OH)	599	t N2O								
Emission Factor	9.32	kgN2O / tHNO3								
Data within the confidence interval										
95% Confidence interval										
Lower bound			1 130	61 538						
Upper bound			2 375	77 158						
Count			4 353	4 610						
as % of Operating Hours			*88%*	*93%*						
Minimum			1 320	65 098						
Maximum			2 374	73 692						
Mean			1 808	69 474						
Standard Deviation			218	1 214						
N2O Emissions (VSG * NCSG * OH)	**620**	**t N2O**								
Emission Factor (EF_BL)	**9.63**	**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	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa
Elimination of extreme values								
Lower limit		0	0	0	0	0	- 50	0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000
Raw Data Measured Range								
Count	**5 461**	7 859	7 298	7 318	8 232	7 461	8 204	8 186
as % of Dataset	*66%*	*95%*	*89%*	*89%*	*100%*	*91%*	*100%*	*99%*
Minimum		0.69	2	55 734	-	3	(0)	0
Maximum		17.36	649	90 166	8 000	19.69	919	693
Mean		13.96	395	73 424	5 396	10.44	811	555
Standard Deviation		3.20	60	3 758	1 542	0.55	255	144
Total		109 676						
N2O Emissions (VSG * NCSG * OH)	159	t N2O						
Emission Factor	1.45	kgN2O / tHNO3						
Data within the confidence interval								
95% Confidence interval								
Lower bound			277	66 057				
Upper bound			514	80 790				
Count			4 590	4 903				
as % of Operating Hours			*84%*	*90%*				
Minimum			278	66 062				
Maximum			514	80 784				
Mean			397	72 603				
Standard Deviation			52	3 305				
N2O Emissions (VSG * NCSG * OH)	**157**	**t N2O**						
Actual Project Emission Factor (EF_PActual)	**1.43**	**kgN2O / tHNO3**						
Abatement Ratio	**85.1%**							
Moving Average Emission Factor Correction	**Actual Factors**	**Moving Average Rule**						
1	2.10	2.10						
2	1.43	1.77						
3	-							
4	-							
5	-							
Project Emission Factor (EF_P)	**1.77**	**kgN2O / tHNO3**						
Abatement Ratio	**81.7%**							

MONITORING REPORT

PROJECT: ACHEMA UKL nitric acid plant N_2O abatement project
LINE: Line 2
MONITORING PERIOD:
FROM: 13/05/2011

TO: 08/12/2011

Prepared by:

VERTIS

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Table of Contents

1. EXECUTIVE SUMMARY

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

The first project campaign on Line 2 started on 30/05/2008. Secondary catalyst was installed on 07/11/2008. Total quantity of emission reductions generated during the fifth project period from 13/05/2011 through 08/12/2011 on Line 2 is **150 047 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	9.51	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	1.75	kgN2O/tHNO3
Nitric Acid Produced in the Baseline Campaign	NAP_BL	60 767	tHNO3
Nitric Acid Produced in the NCSG Baseline Campaign	NAP_BL_NCSG	60 767	tHNO3
Nitric Acid Produced in the Project Campaign	NAP_P	62 374	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**150 047**	**tCOe**
*ER=(EF_BL-EF_P)*NAP_P*GWP/1000*			
Abatement Ratio		**84.6%**	

EMISSION REDUCTION PER YEAR			
Year	2009	2010	2011
Date From			13 May 2011
Date To			08 Dec 2011
Nitric Acid Production			62 374
Emission Reduction			**150 047**
*ER_YR = ER * NAP_P_YR / NAP_P*			

Baseline emission factor established for the Line 2 during baseline measurement carried from 09/11/2007 through 20/05/2008 is 9.51 $kgN_2O/tHNO_3$.

Project emission factor during the fifth project campaign after installation of secondary catalysts on Line 2, which started on 13/05/2011 and went through 08/12/2011 with secondary catalyst installed and commissioned on 07/11/2008, is 1.75 $kgN_2O/tHNO_3$.

During the project campaign 62 374 tonnes of nitric acid was produced.

2. DESCRIPTION OF THE PROJECT ACTIVITY

Purpose of the Project (the “Project”) is the reduction of nitrous oxide (N_2O) emissions from nitric acid production Lines at the UKL-7 nitric acid plant of AB Achema (“Achema” or “the Company”). The Company is situated in Jonava, Lithuania.

Achema has installed and operates secondary N_2O reduction catalysts underneath the primary catalyst precious metal catching and catalytic gauzes package in the ammonium burners of the UKL-7 nitric acid plant.

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 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 requirements 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 the Line-specific basis. Campaign used for baseline measurements on the line 2 has been carried out from 09/11/2007 through 20/05/2008.

N_2O concentration and gas volume flow are monitored by monitoring system complying with requirements of the European Norm 14181.

Monitoring system provides separate readings for N_2O 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 N_2O 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 N_2O concentration of stack gas (NCSG))

The average mass of N_2O emissions per hour is estimated as product of the NCSG and VSG. The N_2O emissions per campaign are estimates product of N_2O 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 N_2O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N_2O 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 N_2O emission factor per tonne of nitric acid produced in the baseline period (EFBL) 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

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from the Line 2 tail gas duct at sampling point located after expansion turbine and transported by sample Line to the Monitoring room A, where the analyzer is located.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis.

N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production lines. N_2O concentration is measured by 3 concentration meters on a switched basis.

N_2O concentration measured data are sent from the analyzer on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

3.1.2 Tail gas flow rate, pressure and temperature

Tail gas flow, pressure and temperature is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section. Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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 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 5 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 N_2O concentration have been measured on the 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 N_2O 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

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

where:

Variable	**Definition**
VSG	Mean stack gas volume flow rate for the project campaign (m^3/h)
NCSG	Mean concentration of N_2O in the stack gas for the project campaign (mgN_2O/m^3)
PE_n	Total N_2O emissions of the n^{th} project campaign (tN_2O)
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 the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this campaign.

4.2 Minimum project emission factor

The minimum average emission factor established factor will be established after 10th project campaign.

4.3 Project Campaign Length

Project campaign production of nitric acid has been below defined nameplate capacity and thus all NAP produced from date of installation of secondary catalysts has been used for calculation of emission reductions.

Because the nitric acid production during the project was higher than the baseline, all of the baseline NCSG values were used to determine the baseline emission factor.

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 N_2O:

$$ER = (EFBL - EFP) * NAP * GWPN_2O \ (tCO_2e)$$

Where:

Variable	**Definition**
ER	Emission reductions of the project for the specific campaign (tCO_2e)
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 ($tN_2O/tHNO_3$)
EFP	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of $EF_{ma,n}$ and EF_n)

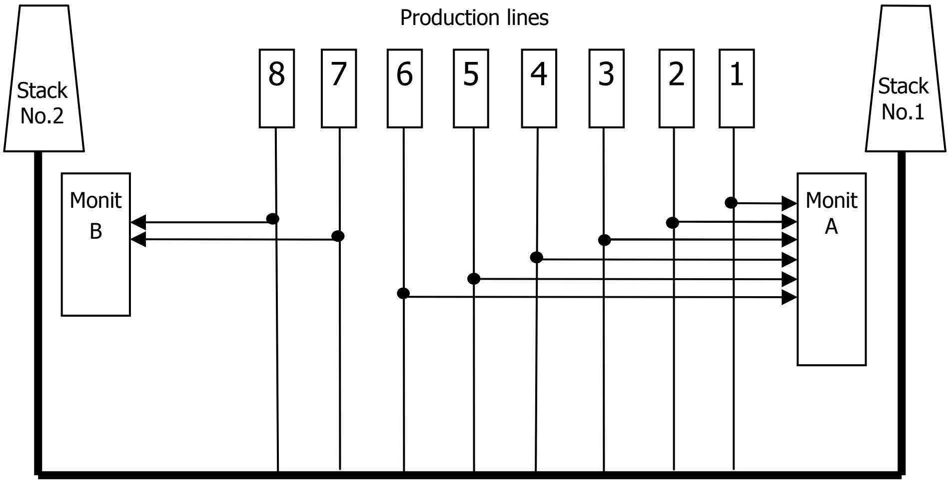
5. MONITORING PLAN

Purpose of the monitoring plan

The purpose of the monitoring plan is to describe the system used to monitor emissions of N_2O from the plant in such a way that is compliant with the prescriptions of the AM0034/Version 02.

Plant description

The UKL-7 nitric acid plant comprises 8 production Lines numbered from 1 through 8, each with its own burner, absorption column and expansion turbine. Each production Line represents a separate nitric acid production unit independent from each other. The tail gasses from each Line are after expansion turbines led to a common stack bus and vented through two interconnected stacks.



Primary catalyst is changed at different times thus it is necessary to measure the emissions from each Line individually. This means that eight separate sets of monitoring equipment are installed to measure tail gas flow, nitric acid production, nitric acid concentration, and the operating conditions. N_2O concentration in the tail gas is measured by 3 switched concentration meters.

Monitoring System architecture

Methodology AM0034/Version 02 requires installation of an N_2O monitoring system that includes both a gas volume flow meter to determine the tail gas mass volume flow and an infrared gas analyser to determine the concentration of N_2O.

But tail gas N_2O concentration meter and tail gas volume flow meter alone are not sufficient for a JI project purposes. In order of being able to calculate the baseline emission factor expressed as tonnage of N_2O in t CO_2e per 1 tonne of HNO_3 (100%), it is necessary to include also HNO_3 measurement, and in order of being able to document normal operating conditions it is necessary to include also operating conditions measurement.

Because of this we use the term Monitoring System (MS) to describe entire monitoring system directly and indirectly used for the JI purposes, while Automated Measurement System (AMS) covers only N_2O emissions and tail gas mass volume part of the MS.

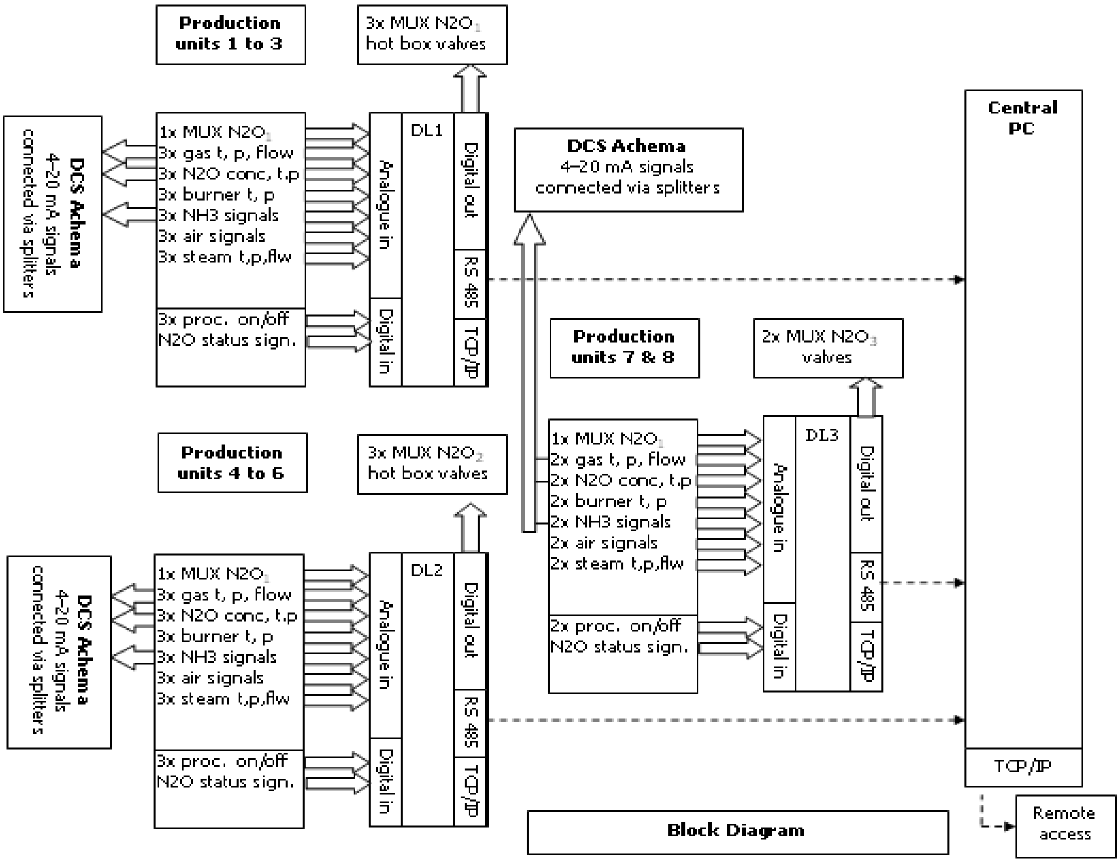
Monitoring System (MS) for purpose of this monitoring plan means:

monitoring system measuring operational conditions;
Ammonia volume flow
Ammonia temperature
Ammonia pressure
Primary air volume flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

nitric acid 100% concentrate production;
Nitric acid concentration
Nitric acid flow
Nitric acid temperature

and newly installed measurement devices for measurement of N2O concentration and tail gas flow, temperature and pressure (AMS)
N_2O concentration in the stack
Stack volume flow rate
Stack gas temperature
Stack gas pressure

Incorporation of the AMS into the MS by interfacing already existing and newly installed measurement devices is documented by the diagram below.



N_2O automated measurement system

Main purpose of the N_2O automated measurement system (AMS) is to measure total mass of N_2O emitted during particular campaigns (both baseline and project). In order of calculation of total mass of N_2O emitted during particular campaign it is necessary to measure on an extractive basis the N_2O concentration in a tail gas and on a non-extractive basis tail gas flow, pressure and temperature.

N_2O concentration

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from respective tail gas ducts at sampling points located after expansion turbines and transported by heated sample lines to the Monitoring room A located next to the main production hall. This applies to 2 concentration meters measuring lines 1-3 and lines 4-6. lines 7-8 are measured by third concentration meter located at the other side of the production hall (Monitoring room B) physically closer to respective production lines 7 and 8.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis. Correction of dry basis ppmV value to real wet tail

gas conditions based on steam flow injected into the system is part of both - the project emissions calculations and baseline emission factor calculations.

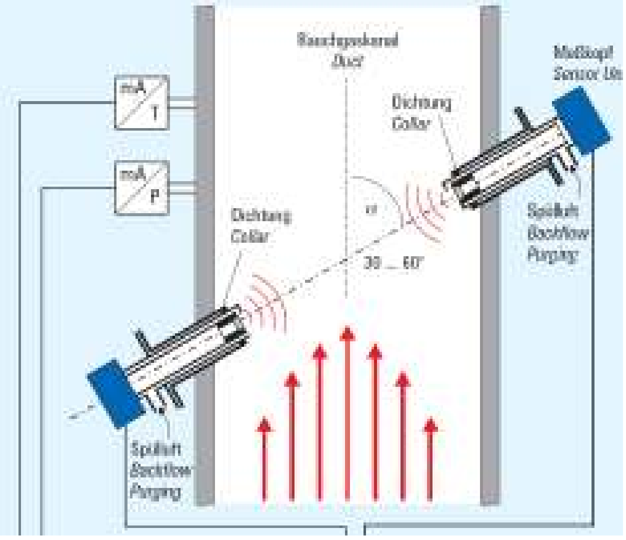
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production Lines. N_2O concentration is measured by 3 concentration meters on a switched basis. Tail gas samples are automatically switched. Under-sampling uncertainty is part of both - the project emissions calculations and baseline emission factor calculations.

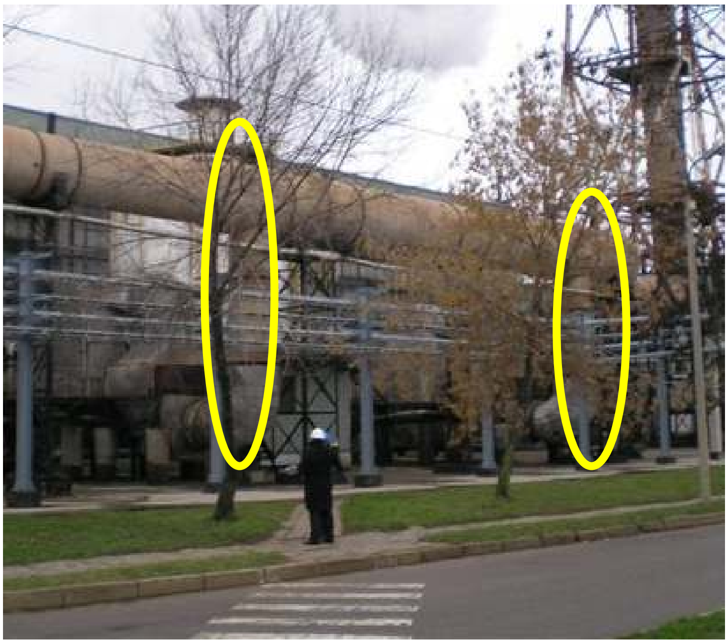
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas flow, pressure and temperature

Tail gas flow is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section.



The tail gas ducts do not allow any optimum location to perform the flow monitoring. The only possible location is the quite short vertical tube behind the 90° “knee”.



Since the flow is not really laminar, a classical Pitot tube one point solution wouldn't allow good results. The ultrasonic system is under these conditions superior to differential pressure. Cross duct monitoring is more accurate than a couple of discrete point averaged pressure.

Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas steam injection elimination

Steam injected into the Achema UKL-7 tail gas for purpose of increasing the turbine output is eliminated from the tail gas mass flow calculation by following formulae:

flow - STVF= Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325)*((100-Humi)/100)

where Humi (water content)=

(Flow_steam*1.2436)/(Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325))*100+0.6

where 1.2436 is the conversion factor from kg/h to Nm3/h and 0.6% is a value of humidity present in a flue gas permanently without steam injection

The Flow_steam parameter necessary for calculation of the water content in the dataloggers is provided in the kg/h unit.

Achema measures steam flow in kg/h using formula Q=C*sqrt(dp) , where C is flow constant which is already integrated using an orifice plate sizing program. The orifice plate calculation for injection steam has been done for temperature 250˚C and pressure 6 bar.

Flow steam in kg/h measured by using the constant steam T and P values is then recalculated to actual steam T and P values valid for relevant hours and as result the STVF value cleaned of the steam injected is used for further emission reductions calculations.

EN14181 compliance

As required by the AM0034/Version 02 methodology the N_2O automated measurement system (AMS) complies with requirements of the technical norm EN14181. N_2O AMS consists from the N_2O concentration meter and integrated flowmeter (F, T, P). Both measurement devices are QAL1 certified (concentration meter for the N_2O measurand specifically) and after full commissioning of the monitoring system there was the QAL2 test carried out by an independent laboratory certified according to ISO17025.

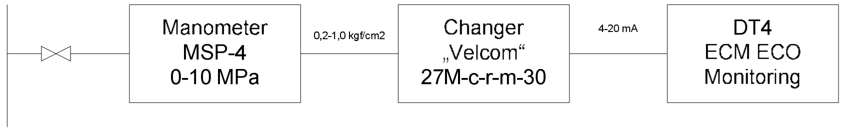
Operating conditions

For purpose of the baseline emissions factor setting it is necessary to monitor and report operating conditions in all 8 burners. Namely:

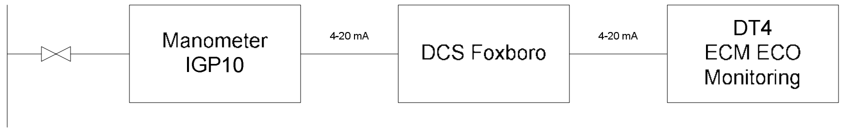
Ammonia flow
Ammonia temperature
Ammonia pressure
Primary air flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

All these parameters are measured by the plant monitoring system as presented on diagrams below:

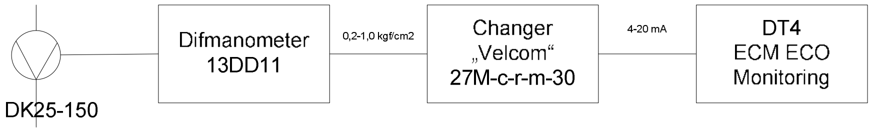
P in mixer 1-6 line



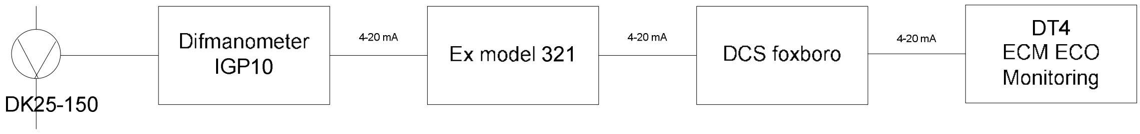
P in mixer 7-8 line



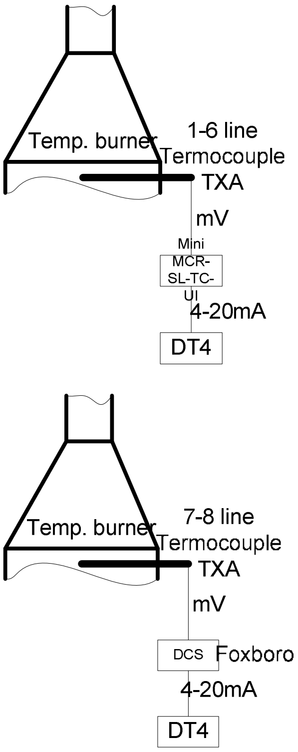
NH3 to mixer 1-6 line



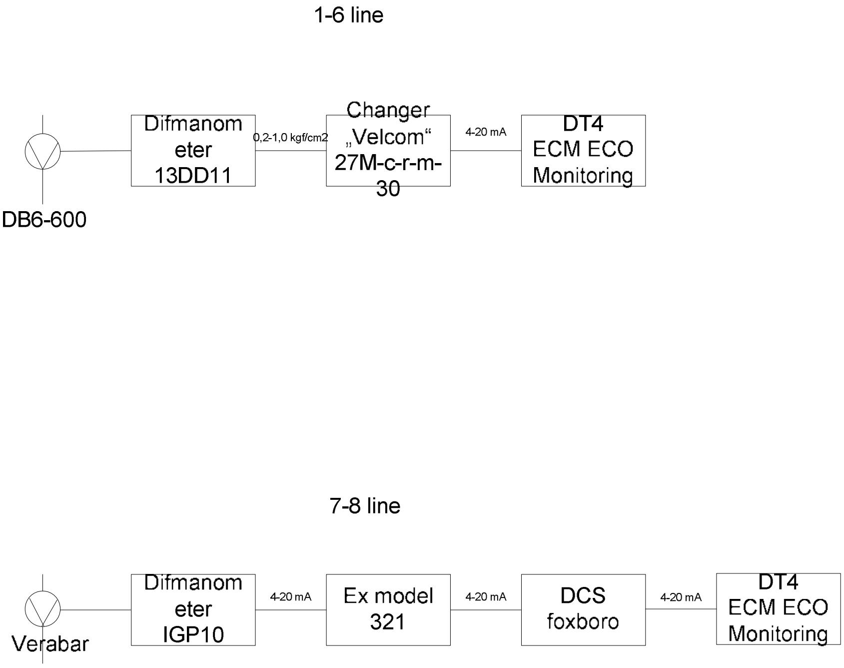
NH3 to mixer 7-8 line



T in burner



Air to mixer



Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further. Maintenance procedures for the ammonia oxidation parameters follow the existing procedures for the operation of the nitric acid plant.

Nitric acid production

Nitric acid concentration is based on two components: nitric acid and water. Standard monitoring method is on-Line refractometry. Measurement of nitric acid (100%) mass volume production per campaign is necessary for calculation of the baseline emissions factor. Nitric acid concentration on all 8 Lines is measured by K-Patents PR-23-GP refractometers.

This analyzer is applying a prism to “return” a generated optical beam back to an LCD detector.

The detector is measuring refraction of monitored liquid based on known refraction of water and nitric acid. The instrument is calibrated for percent concentration of nitric acid. The analyzer is mounted on DIN-flange 2656, PN25 DN80. The optical prism does not require cleaning.

PR-23-GP characteristics:

Measuring RI is a direct concentration measurement principle. No need to rely or convert magnitudes.
Digital instrument – no calibration drift
As it is a robust instrument it is maintenance free
Dual connectivity if the installation positions allow.
On-Line data logging, through Ethernet, on whichever web browser.
No influence by bubbles or particles. It is very common that air enters the process pipeline and still the refractometer measures accurately.

Nitric acid concentration data are in an analog 4-20mA format provided to dataloggers which process these signals further.

In order of being able to calculate total mass volume of nitric acid 100% concentrate produced during the baseline campaign it is necessary to monitor also nitric acid flow and temperature. Measurement of pressure is not necessary for determination of the nitric acid mass volume flow, because nitric acid is in form of liquid and as such it has stabile pressure characteristic.

Signals obtained from the nitric acid flow and temperature measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Nitric acid flow and temperature measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further.

After installation of refractometers there have been occurrences of their failure and following repair service by the manufacturer. For this period starting from 08/11/2007 and ending on 29/07/2008 project uses HNO_3 concentration data provided by the laboratory measurements.

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:

$$Xo=Xn=X$$

where:

Xn: X new
Xo: X 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:

$$Yn=An + (Bn/Bo)*(Yo-Ao)$$

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 “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

Based on the real conditions measured and applied by the AMS for normalization (TSG in °C and PSG in hPa), the stack gas volume flow values are converted to real conditions before the regression analysis using the ideal gas law. The actual gas volume flow rates are derived from gas velocity measurements, therefore, before applying the regression analysis the gas speed is calculated from the volume flow and the duct cross-section and is fed into the calibrating equation. The calibrated values derived from the calibrating equation then converted back to normalized units using the calibrated real conditions (calibrated TSG and PSG). The normalized calibrated stack gas flow rates are further fed into the emission calculation model for further 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 mgN_2O/m_3. The concentration was converted to ppmv to make it compatible with the regression Lines parameters. The nitrous gas concentration values are then calibrated using the provided regression Lines parameters and are input in the model.

6.4 Stack gas Temperature

The stack gas temperature was calibrated by the regression conversion formula

6.5 Stack gas Pressure

The calibration report provides us with a regression Line for the stack gas pressure. We calibrate the readings of the measurements system using the regression formula and applying the values (in kPa).

7. EMISSION REDUCTION CALCULATIONS

Table T 2 illustrates the establishment of historic campaign length based on 5 previous campaigns. Average production in 5 campaigns preceding the baseline campaign was 62 710 $tHNO_3$ and time duration was on average 239 days. Table contains also information on suppliers of primary catalysts for the line 2.

T 2 Historic campaigns

Line	ACHEMA UKL-2	Production	Start	End	Days	Production per day	Primary Catalyst	Composition
Historic Campaigns	**1** t HNO3	63 318	07 Jun 2004	26 Jan 2005	233	272	Heraeus	N/A *
	2 t HNO3	65 490	27 Jan 2005	21 Sep 2005	237	276	Umicore	N/A *
	3 t HNO3	51 101	22 Sep 2005	10 Apr 2006	200	256	Heraeus	N/A *
	4 t HNO3	63 008	11 Apr 2006	24 Jan 2007	288	219	Heraeus	N/A *
	5 t HNO3	70 635	14 Mar 2007	08 Nov 2007	239	296	Johnson Matthey	N/A *
Average HNO3 production	t HNO3	**62 710**			**239**	**262**	* Confidential but available for the verification	
Project Campaigns	**BL** t HNO3	60 767	09 Nov 2007	20 May 2008	193	315	Johnson Matthey	N/A *
	PL t HNO3	62 374	13 May 2011	08 Dec 2011	209	298	Johnson Matthey	N/A *

The project campaign production value of 62 374 tHNO3 was lower than historic nitric acid production set at level of 62 710 tHNO3.

It is business as usual scenario in Achema UKL-7 plant to keep using primary catalysts from several suppliers and with several compositions. Selection of primary catalysts is determined by technical parameters of their use and price levels offered by suppliers in specific time. Primary catalysts used during the baseline campaign, if other than used in previous campaign/s, did not increase emissions of N2O as confirmed by relevant statements provided to the verifier.

T 3 and Chart C 1 define the length of the baseline campaign. Baseline campaign measurements for this project campaign started on 09/11/2007 and continued through 20/05/2008 when the 60 767 $tHNO_3$ nitric acid production was reached. The measurement of baseline Nitrous Acid Concentration (NCSG) was carried out until production reached - $tHNO_3$.

T 3 Baseline campaign length

ACHEMA UKL-2	Historic Campaings End	Start of Baseline Measurement	End of Baseline Measurement NCSG	End of Baseline Measurement	End of Baseline Campaign
Dates	2007 Nov 08	2007 Nov 09	2008 May 20	2008 May 20	2008 May 21
Baseline Factor kgN2O/tHNO3	-	-	9.51	9.51	9.51
Production tHNO3		-	60 767	60 767	-
Per Day Production tHNO3	261.9				
Baseline less Historic Production	**(1 943.4)**				
Baseline less Historic Days	**(7.4)**				

C 1 Baseline campaign length

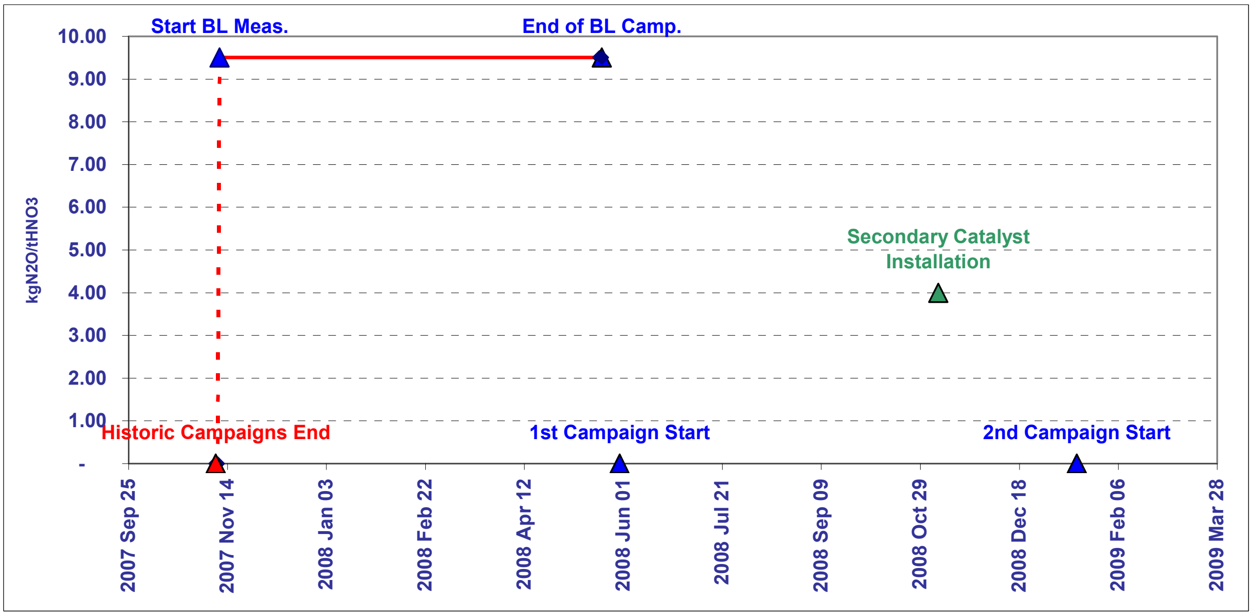


Table T 4 illustrates the calculation of the baseline emission factor on Line 2 using the method as defined in the CDM methodology AM0034 and in the PDD. We have not used overlapping approach allowed by the PDD. Baseline emission factor was determined based on raw data measured from 09/11/2007 through 20/05/2008.

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 N_2O 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 N_2O 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 618 tN_2O.

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

The UNC factor defined by the QAL2 report is 6.460%, which is further modified by an uncertainty of 0.087% due to under-sampling. As a result we have arrived to the baseline emission factor of 9.51 $kgN_2O/tHNO_3$.

Table T 5 shows the calculation of the project emission factor on Line 2 during the project campaign. Project campaign started on 13/05/2011 and went through 08/12/2011.

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

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

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

$$PE_n = VSG * NCSG * 10\text{-}9 * OH\ (tN2O)$$

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 350 tHNO3/day) we have determined the project campaign specific emission factor at value of 1.75 kgN2O/tHNO3.

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

Because the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this campaign.

T 4 Baseline emission factor

BASELINE EMISSION FACTOR										
Parameter *Code* *Unit*	Operating Hours OH h	Nitric Acid Production NAP t/h	N2O Concentration NCSG mg N2O/Nm3	Gas Volume Flow VSG Nm3/h	Ammonia Flow Rate AFR Nm3/h	Ammonia to Air Ratio AIFR %	Oxidation Temperature OT °C	Oxidation Pressure OP kPa	AMS in Operation h	Nitric Acid Production NCSG NAP t/h
Elimination of extreme values										
Lower limit		0	0	0	0	0	- 50	0		0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000		50
Raw Data Measured Range										
Count	**4 254**	4 633	4 353	4 216	4 296	4 277	4 606	4 576	3 828	4 633
as % of Dataset	*92%*	*100%*	*94%*	*91%*	*93%*	*92%*	*99%*	*99%*	*83%*	*100%*
Minimum		-	0	140	2 069	-	42	5		-
Maximum		15.73	2 356	106 649	6 243	18.13	1 100	679		16
Mean		13.12	1 576	83 679	5 815	9.78	843	604		13
Standard Deviation		3.81	323	18 036	263	1.67	207	45		4
Total		60 767								60 767
N2O Emissions (VSG * NCSG * OH)	561	t N2O								
Emission Factor	8.64	kgN2O / tHNO3								
Permitted Range										
Minimum					4 500	0	880	0		
Maximum					7 500	11.70	910	800		
Data within the permitted range										
Count	**3 710**		3 710	3 710					3 828	
as % of Operating Hours	***87%***		*87%*	*87%*					*90%*	
Minimum			465	10 197						
Maximum			2 356	105 388						
Mean			1 588	85 591						
Standard Deviation			293	14 825						
N2O Emissions (VSG * NCSG * OH)	578	t N2O								
Emission Factor	8.90	kgN2O / tHNO3								
Data within the confidence interval										
95% Confidence interval										
Lower bound			1 014	56 534						
Upper bound			2 162	114 648						
Count			3 430	3 604						
as % of Operating Hours			*81%*	*85%*						
Minimum			1 118	77 416						
Maximum			2 156	105 388						
Mean			1 654	87 784						
Standard Deviation			173	7 591						
N2O Emissions (VSG * NCSG * OH)	**618**	**t N2O**								
Emission Factor (EF_BL)	**9.51**	**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	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa
Elimination of extreme values								
Lower limit		0	0	0	0	0	- 50	0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000
Raw Data Measured Range								
Count	**4 231**	4 814	4 177	4 151	4 898	4 523	4 985	4 985
as % of Dataset	*84%*	*96%*	*83%*	*83%*	*98%*	*90%*	*99%*	*99%*
Minimum		3.34	140	55 634	277	6	20	2
Maximum		18.07	598	86 741	6 619	15.39	1 100	673
Mean		12.96	298	72 870	5 283	10.85	767	578
Standard Deviation		3.37	53	2 239	1 663	0.49	299	116
Total		62 374						
N2O Emissions (VSG * NCSG * OH)	92	t N2O						
Emission Factor	1.47	kgN2O / tHNO3						
Data within the confidence interval								
95% Confidence interval								
Lower bound			195	68 481				
Upper bound			401	77 259				
Count			3 677	3 946				
as % of Operating Hours			*87%*	*93%*				
Minimum			195	68 508				
Maximum			401	77 255				
Mean			297	72 776				
Standard Deviation			45	2 006				
N2O Emissions (VSG * NCSG * OH)	**92**	**t N2O**						
Actual Project Emission Factor (EF_PActual)	**1.47**	**kgN2O / tHNO3**						
Abatement Ratio	**84.6%**							

Moving Average Emission Factor Correction	Actual Factors	Moving Average Rule
1	1.80	1.80
2	1.84	1.84
3	1.99	1.99
4	1.67	1.83
5	1.47	1.75

Project Emission Factor (EF_P)	**1.75**	**kgN2O / tHNO3**
Abatement Ratio	**81.5%**	

MONITORING REPORT

PROJECT: ACHEMA UKL nitric acid plant N_2O abatement project
LINE: Line 3
MONITORING PERIOD:
FROM: 19/11/2010

TO: 25/08/2011

Prepared by:

VERTIS FINANCE

www.vertisfinance.com

Table of Contents

1. EXECUTIVE SUMMARY

This monitoring report determines baseline emission factor for the Line 3 of ACHEMA UKLnitric acid plant and quantity of emission reduction generated during the fourth project campaign on Line 3.

The first campaign on Line 3 started on 27/08/2008. Secondary catalyst was installed on 04/07/2008. Total quantity of emission reductions generated during the fourth project period from 19/11/2010 through 25/08/2011 on Line 3 is **69 520 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	5.46	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	2.76	kgN2O/tHNO3
Nitric Acid Produced in the Baseline Campaign	NAP_BL	59 042	tHNO3
Nitric Acid Produced in the NCSG Baseline Campaign	NAP_BL_NCSG	59 042	tHNO3
Nitric Acid Produced in the Project Campaign	NAP_P	83 058	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**69 520**	**tCOe**
*ER=(EF_BL-EF_P)*NAP_P*GWP/1000*			
Abatement Ratio		**53.6%**	

EMISSION REDUCTION PER YEAR			
Year	2009	2010	2011
Date From		19 Nov 2010	01 Jan 2011
Date To		31 Dec 2010	25 Aug 2011
Nitric Acid Production		12 366	70 693
Emission Reduction		**10 350**	**59 170**
*ER_YR = ER * NAP_P_YR / NAP_P*			

Baseline emission factor established for the Line 3 during baseline measurement carried using overlapping approach from 01/02/2008 to 04/07/2008 and from 01/09/2007 through 03/11/2007 is 5.46 $kgN_2O/tHNO_3$.

Project emission factor during fourth project campaign after installation of secondary catalysts on Line 3, which started on 19/11/2010 and went through 25/08/2011 with secondary catalyst installed and commissioned on 04/07/2008, is 2.76 $kgN_2O/tHNO_3$.

During the project campaign 83 058 tonnes of nitric acid was produced.

2. DESCRIPTION OF THE PROJECT ACTIVITY

Purpose of the Project (the “Project”) is the reduction of nitrous oxide (N_2O) emissions from nitric acid production Lines at the UKL-7 nitric acid plant of AB Achema (“Achema” or “the Company”). The Company is situated in Jonava, Lithuania.

Achema has installed and operates secondary N_2O reduction catalysts underneath the primary catalyst precious metal catching and catalytic gauzes package in the ammonium burners of the UKL-7 nitric acid plant.

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 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 requirements 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 the Line-specific basis. Campaign used for baseline measurements on the line 3 has been carried out using overlapping approach from 01/02/2008 to 04/07/2008 and from 01/09/2007 through 03/11/2007.

N_2O concentration and gas volume flow are monitored by monitoring system complying with requirements of the European Norm 14181.

Monitoring system provides separate readings for N_2O 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 N_2O 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 N_2O concentration of stack gas (NCSG))

The average mass of N_2O emissions per hour is estimated as product of the NCSG and VSG. The N_2O emissions per campaign are estimates product of N_2O 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 N_2O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N_2O 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 N_2O emission factor per tonne of nitric acid produced in the baseline period (EFBL) 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

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from the Line 3 tail gas duct at sampling point located after expansion turbine and transported by sample Line to the Monitoring room B, where the analyzer is located.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis.

N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production lines. N_2O concentration is measured by 3 concentration meters on a switched basis.

N_2O concentration measured data are sent from the analyzer on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

3.1.2 Tail gas flow rate, pressure and temperature

Tail gas flow, pressure and temperature is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section. Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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 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 5 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 N_2O concentration have been measured on the 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 N_2O 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

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

where:

Variable	**Definition**
VSG	Mean stack gas volume flow rate for the project campaign (m^3/h)
NCSG	Mean concentration of N_2O in the stack gas for the project campaign (mgN_2O/m^3)
PE_n	Total N_2O emissions of the n^{th} project campaign (tN_2O)
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 the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this campaign.

4.2 Minimum project emission factor

Because this campaign was fourth 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 below defined nameplate capacity and thus all NAP produced from date of installation of secondary catalysts has been used for calculation of emission reductions.

Because the nitric acid production during the project was higher than the baseline, all of the baseline NCSG values were used to determine the baseline emission factor.

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 N_2O:

$$ER = (EFBL – EFP) * NAP * GWPN_2O \ (tCO_2e)$$

Where:

Variable	**Definition**
ER	Emission reductions of the project for the specific campaign (tCO_2e)
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 ($tN_2O/tHNO_3$)
EFP	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of $EF_{ma,n}$ and EF_n)

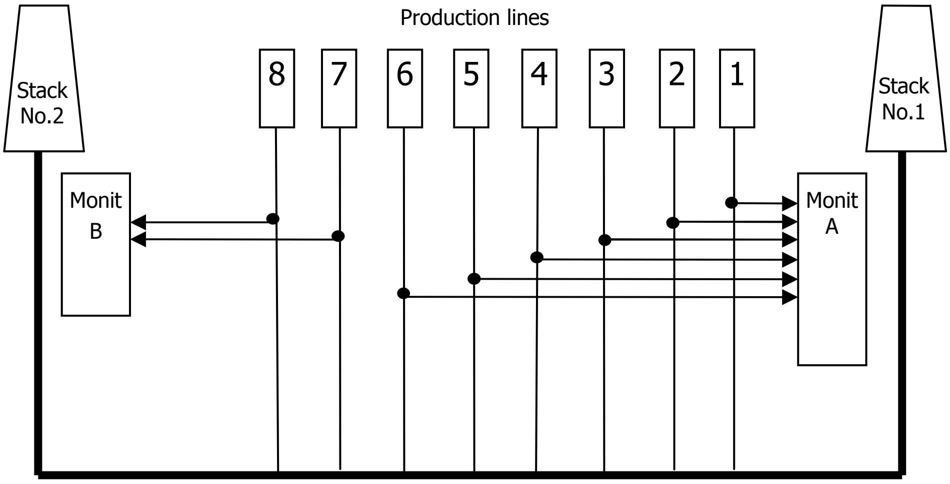
5. MONITORING PLAN

Purpose of the monitoring plan

The purpose of the monitoring plan is to describe the system used to monitor emissions of N_2O from the plant in such a way that is compliant with the prescriptions of the AM0034/Version 02.

Plant description

The UKL-7 nitric acid plant comprises 8 production Lines numbered from 1 through 8, each with its own burner, absorption column and expansion turbine. Each production Line represents a separate nitric acid production unit independent from each other. The tail gasses from each Line are after expansion turbines led to a common stack bus and vented through two interconnected stacks.



Primary catalyst is changed at different times thus it is necessary to measure the emissions from each Line individually. This means that eight separate sets of monitoring equipment are installed to measure tail gas flow, nitric acid production, nitric acid concentration, and the operating conditions. N_2O concentration in the tail gas is measured by 3 switched concentration meters.

Monitoring System architecture

Methodology AM0034/Version 02 requires installation of an N_2O monitoring system that includes both a gas volume flow meter to determine the tail gas mass volume flow and an infrared gas analyser to determine the concentration of N_2O.

But tail gas N_2O concentration meter and tail gas volume flow meter alone are not sufficient for a JI project purposes. In order of being able to calculate the baseline emission factor expressed as tonnage of N_2O in t CO_2e per 1 tonne of HNO_3 (100%), it is necessary to include also HNO_3 measurement, and in order of being able to document normal operating conditions it is necessary to include also operating conditions measurement.

Because of this we use the term Monitoring System (MS) to describe entire monitoring system directly and indirectly used for the JI purposes, while Automated Measurement System (AMS) covers only N_2O emissions and tail gas mass volume part of the MS.

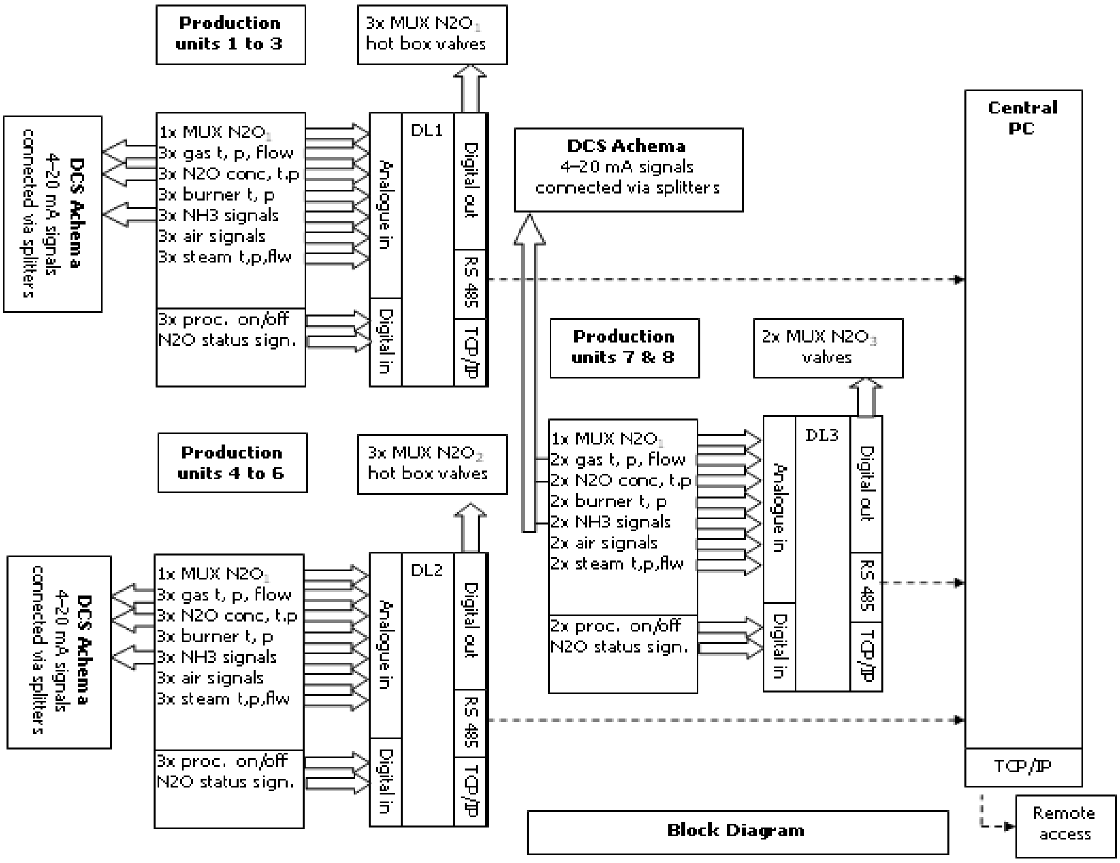
Monitoring System (MS) for purpose of this monitoring plan means:

monitoring system measuring operational conditions;
Ammonia volume flow
Ammonia temperature
Ammonia pressure
Primary air volume flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

nitric acid 100% concentrate production;
Nitric acid concentration
Nitric acid flow
Nitric acid temperature

and newly installed measurement devices for measurement of N2O concentration and tail gas flow, temperature and pressure (AMS)
N_2O concentration in the stack
Stack volume flow rate
Stack gas temperature
Stack gas pressure

Incorporation of the AMS into the MS by interfacing already existing and newly installed measurement devices is documented by the diagram below.



N_2O automated measurement system

Main purpose of the N_2O automated measurement system (AMS) is to measure total mass of N_2O emitted during particular campaigns (both baseline and project). In order of calculation of total mass of N_2O emitted during particular campaign it is necessary to measure on an extractive basis the N_2O concentration in a tail gas and on a non-extractive basis tail gas flow, pressure and temperature.

N_2O concentration

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from respective tail gas ducts at sampling points located after expansion turbines and transported by heated sample lines to the Monitoring room A located next to the main production hall. This applies to 2 concentration meters measuring lines 1-3 and lines 4-6. lines 7-8 are measured by third concentration meter located at the other side of the production hall (Monitoring room B) physically closer to respective production lines 7 and 8.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis. Correction of dry basis ppmV value to real wet tail

gas conditions based on steam flow injected into the system is part of both - the project emissions calculations and baseline emission factor calculations.

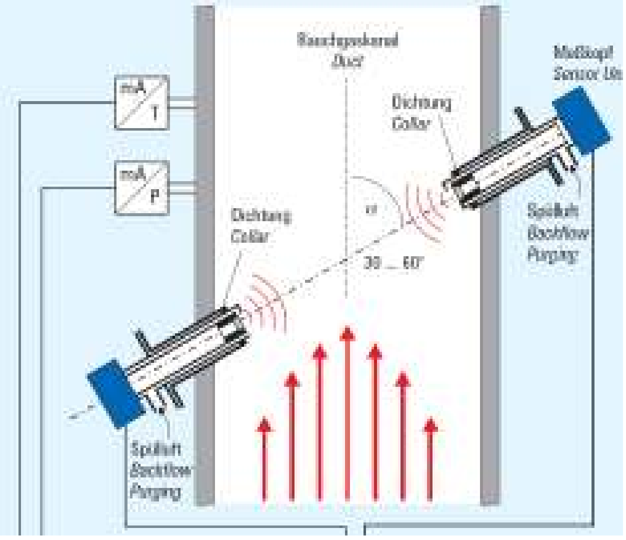
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production Lines. N_2O concentration is measured by 3 concentration meters on a switched basis. Tail gas samples are automatically switched. Under-sampling uncertainty is part of both - the project emissions calculations and baseline emission factor calculations.

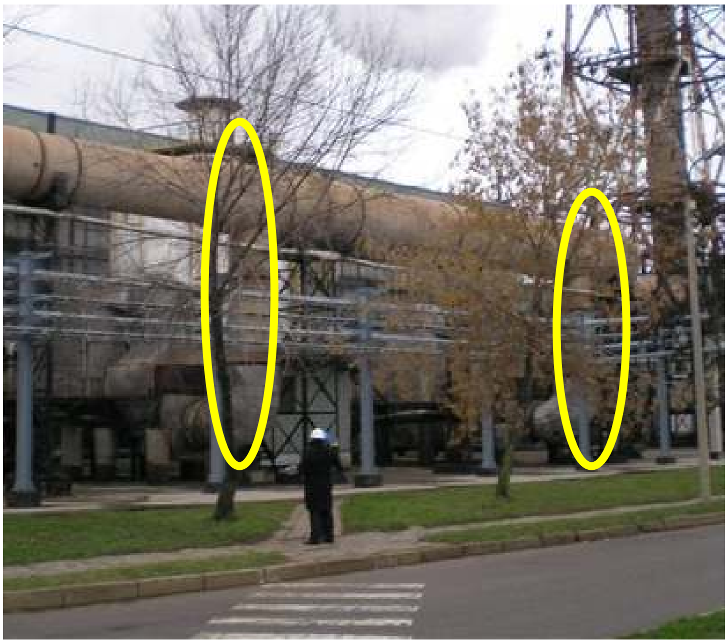
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas flow, pressure and temperature

Tail gas flow is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section.



The tail gas ducts do not allow any optimum location to perform the flow monitoring. The only possible location is the quite short vertical tube behind the 90° “knee”.



Since the flow is not really laminar, a classical Pitot tube one point solution wouldn't allow good results. The ultrasonic system is under these conditions superior to differential pressure. Cross duct monitoring is more accurate than a couple of discrete point averaged pressure.

Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas steam injection elimination

Steam injected into the Achema UKL-7 tail gas for purpose of increasing the turbine output is eliminated from the tail gas mass flow calculation by following formulae:

flow - STVF=Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325)*((100-Humi)/100)

where Humi (water content)=

(Flow_steam*1.2436)/(Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325))*100+0.6

where 1.2436 is the conversion factor from kg/h to Nm3/h and 0.6% is a value of humidity present in a flue gas permanently without steam injection

The Flow_steam parameter necessary for calculation of the water content in the dataloggers is provided in the kg/h unit.

Achema measures steam flow in kg/h using formula Q=C*sqrt(dp) , where C is flow constant which is already integrated using an orifice plate sizing program. The orifice plate calculation for injection steam has been done for temperature 250˚C and pressure 6 bar.

Flow steam in kg/h measured by using the constant steam T and P values is then recalculated to actual steam T and P values valid for relevant hours and as result the STVF value cleaned of the steam injected is used for further emission reductions calculations.

EN14181 compliance

As required by the AM0034/Version 02 methodology the N_2O automated measurement system (AMS) complies with requirements of the technical norm EN14181. N_2O AMS consists from the N_2O concentration meter and integrated flowmeter (F, T, P). Both measurement devices are QAL1 certified (concentration meter for the N_2O measurand specifically) and after full commissioning of the monitoring system there was the QAL2 test carried out by an independent laboratory certified according to ISO17025.

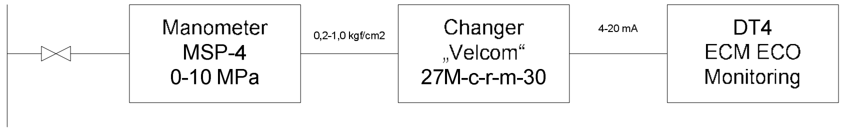
Operating conditions

For purpose of the baseline emissions factor setting it is necessary to monitor and report operating conditions in all 8 burners. Namely:

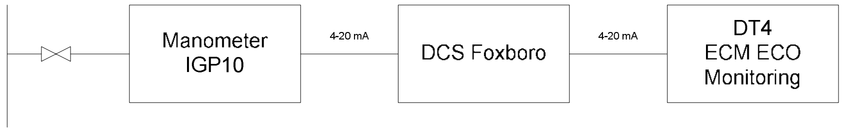
Ammonia flow
Ammonia temperature
Ammonia pressure
Primary air flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

All these parameters are measured by the plant monitoring system as presented on diagrams below:

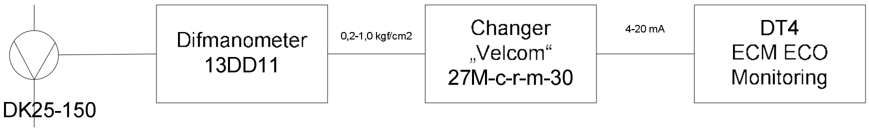
P in mixer 1-6 line



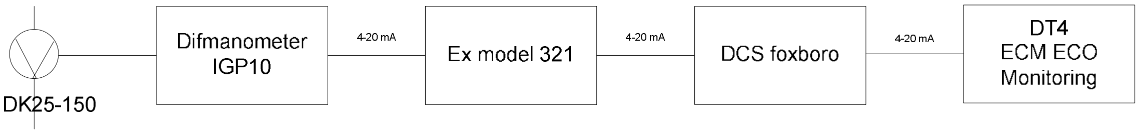
P in mixer 7-8 line



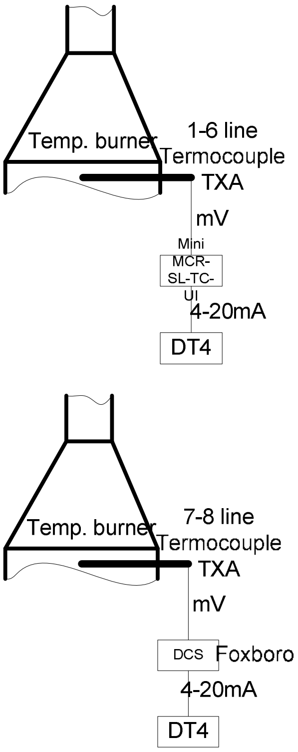
NH3 to mixer 1-6 line



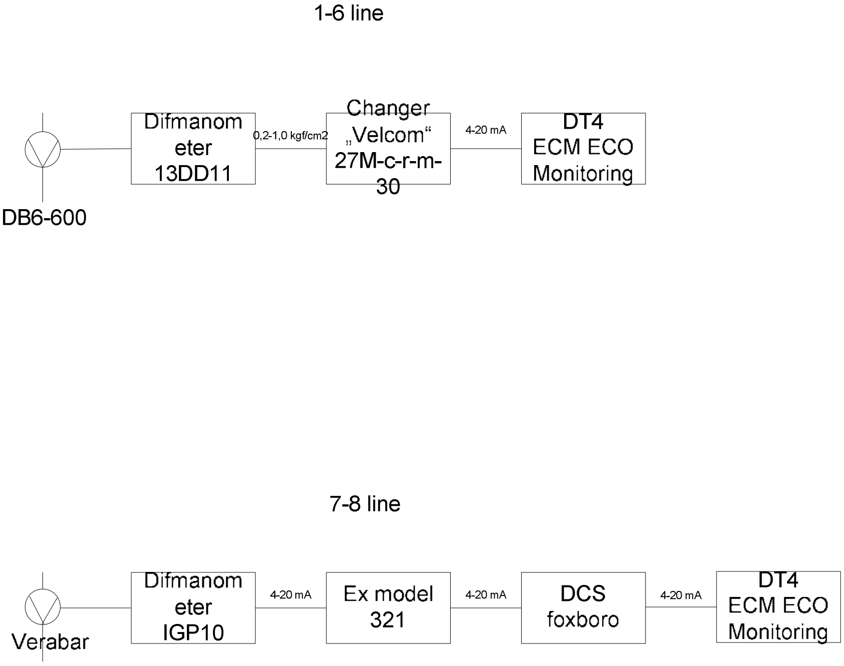
NH3 to mixer 7-8 line



T in burner



Air to mixer



Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further. Maintenance procedures for the ammonia oxidation parameters follow the existing procedures for the operation of the nitric acid plant.

Nitric acid production

Nitric acid concentration is based on two components: nitric acid and water. Standard monitoring method is on-Line refractometry. Measurement of nitric acid (100%) mass volume production per campaign is necessary for calculation of the baseline emissions factor. Nitric acid concentration on all 8 Lines is measured by K-Patents PR-23-GP refractometers.

This analyzer is applying a prism to “return” a generated optical beam back to an LCD detector.

The detector is measuring refraction of monitored liquid based on known refraction of water and nitric acid. The instrument is calibrated for percent concentration of nitric acid. The analyzer is mounted on DIN-flange 2656, PN25 DN80. The optical prism does not require cleaning.

PR-23-GP characteristics:

Measuring RI is a direct concentration measurement principle. No need to rely or convert magnitudes.
Digital instrument – no calibration drift
As it is a robust instrument it is maintenance free
Dual connectivity if the installation positions allow.
On-Line data logging, through Ethernet, on whichever web browser.
No influence by bubbles or particles. It is very common that air enters the process pipeline and still the refractometer measures accurately.

Nitric acid concentration data are in an analog 4-20mA format provided to dataloggers which process these signals further.

In order of being able to calculate total mass volume of nitric acid 100% concentrate produced during the baseline campaign it is necessary to monitor also nitric acid flow and temperature. Measurement of pressure is not necessary for determination of the nitric acid mass volume flow, because nitric acid is in form of liquid and as such it has stabile pressure characteristic.

Signals obtained from the nitric acid flow and temperature measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Nitric acid flow and temperature measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further.

After installation of refractometers there have been occurrences of their failure and following repair service by the manufacturer. For this period starting from 09/11/2007 and ending on 30/07/2008 project uses HNO3 concentration data provided by the laboratory measurements.

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:

Xn: X new
Xo: X 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:

$$Yn=An + (Bn/Bo)*(Yo-Ao)$$

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 “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

Based on the real conditions measured and applied by the AMS for normalization (TSG in °C and PSG in hPa), the stack gas volume flow values are converted to real conditions before the regression analysis using the ideal gas law. The actual gas volume flow rates are derived from gas velocity measurements, therefore, before applying the regression analysis the gas speed is calculated from the volume flow and the duct cross-section and is fed into the calibrating equation. The calibrated values derived from the calibrating equation then converted back to normalized units using the calibrated real conditions (calibrated TSG and PSG). The normalized calibrated stack gas flow rates are further fed into the emission calculation model for further 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 mgN_2O/m_3. The concentration was converted to ppmv to make it compatible with the regression Lines parameters. The nitrous gas concentration values are then calibrated using the provided regression Lines parameters and are input in the model.

6.4 Stack gas Temperature

The stack gas temperature was calibrated by the regression conversion formula

6.5 Stack gas Pressure

The calibration report provides us with a regression Line for the stack gas pressure. We calibrate the readings of the measurements system using the regression formula and applying the values (in kPa).

7. EMISSION REDUCTION CALCULATIONS

Table T 2 illustrates the establishment of historic campaign length based on 5 previous campaigns. Average production in 5 campaigns preceding the baseline campaign was 59 680 $tHNO_3$ and time duration was on average 316 days. Table contains also information on suppliers of primary catalysts for the line 3. As shown in the table, it is usual practice in Achema to use primary catalysts from various suppliers.

T 2 Historic campaigns

Line	ACHEMA UKL-3	Production	Start	End	Days	Production per day	Primary Catalyst	Composition
Historic Campaigns	**1** t HNO3	64 017	05 Feb 2004	09 Oct 2005	612	105	Heraeus	N/A *
	2 t HNO3	63 115	10 Oct 2005	28 Jun 2006	261	242	Heraeus	N/A *
	3 t HNO3	59 912	01 Jul 2005	24 Jan 2006	207	289	Heraeus	N/A *
	4 t HNO3	56 702	25 Jan 2006	23 Nov 2006	302	188	Heraeus	N/A *
	5 t HNO3	54 654	24 Dec 2006	09 Jul 2007	197	277	Heraeus	N/A *
Average HNO3 production	t HNO3	**59 680**			**316**	**189**	* Confidential but available for the verification	
Project Campaigns	**BL** t HNO3	59 042	01 Sep 2007	04 Jul 2008	308	192	Heraeus	N/A *
	PL t HNO3	83 058	19 Nov 2010	25 Aug 2011	280	297	Heraeus	N/A *

The project campaign production value of 83 058 tHNO3 was higher than historic nitric acid production set at level of 59 680 tHNO3.

It is business as usual scenario in Achema UKL-7 plant to keep using primary catalysts from several suppliers and with several compositions. Selection of primary catalysts is determined by technical parameters of their use and price levels offered by suppliers in specific time. Primary catalysts used during the baseline campaign, if other than used in previous campaign/s, did not increase emissions of N2O as confirmed by relevant statements provided to the verifier.

T 3 and Chart C 1 define the length of the baseline campaign. Baseline campaign measurements for this project campaign started using overlapping approach from 01/02/2008 to 04/07/2008 then from 01/09/2007 through 03/11/2007 when the 59 042 $tHNO_3$ nitric acid production was reached. The baseline measurement for N2O concentration (NCSG) was carried out until the production of 59 042 $tHNO_3$ was reached.

We have two campaigns available that we can use for the baseline. AMS was installed in the middle of the first campaign, whereas the secondary catalyst was installed in the middle of the consecutive second one. We use these two campaigns to construct the baseline campaign using the overlapping approach as set out by the PDD. To get a clear start, that is, the baseline series has to start with a primary catalyst change, we use the beginning of the second campaign as the basis, until the secondary catalyst installation is reached. If this baseline turns out to be shorter than the project line, we use data available from the first campaign from the AMS installation to overlap the two series, and get a comparable baseline. Since we use the earliest available data from the first campaign, where emissions are generally lower, this is a conservative approach and fully in line with the PDD.

T 3 Baseline campaign length

ACHEMA UKL-3	Historic Campaings End	Start of Baseline Measurement	End of Baseline Measurement NCSG	End of Baseline Measurement	End of Baseline Campaign
Dates	2007 Jul 09	2007 Sep 01	2008 Jul 04	2008 Jul 04	2008 Jul 05
Baseline Factor kgN2O/tHNO3	-	-	5.46	5.46	5.46
Production tHNO3		-	59 042	59 042	-
Per Day Production tHNO3	189.0				
Baseline less Historic Production	(637.7)				
Baseline less Historic Days	(3.4)				

C 1 Baseline campaign length

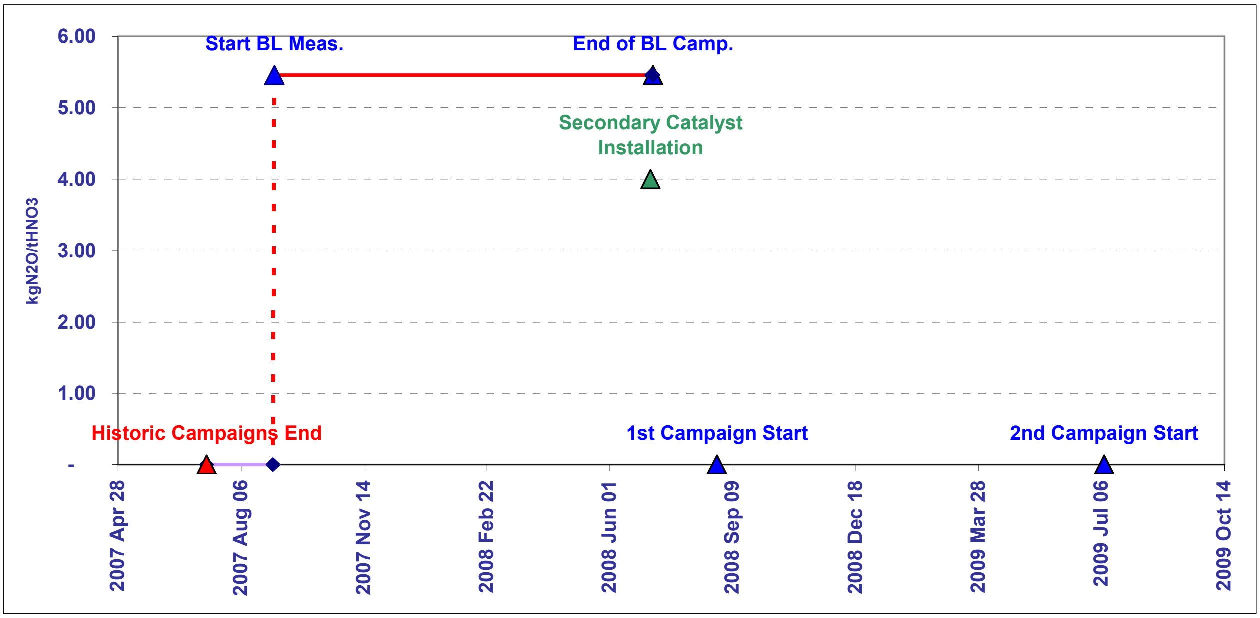


Table T 4 illustrates the calculation of the baseline emission factor on line 3 using the method as defined in the CDM methodology AM0034 and in the PDD.

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 N_2O 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 N_2O 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 342 tN_2O.

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

The UNC factor defined by the QAL2 report is 5.630%, which was further modified by an uncertainty of 0.090% due to under-sampling. As a result we have arrived to the baseline emission factor of 5.46 $kgN_2O/tHNO_3$.

Table T 5 shows the calculation of the project emission factor on Line 3 during the project campaign. Project campaign started on 19/11/2010 and went through 25/08/2011.

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

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

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

$PEn = VSG * NCSG * 10\text{-}9 * OH (tN_2O)$

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 350 tHNO3/day) we have determined the project campaign specific emission factor at value of 2.76 kgN2O/tHNO3.

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

Because the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this 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	AMS in Operation	Nitric Acid Production NCSG
Code	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP		NAP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa	h	t/h
Elimination of extreme values										
Lower limit		0	0	0	0	0	- 50	0		0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000		50
Raw Data Measured Range										
Count	**4 524**	5 074	4 743	4 623	5 148	4 843	5 235	5 232	4 155	5 074
as % of Dataset	*86%*	*97%*	*90%*	*88%*	*98%*	*92%*	*100%*	*100%*	*79%*	*97%*
Minimum		-	0	10	1	0	0	0		-
Maximum		16.63	1 864	90 517	6 221	19.99	906	626		17
Mean		11.64	1 104	67 849	4 974	10.52	794	545		12
Standard Deviation		5.03	291	11 542	1 802	1.62	258	118		5
Total		59 042								59 042
N2O Emissions (VSG * NCSG * OH)	339	t N2O								
Emission Factor	5.42	kgN2O / tHNO3								
Permitted Range										
Minimum					4 500	0	880	0		
Maximum					7 500	11.70	910	800		
Data within the permitted range										
Count	**4 087**		3 816	3 994					4 155	
as % of Operating Hours	***90%***		*84%*	*88%*					*92%*	
Minimum			381	-						
Maximum			1 864	77 232						
Mean			1 118	64 988						
Standard Deviation			147	14 287						
N2O Emissions (VSG * NCSG * OH)	329	t N2O								
Emission Factor	5.26	kgN2O / tHNO3								
Data within the confidence interval										
95% Confidence interval										
Lower bound			829	36 985						
Upper bound			1 407	92 991						
Count			3 659	3 816						
as % of Operating Hours			*81%*	*84%*						
Minimum			830	48 852						
Maximum			1 407	77 232						
Mean			1 110	68 019						
Standard Deviation			125	2 721						
N2O Emissions (VSG * NCSG * OH)	**342**	**t N2O**								
Emission Factor (EF_BL)	**5.46**	**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	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa
Elimination of extreme values								
Lower limit		0	0	0	0	0 -	50	0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000
Raw Data Measured Range								
Count	**6 245**	6 256	6 147	6 172	6 681	6 250	6 681	6 681
as % of Dataset	*93%*	*93%*	*92%*	*92%*	*100%*	*93%*	*100%*	*100%*
Minimum		1.30	200	317	141	5	1	5
Maximum		15.59	916	98 414	7 356	19.50	992	689
Mean		13.28	478	70 997	5 633	10.33	848	600
Standard Deviation		1.46	143	3 796	861	0.19	174	75
Total		83 058						
N2O Emissions (VSG * NCSG * OH)	212	t N2O						
Emission Factor	2.55	kgN2O / tHNO3						
Data within the confidence interval								
95% Confidence interval								
Lower bound			197	63 557				
Upper bound			758	78 437				
Count			6 029	5 940				
as % of Operating Hours			*97%*	*95%*				
Minimum			200	63 568				
Maximum			758	78 420				
Mean			477	70 691				
Standard Deviation			143	3 231				
N2O Emissions (VSG * NCSG * OH)	**210**	**t N2O**						
Actual Project Emission Factor (EF_PActual)	**2.53**	**kgN2O / tHNO3**						
Abatement Ratio	**53.6%**							

Moving Average Emission Factor Correction		Actual Factors	Moving Average Rule
	1	1.92	1.92
	2	3.01	3.01
	3	3.57	3.57
	4	2.53	2.76
	5	-	

Project Emission Factor (EF_P)	**2.76**	**kgN2O / tHNO3**
Abatement Ratio	**49.5%**	

MONITORING REPORT

PROJECT: **ACHEMA UKL nitric acid plant N_2O abatement project**
LINE: **Line 4**
MONITORING PERIOD:
FROM: **16/03/2011**

TO: **05/10/2011**

Prepared by:

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Table of Contents

1. EXECUTIVE SUMMARY

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

The first project campaign on Line 4 started on 01/08/2008. Secondary catalyst was installed on 06/10/2008. Total quantity of emission reductions generated during the fourth project period from 16/03/2011 through 05/10/2011 on Line 4 is **105 340 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	7.73	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	2.19	kgN2O/tHNO3
Nitric Acid Produced in the Baseline Campaign	NAP_BL	58 683	tHNO3
Nitric Acid Produced in the NCSG Baseline Campaign	NAP_BL_NCSG	58 683	tHNO3
Nitric Acid Produced in the Project Campaign	NAP_P	61 337	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**105 340**	**tCOe**
*ER=(EF_BL-EF_P)*NAP_P*GWP/1000*			
Abatement Ratio		**77.4%**	

EMISSION REDUCTION PER YEAR			
Year	2009	2010	2011
Date From			16 Mar 2011
Date To			05 Oct 2011
Nitric Acid Production			61 337
Emission Reduction			**105 340**
*ER_YR = ER * NAP_P_YR / NAP_P*			

Baseline emission factor established for the Line 4 during baseline measurement carried from 28/12/2007 through 31/07/2008 is 7.73 kgN_2O/tHNO_3.

Project emission factor during the fourth project campaign after installation of secondary catalysts on Line 4, which started on 16/03/2011 and went through 05/10/2011 with secondary catalyst installed and commissioned on 06/10/2008, is 2.19 kgN_2O/tHNO_3.

During the project campaign 61 337 tonnes of nitric acid was produced.

2. DESCRIPTION OF THE PROJECT ACTIVITY

Purpose of the Project (the “Project”) is the reduction of nitrous oxide (N_2O) emissions from nitric acid production Lines at the UKL-7 nitric acid plant of AB Achema (“Achema” or “the Company”). The Company is situated in Jonava, Lithuania.

Achema has installed and operates secondary N_2O reduction catalysts underneath the primary catalyst precious metal catching and catalytic gauzes package in the ammonium burners of the UKL-7 nitric acid plant.

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 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 requirements 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 the Line-specific basis. Campaign used for baseline measurements on the line 4 has been carried out from 28/12/2007 through 31/07/2008.

N_2O concentration and gas volume flow are monitored by monitoring system complying with requirements of the European Norm 14181.

Monitoring system provides separate readings for N_2O 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 N_2O 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 N_2O concentration of stack gas (NCSG))

The average mass of N_2O emissions per hour is estimated as product of the NCSG and VSG. The N_2O emissions per campaign are estimates product of N_2O 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 N_2O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N_2O 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 N_2O emission factor per tonne of nitric acid produced in the baseline period (EFBL) 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

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from the Line 4 tail gas duct at sampling point located after expansion turbine and transported by sample Line to the Monitoring room A, where the analyzer is located.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis.

N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production lines. N_2O concentration is measured by 3 concentration meters on a switched basis.

N_2O concentration measured data are sent from the analyzer on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

3.1.2 Tail gas flow rate, pressure and temperature

Tail gas flow, pressure and temperature is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section. Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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 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 5 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 N_2O concentration have been measured on the 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 N_2O 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

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

where:

Variable	**Definition**
VSG	Mean stack gas volume flow rate for the project campaign (m^3/h)
NCSG	Mean concentration of N_2O in the stack gas for the project campaign (mgN_2O/m^3)
PE_n	Total N_2O emissions of the n^{th} project campaign (tN_2O)
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 the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this campaign.

4.2 Minimum project emission factor

The minimum average emission factor established factor will be established after 10th project campaign.

4.3 Project Campaign Length

Project campaign production of nitric acid has been below defined nameplate capacity and thus all NAP produced from date of installation of secondary catalysts has been used for calculation of emission reductions.

Because the nitric acid production during the project was higher than the baseline, all of the baseline NCSG values were used to determine the baseline emission factor.

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 N_2O:

$$ER = (EFBL – EFP) * NAP * GWPN_2O \ (tCO_2e)$$

Where:

Variable	**Definition**
ER	Emission reductions of the project for the specific campaign (tCO_2e)
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 ($tN_2O/tHNO_3$)
EFP	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of $EF_{ma,n}$ and EF_n)

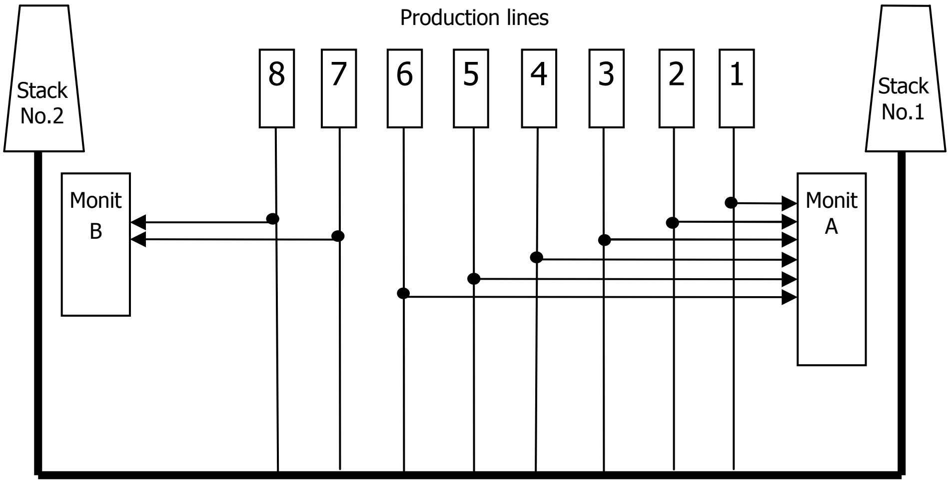
5. MONITORING PLAN

Purpose of the monitoring plan

The purpose of the monitoring plan is to describe the system used to monitor emissions of N_2O from the plant in such a way that is compliant with the prescriptions of the AM0034/Version 02.

Plant description

The UKL-7 nitric acid plant comprises 8 production Lines numbered from 1 through 8, each with its own burner, absorption column and expansion turbine. Each production Line represents a separate nitric acid production unit independent from each other. The tail gasses from each Line are after expansion turbines led to a common stack bus and vented through two interconnected stacks.



Primary catalyst is changed at different times thus it is necessary to measure the emissions from each Line individually. This means that eight separate sets of monitoring equipment are installed to measure tail gas flow, nitric acid production, nitric acid concentration, and the operating conditions. N_2O concentration in the tail gas is measured by 3 switched concentration meters.

Monitoring System architecture

Methodology AM0034/Version 02 requires installation of an N_2O monitoring system that includes both a gas volume flow meter to determine the tail gas mass volume flow and an infrared gas analyser to determine the concentration of N_2O.

But tail gas N_2O concentration meter and tail gas volume flow meter alone are not sufficient for a JI project purposes. In order of being able to calculate the baseline emission factor expressed as tonnage of N_2O in t CO_2e per 1 tonne of HNO_3 (100%), it is necessary to include also HNO_3 measurement, and in order of being able to document normal operating conditions it is necessary to include also operating conditions measurement.

Because of this we use the term Monitoring System (MS) to describe entire monitoring system directly and indirectly used for the JI purposes, while Automated Measurement System (AMS) covers only N_2O emissions and tail gas mass volume part of the MS.

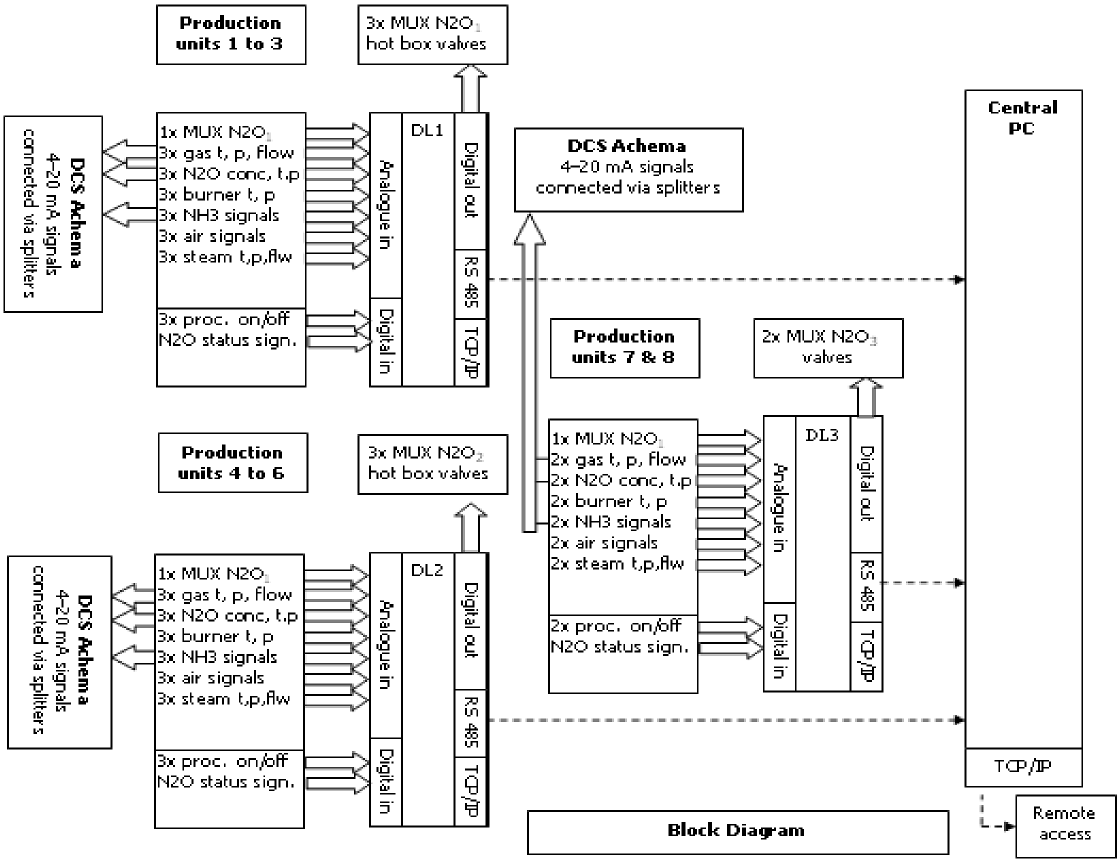
Monitoring System (MS) for purpose of this monitoring plan means:

monitoring system measuring operational conditions;
Ammonia volume flow
Ammonia temperature
Ammonia pressure
Primary air volume flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

nitric acid 100% concentrate production;
Nitric acid concentration
Nitric acid flow
Nitric acid temperature

and newly installed measurement devices for measurement of N2O concentration and tail gas flow, temperature and pressure (AMS)
N_2O concentration in the stack
Stack volume flow rate
Stack gas temperature
Stack gas pressure

Incorporation of the AMS into the MS by interfacing already existing and newly installed measurement devices is documented by the diagram below.



N_2O automated measurement system

Main purpose of the N_2O automated measurement system (AMS) is to measure total mass of N_2O emitted during particular campaigns (both baseline and project). In order of calculation of total mass of N_2O emitted during particular campaign it is necessary to measure on an extractive basis the N_2O concentration in a tail gas and on a non-extractive basis tail gas flow, pressure and temperature.

N_2O concentration

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from respective tail gas ducts at sampling points located after expansion turbines and transported by heated sample lines to the Monitoring room A located next to the main production hall. This applies to 2 concentration meters measuring lines 1-3 and lines 4-6. lines 7-8 are measured by third concentration meter located at the other side of the production hall (Monitoring room B) physically closer to respective production lines 7 and 8.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis. Correction of dry basis ppmV value to real wet tail

gas conditions based on steam flow injected into the system is part of both - the project emissions calculations and baseline emission factor calculations.

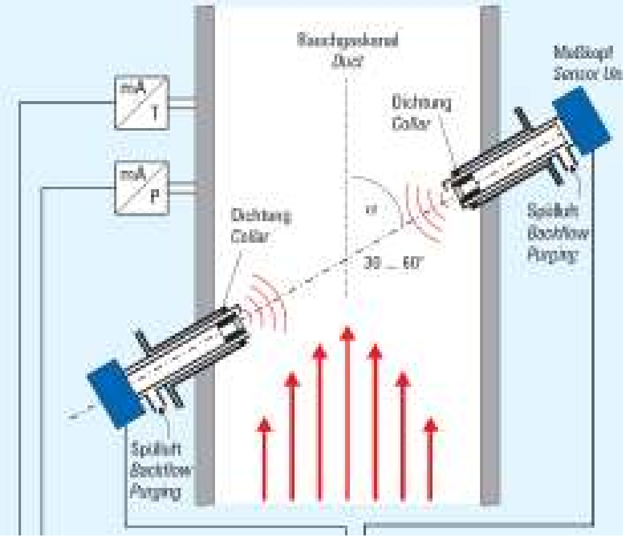
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production Lines. N_2O concentration is measured by 3 concentration meters on a switched basis. Tail gas samples are automatically switched. Under-sampling uncertainty is part of both - the project emissions calculations and baseline emission factor calculations.

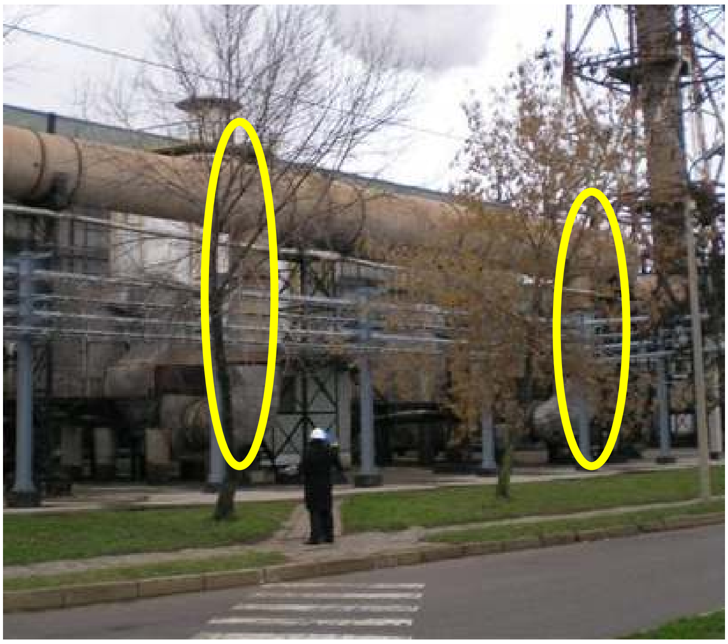
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas flow, pressure and temperature

Tail gas flow is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section.



The tail gas ducts do not allow any optimum location to perform the flow monitoring. The only possible location is the quite short vertical tube behind the 90° “knee”.



Since the flow is not really laminar, a classical Pitot tube one point solution wouldn't allow good results. The ultrasonic system is under these conditions superior to differential pressure. Cross duct monitoring is more accurate than a couple of discrete point averaged pressure.

Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas steam injection elimination

Steam injected into the Achema UKL-7 tail gas for purpose of increasing the turbine output is eliminated from the tail gas mass flow calculation by following formulae:

flow - STVF= Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325)*((100-Humi)/100)

where Humi (water content)=

(Flow_steam*1.2436)/(Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325))*100+0.6

where 1.2436 is the conversion factor from kg/h to Nm3/h and 0.6% is a value of humidity present in a flue gas permanently without steam injection

The Flow_steam parameter necessary for calculation of the water content in the dataloggers is provided in the kg/h unit.

Achema measures steam flow in kg/h using formula Q=C*sqrt(dp) , where C is flow constant which is already integrated using an orifice plate sizing program. The orifice plate calculation for injection steam has been done for temperature 250˚C and pressure 6 bar.

Flow steam in kg/h measured by using the constant steam T and P values is then recalculated to actual steam T and P values valid for relevant hours and as result the STVF value cleaned of the steam injected is used for further emission reductions calculations.

EN14181 compliance

As required by the AM0034/Version 02 methodology the N_2O automated measurement system (AMS) complies with requirements of the technical norm EN14181. N_2O AMS consists from the N_2O concentration meter and integrated flowmeter (F, T, P). Both measurement devices are QAL1 certified (concentration meter for the N_2O measurand specifically) and after full commissioning of the monitoring system there was the QAL2 test carried out by an independent laboratory certified according to ISO17025.

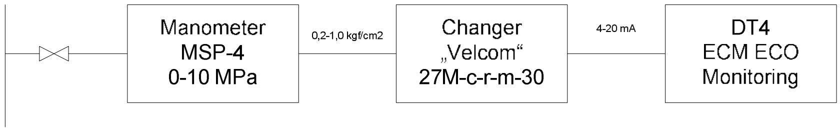
Operating conditions

For purpose of the baseline emissions factor setting it is necessary to monitor and report operating conditions in all 8 burners. Namely:

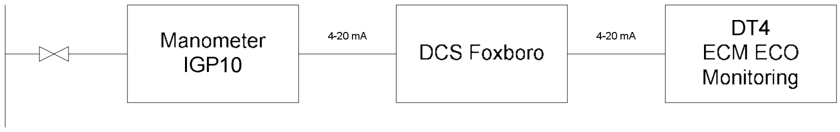
Ammonia flow
Ammonia temperature
Ammonia pressure
Primary air flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

All these parameters are measured by the plant monitoring system as presented on diagrams below:

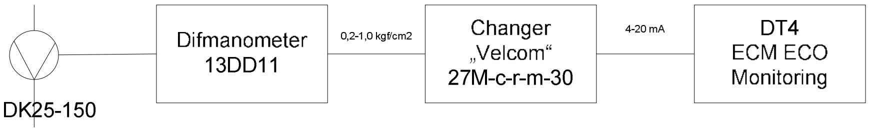
P in mixer 1-6 line



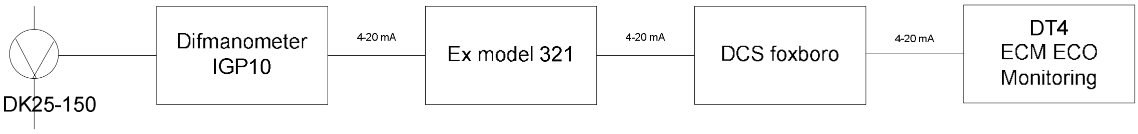
P in mixer 7-8 line



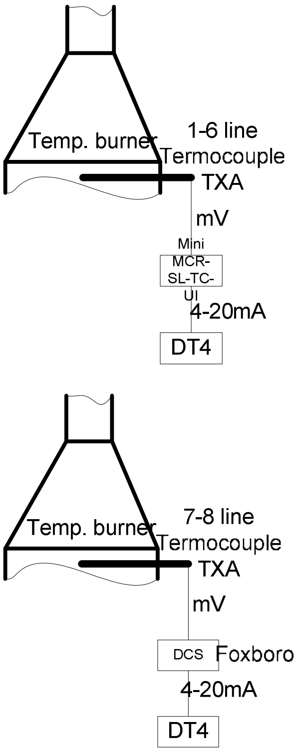
NH3 to mixer 1-6 line



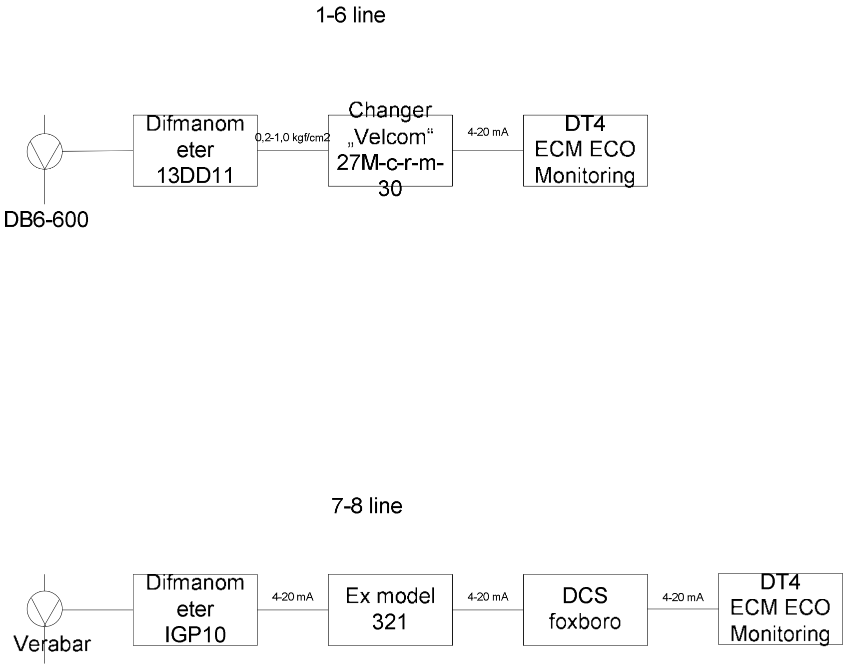
NH3 to mixer 7-8 line



T in burner



Air to mixer



Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further. Maintenance procedures for the ammonia oxidation parameters follow the existing procedures for the operation of the nitric acid plant.

Nitric acid production

Nitric acid concentration is based on two components: nitric acid and water. Standard monitoring method is on-Line refractometry. Measurement of nitric acid (100%) mass volume production per campaign is necessary for calculation of the baseline emissions factor. Nitric acid concentration on all 8 Lines is measured by K-Patents PR-23-GP refractometers.

This analyzer is applying a prism to “return” a generated optical beam back to an LCD detector.

The detector is measuring refraction of monitored liquid based on known refraction of water and nitric acid. The instrument is calibrated for percent concentration of nitric acid. The analyzer is mounted on DIN-flange 2656, PN25 DN80. The optical prism does not require cleaning.

PR-23-GP characteristics:

Measuring RI is a direct concentration measurement principle. No need to rely or convert magnitudes.
Digital instrument – no calibration drift
As it is a robust instrument it is maintenance free
Dual connectivity if the installation positions allow.
On-Line data logging, through Ethernet, on whichever web browser.
No influence by bubbles or particles. It is very common that air enters the process pipeline and still the refractometer measures accurately.

Nitric acid concentration data are in an analog 4-20mA format provided to dataloggers which process these signals further.

In order of being able to calculate total mass volume of nitric acid 100% concentrate produced during the baseline campaign it is necessary to monitor also nitric acid flow and temperature. Measurement of pressure is not necessary for determination of the nitric acid mass volume flow, because nitric acid is in form of liquid and as such it has stabile pressure characteristic.

Signals obtained from the nitric acid flow and temperature measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Nitric acid flow and temperature measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further.

After installation of refractometers there have been occurrences of their failure and following repair service by the manufacturer. For this period starting from 31/10/2007 and ending on 10/09/2008 project uses HNO_3 concentration data provided by the laboratory measurements.

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
X_o: X 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:

$$Yn=An + (Bn/Bo)*(Yo-Ao)$$

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 “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

Based on the real conditions measured and applied by the AMS for normalization (TSG in °C and PSG in hPa), the stack gas volume flow values are converted to real conditions before the regression analysis using the ideal gas law. The actual gas volume flow rates are derived from gas velocity measurements, therefore, before applying the regression analysis the gas speed is calculated from the volume flow and the duct cross-section and is fed into the calibrating equation. The calibrated values derived from the calibrating equation then converted back to normalized units using the calibrated real conditions (calibrated TSG and PSG). The normalized calibrated stack gas flow rates are further fed into the emission calculation model for further 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 mgN_2O/m_3. The concentration was converted to ppmv to make it compatible with the regression Lines parameters. The nitrous gas concentration values are then calibrated using the provided regression Lines parameters and are input in the model.

6.4 Stack gas Temperature

The stack gas temperature was calibrated by the regression conversion formula

6.5 Stack gas Pressure

The calibration report provides us with a regression Line for the stack gas pressure. We calibrate the readings of the measurements system using the regression formula and applying the values (in kPa).

7. EMISSION REDUCTION CALCULATIONS

Table T 2 illustrates the establishment of historic campaign length based on 5 previous campaigns. Average production in 5 campaigns preceding the baseline campaign was 65 823 $tHNO_3$ and time duration was on average 275 days. Table contains also information on suppliers of primary catalysts for the line 4.

T 2 Historic campaigns

Line	ACHEMA UKL-4	Production	Start	End	Days	Production per day	Primary Catalyst	Composition
Historic Campaigns	**1** t HNO3	69 782	18 Apr 2003	11 Dec 2003	237	294	Johnson Matthey	N/A *
	2 t HNO3	65 420	11 Dec 2003	06 Dec 2004	361	181	Johnson Matthey	N/A *
	3 t HNO3	66 129	07 Dec 2004	08 Nov 2005	336	197	Umicore	N/A *
	4 t HNO3	66 826	22 Mar 2006	23 Nov 2006	246	272	Johnson Matthey	N/A *
	5 t HNO3	60 959	23 Nov 2006	04 Jun 2007	193	316	Johnson Matthey	N/A *
Average HNO3 production	t HNO3	**65 823**			**275**	**240**	* Confidential but available for the verification	
Project Campaigns	**BL** t HNO3	58 683	28 Dec 2007	31 Jul 2008	216	272	Johnson Matthey	N/A *
	PL t HNO3	61 337	16 Mar 2011	05 Oct 2011	203	302	Johnson Matthey	N/A *

The project campaign production value of 61 337 tHNO3 was lower than historic nitric acid production set at level of 65 823 tHNO3.

It is business as usual scenario in Achema UKL-7 plant to keep using primary catalysts from several suppliers and with several compositions. Selection of primary catalysts is determined by technical parameters of their use and price levels offered by suppliers in specific time. Primary catalysts used during the baseline campaign, if other than used in previous campaign/s, did not increase emissions of N2O as confirmed by relevant statements provided to the verifier.

T 3 and Chart C 1 define the length of the baseline campaign. Baseline campaign measurements for this project campaign started on 28/12/2007 and continued through 31/07/2008 when the 58 683 $tHNO_3$ nitric acid production was reached. The measurement of baseline Nitrous Acid Concentration (NCSG) was carried out until production reached - $tHNO_3$.

T 3 Baseline campaign length

ACHEMA UKL-4	Historic Campaings End	Start of Baseline Measurement	End of Baseline Measurement NCSG	End of Baseline Measurement	End of Baseline Campaign
Dates	2007 Jun 04	2007 Dec 28	2008 Jul 31	2008 Jul 31	2008 Aug 01
Baseline Factor kgN2O/tHNO3	-	-	7.73	7.73	7.73
Production tHNO3		-	58 683	58 683	-
Per Day Production tHNO3	239.7				
Baseline less Historic Production	**(7 140.4)**				
Baseline less Historic Days	**(29.8)**				

C 1 Baseline campaign length

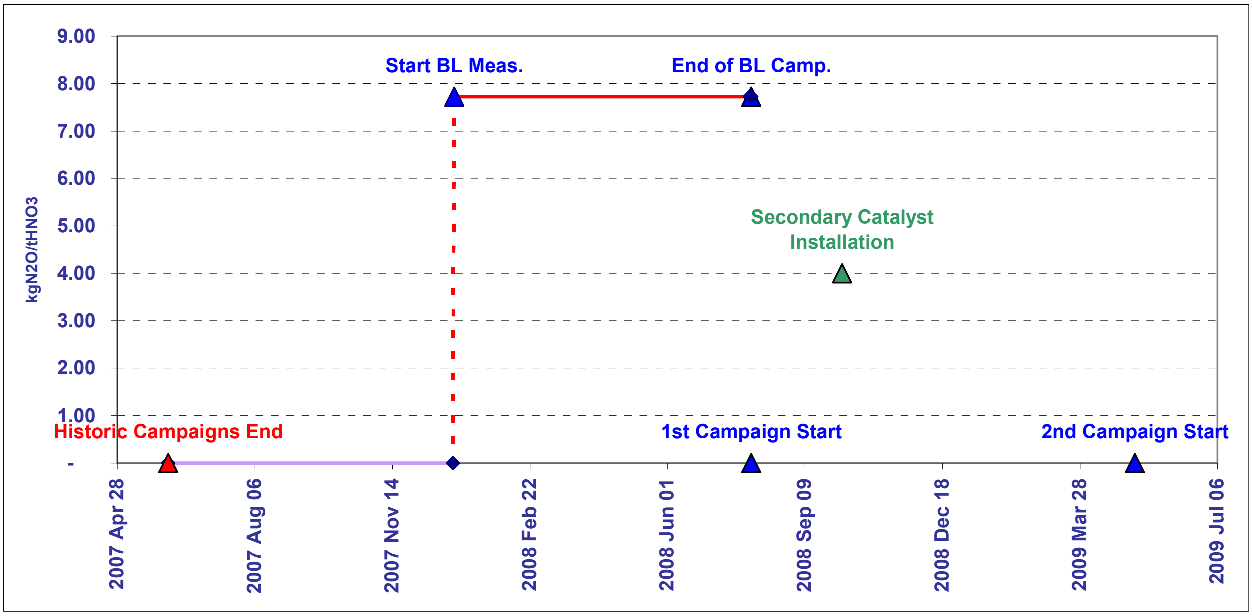


Table T 4 illustrates the calculation of the baseline emission factor on Line 4 using the method as defined in the CDM methodology AM0034 and in the PDD. We have not used overlapping approach allowed by the PDD. Baseline emission factor was determined based on raw data measured from 28/12/2007 through 31/07/2008.

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 N_2O 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 N_2O 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 479 tN_2O.

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

The UNC factor defined by the QAL2 report is 5.450%, which is further modified by an uncertainty of 0.104% due to under-sampling. As a result we have arrived to the baseline emission factor of 7.73 $kgN_2O/tHNO_3$.

Table T 5 shows the calculation of the project emission factor on Line 4 during the project campaign. Project campaign started on 16/03/2011 and went through 05/10/2011.

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

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

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

$PE_n = VSG * NCSG * 10\text{-}9 * OH\ (tN2O)$

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 350 tHNO3/day) we have determined the project campaign specific emission factor at value of 2.19 kgN2O/tHNO3.

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

Because the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this 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	AMS in Operation	Nitric Acid Production
Code	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP		NAP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa	h	t/h
Elimination of extreme values										
Lower limit		0	0	0	0	0	- 50	0		0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000		50
Raw Data Measured Range										
Count	**4 564**	4 906	4 891	4 467	4 733	5 086	5 161	4 755	4 028	4 906
as % of Dataset	*88%*	*95%*	*94%*	*86%*	*91%*	*98%*	*100%*	*92%*	*78%*	*95%*
Minimum		-	0	-	266	-	1	3		-
Maximum		15.12	2 925	83 541	6 465	19.28	906	634		15
Mean		11.96	1 485	66 846	5 718	9.71	791	572		12
Standard Deviation		4.35	378	10 182	881	2.96	272	62		4
Total		58 683								58 683
N2O Emissions (VSG * NCSG * OH)	453	t N2O								
Emission Factor	7.30	kgN2O / tHNO3								
Permitted Range										
Minimum					4 500	0	880	0		
Maximum					7 500	11.70	910	800		
Data within the permitted range										
Count	**4 399**		4 152	4 210					4 028	
as % of Operating Hours	***96%***		*91%*	*92%*					*88%*	
Minimum			511	-						
Maximum			2 208	75 876						
Mean			1 511	67 275						
Standard Deviation			274	8 270						
N2O Emissions (VSG * NCSG * OH)	464	t N2O								
Emission Factor	7.47	kgN2O / tHNO3								
Data within the confidence interval										
95% Confidence interval										
Lower bound			973	51 066						
Upper bound			2 048	83 484						
Count			3 735	4 149						
as % of Operating Hours			*82%*	*91%*						
Minimum			1 108	59 513						
Maximum			2 046	75 876						
Mean			1 540	68 235						
Standard Deviation			203	2 154						
N2O Emissions (VSG * NCSG * OH)	**479**	**t N2O**								
Emission Factor (EF_BL)	**7.73**	**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	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa
Elimination of extreme values								
Lower limit		0	0	0	0	0	- 50	0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000
Raw Data Measured Range								
Count	**4 478**	4 460	4 442	4 428	4 606	4 585	4 847	4 737
as % of Dataset	*92%*	*92%*	*91%*	*91%*	*95%*	*94%*	*99%*	*97%*
Minimum		-	192	47 047	321	3	(18)	2
Maximum		17.28	748	111 049	6 357	19.82	911	671
Mean		13.75	399	59 990	5 734	10.42	839	619
Standard Deviation		3.49	103	8 985	611	0.79	202	59
Total		61 337						

N2O Emissions (VSG * NCSG * OH)	107	t N2O
Emission Factor	1.75	kgN2O / tHNO3

Data within the confidence interval		
95% Confidence interval	NCSG	VSG
Lower bound	197	42 380
Upper bound	601	77 600
Count	3 836	4 062
as % of Operating Hours	*86%*	*91%*
Minimum	202	45 703
Maximum	600	77 588
Mean	398	60 022
Standard Deviation	99	8 696

N2O Emissions (VSG * NCSG * OH)	**107**	**t N2O**
Actual Project Emission Factor (EF_PActual)	**1.74**	**kgN2O / tHNO3**
Abatement Ratio	**77.4%**	

Moving Average Emission Factor Correction		**Actual Factors**	**Moving Average Rule**
	1	2.77	2.77
	2	2.37	2.57
	3	1.87	2.34
	4	1.74	2.19
	5	-	

Project Emission Factor (EF_P)	**2.19**	**kgN2O / tHNO3**
Abatement Ratio	**71.7%**	

MONITORING REPORT

PROJECT: ACHEMA UKL nitric acid plant N_2O abatement project
LINE: Line 5
MONITORING PERIOD:
FROM: 17/03/2011

TO: 09/11/2011

Prepared by:

VERTIS

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Table of Contents

1. EXECUTIVE SUMMARY

This monitoring report determines baseline emission factor for the Line 5 of ACHEMA UKL nitric acid plant and quantity of emission reduction generated during the fourth project campaign on Line 5.

The first project campaign on Line 5 started on 02/07/2008. Secondary catalyst was installed on 02/07/2008. Total quantity of emission reductions generated during the fourth project period from 17/03/2011 through 09/11/2011 on Line 5 is **82 177 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	6.61	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	2.09	kgN2O/tHNO3
Nitric Acid Produced in the Baseline Campaign	NAP_BL	55 079	tHNO3
Nitric Acid Produced in the NCSG Baseline Campaign	NAP_BL_NCSG	55 079	tHNO3
Nitric Acid Produced in the Project Campaign	NAP_P	58 648	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**82 177**	**tCOe**
*ER=(EF_BL-EF_P)*NAP_P*GWP/1000*			
Abatement Ratio		**74.1%**	

EMISSION REDUCTION PER YEAR			
Year	2009	2010	2011
Date From			17 Mar 2011
Date To			09 Nov 2011
Nitric Acid Production			58 648
Emission Reduction			**82 177**
*ER_YR = ER * NAP_P_YR / NAP_P*			

Baseline emission factor established for the Line 5 during baseline measurement carried from 29/11/2007 through 17/06/2008 is 6.61 $kgN_2O/tHNO_3$.

Project emission factor during the fourth project campaign after installation of secondary catalysts on Line 5, which started on 17/03/2011 and went through 09/11/2011 with secondary catalyst installed and commissioned on 02/07/2008, is 2.09 $kgN_2O/tHNO_3$.

During the project campaign 58 648 tonnes of nitric acid was produced.

2. DESCRIPTION OF THE PROJECT ACTIVITY

Purpose of the Project (the “Project”) is the reduction of nitrous oxide (N_2O) emissions from nitric acid production Lines at the UKL-7 nitric acid plant of AB Achema (“Achema” or “the Company”). The Company is situated in Jonava, Lithuania.

Achema has installed and operates secondary N_2O reduction catalysts underneath the primary catalyst precious metal catching and catalytic gauzes package in the ammonium burners of the UKL-7 nitric acid plant.

This monitoring report contains information on Line 5 emission reductions including information on baseline emission factor setting for the Line 5.

The separate treatment of 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 requirements 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 5 has been established on the Line-specific basis. Campaign used for baseline measurements on the line 5 has been carried out from 29/11/2007 through 17/06/2008.

N_2O concentration and gas volume flow are monitored by monitoring system complying with requirements of the European Norm 14181.

Monitoring system provides separate readings for N_2O 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 N_2O 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 N_2O concentration of stack gas (NCSG))

The average mass of N_2O emissions per hour is estimated as product of the NCSG and VSG. The N_2O emissions per campaign are estimates product of N_2O 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 N_2O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N_2O 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 N_2O emission factor per tonne of nitric acid produced in the baseline period (EFBL) 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

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from the Line 5 tail gas duct at sampling point located after expansion turbine and transported by sample Line to the Monitoring room A, where the analyzer is located.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis.

N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production lines. N_2O concentration is measured by 3 concentration meters on a switched basis.

N_2O concentration measured data are sent from the analyzer on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

3.1.2 Tail gas flow rate, pressure and temperature

Tail gas flow, pressure and temperature is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section. Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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 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 5 campaigns), has been used as a cap on the length of the baseline campaign.

4. PROJECT EMISSIONS

During the first project campaign on line 5 the tail gas volume flow in the stack of the nitric acid plant as well as N_2O concentration have been measured on the 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 N_2O 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

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

where:

Variable	**Definition**
VSG	Mean stack gas volume flow rate for the project campaign (m^3/h)
NCSG	Mean concentration of N_2O in the stack gas for the project campaign (mgN_2O/m^3)
PE_n	Total N_2O emissions of the n^{th} project campaign (tN_2O)
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 the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this campaign.

4.2 Minimum project emission factor

The minimum average emission factor established factor will be established after 10th project campaign.

4.3 Project Campaign Length

Project campaign production of nitric acid has been below defined nameplate capacity and thus all NAP produced from date of installation of secondary catalysts has been used for calculation of emission reductions.

Because the nitric acid production during the project was higher than the baseline, all of the baseline NCSG values were used to determine the baseline emission factor.

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 N_2O:

$$ER = (EFBL - EFP) * NAP * GWPN_2O \ (tCO_2e)$$

Where:

Variable	**Definition**
ER	Emission reductions of the project for the specific campaign (tCO_2e)
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 ($tN_2O/tHNO_3$)
EFP	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of $EF_{ma,n}$ and EF_n)

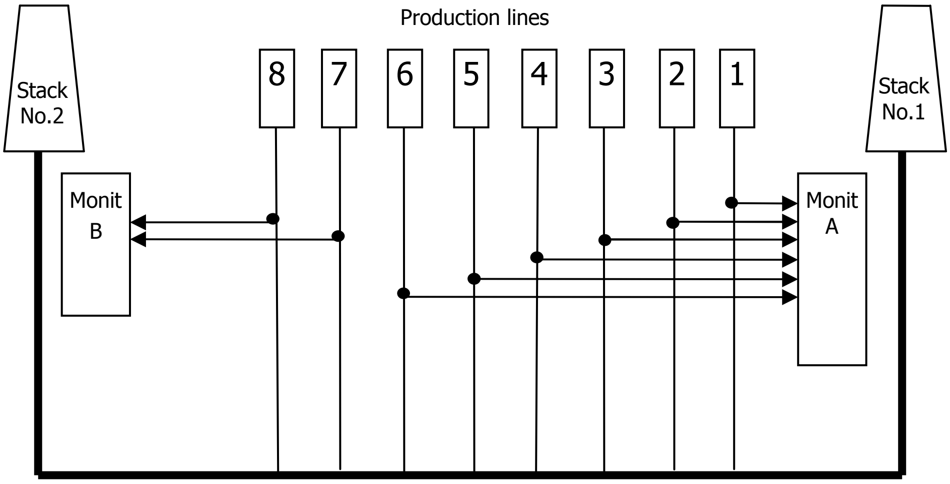
5. MONITORING PLAN

Purpose of the monitoring plan

The purpose of the monitoring plan is to describe the system used to monitor emissions of N_2O from the plant in such a way that is compliant with the prescriptions of the AM0034/Version 02.

Plant description

The UKL-7 nitric acid plant comprises 8 production Lines numbered from 1 through 8, each with its own burner, absorption column and expansion turbine. Each production Line represents a separate nitric acid production unit independent from each other. The tail gasses from each Line are after expansion turbines led to a common stack bus and vented through two interconnected stacks.



Primary catalyst is changed at different times thus it is necessary to measure the emissions from each Line individually. This means that eight separate sets of monitoring equipment are installed to measure tail gas flow, nitric acid production, nitric acid concentration, and the operating conditions. N_2O concentration in the tail gas is measured by 3 switched concentration meters.

Monitoring System architecture

Methodology AM0034/Version 02 requires installation of an N_2O monitoring system that includes both a gas volume flow meter to determine the tail gas mass volume flow and an infrared gas analyser to determine the concentration of N_2O.

But tail gas N_2O concentration meter and tail gas volume flow meter alone are not sufficient for a JI project purposes. In order of being able to calculate the baseline emission factor expressed as tonnage of N_2O in t CO_2e per 1 tonne of HNO_3 (100%), it is necessary to include also HNO_3 measurement, and in order of being able to document normal operating conditions it is necessary to include also operating conditions measurement.

Because of this we use the term Monitoring System (MS) to describe entire monitoring system directly and indirectly used for the JI purposes, while Automated Measurement System (AMS) covers only N_2O emissions and tail gas mass volume part of the MS.

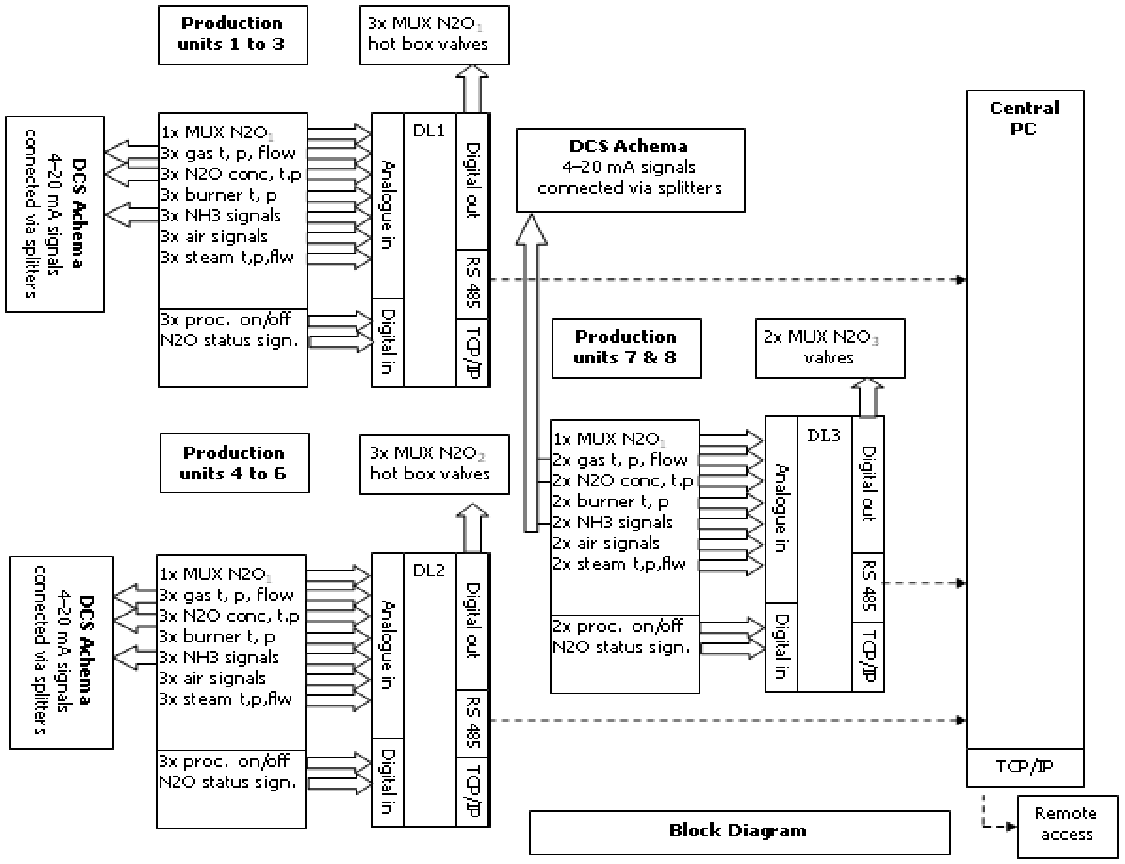
Monitoring System (MS) for purpose of this monitoring plan means:

monitoring system measuring operational conditions;
Ammonia volume flow
Ammonia temperature
Ammonia pressure
Primary air volume flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

nitric acid 100% concentrate production;
Nitric acid concentration
Nitric acid flow
Nitric acid temperature

and newly installed measurement devices for measurement of N2O concentration and tail gas flow, temperature and pressure (AMS)
N_2O concentration in the stack
Stack volume flow rate
Stack gas temperature
Stack gas pressure

Incorporation of the AMS into the MS by interfacing already existing and newly installed measurement devices is documented by the diagram below.



N_2O automated measurement system

Main purpose of the N_2O automated measurement system (AMS) is to measure total mass of N_2O emitted during particular campaigns (both baseline and project). In order of calculation of total mass of N_2O emitted during particular campaign it is necessary to measure on an extractive basis the N_2O concentration in a tail gas and on a non-extractive basis tail gas flow, pressure and temperature.

N_2O concentration

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from respective tail gas ducts at sampling points located after expansion turbines and transported by heated sample lines to the Monitoring room A located next to the main production hall. This applies to 2 concentration meters measuring lines 1-3 and lines 4-6. lines 7-8 are measured by third concentration meter located at the other side of the production hall (Monitoring room B) physically closer to respective production lines 7 and 8.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis. Correction of dry basis ppmV value to real wet tail

gas conditions based on steam flow injected into the system is part of both - the project emissions calculations and baseline emission factor calculations.

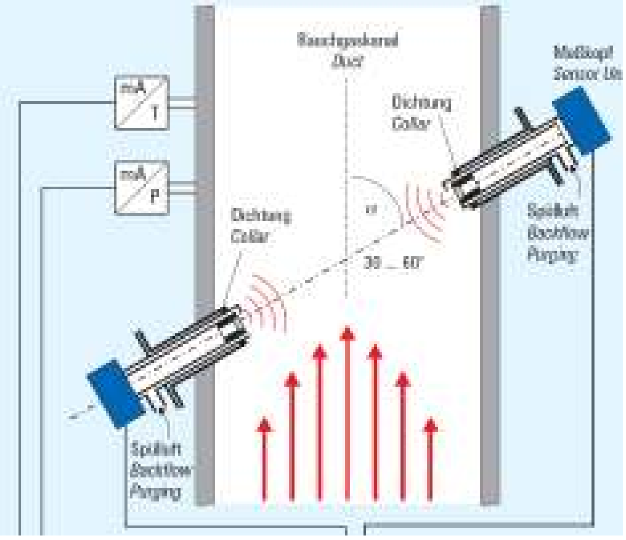
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production Lines. N_2O concentration is measured by 3 concentration meters on a switched basis. Tail gas samples are automatically switched. Under-sampling uncertainty is part of both - the project emissions calculations and baseline emission factor calculations.

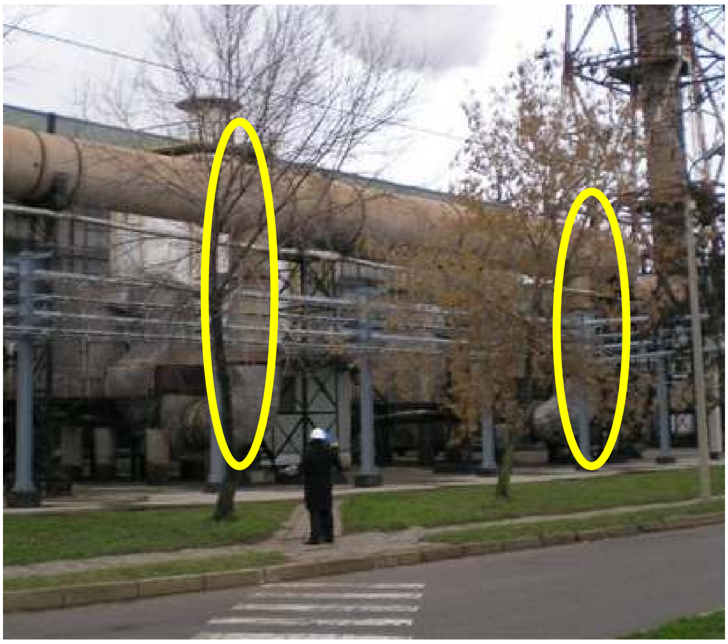
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas flow, pressure and temperature

Tail gas flow is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section.



The tail gas ducts do not allow any optimum location to perform the flow monitoring. The only possible location is the quite short vertical tube behind the 90° “knee”.



Since the flow is not really laminar, a classical Pitot tube one point solution wouldn't allow good results. The ultrasonic system is under these conditions superior to differential pressure. Cross duct monitoring is more accurate than a couple of discrete point averaged pressure.

Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas steam injection elimination

Steam injected into the Achema UKL-7 tail gas for purpose of increasing the turbine output is eliminated from the tail gas mass flow calculation by following formulae:

flow - STVF= Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325)*((100-Humi)/100)

where Humi (water content)=

(Flow_steam*1.2436)/(Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325))*100+0.6

where 1.2436 is the conversion factor from kg/h to Nm3/h and 0.6% is a value of humidity present in a flue gas permanently without steam injection

The Flow_steam parameter necessary for calculation of the water content in the dataloggers is provided in the kg/h unit.

Achema measures steam flow in kg/h using formula Q=C*sqrt(dp) , where C is flow constant which is already integrated using an orifice plate sizing program. The orifice plate calculation for injection steam has been done for temperature 250˚C and pressure 6 bar.

Flow steam in kg/h measured by using the constant steam T and P values is then recalculated to actual steam T and P values valid for relevant hours and as result the STVF value cleaned of the steam injected is used for further emission reductions calculations.

EN14181 compliance

As required by the AM0034/Version 02 methodology the N_2O automated measurement system (AMS) complies with requirements of the technical norm EN14181. N_2O AMS consists from the N_2O concentration meter and integrated flowmeter (F, T, P). Both measurement devices are QAL1 certified (concentration meter for the N_2O measurand specifically) and after full commissioning of the monitoring system there was the QAL2 test carried out by an independent laboratory certified according to ISO17025.

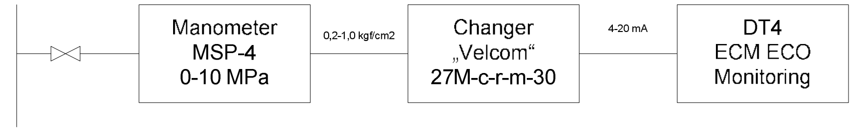
Operating conditions

For purpose of the baseline emissions factor setting it is necessary to monitor and report operating conditions in all 8 burners. Namely:

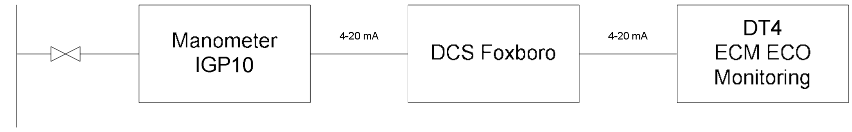
Ammonia flow
Ammonia temperature
Ammonia pressure
Primary air flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

All these parameters are measured by the plant monitoring system as presented on diagrams below:

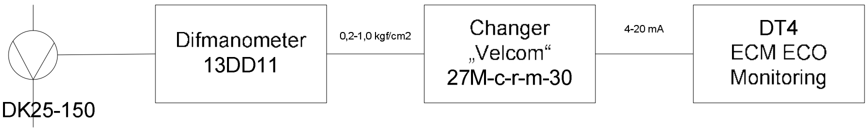
P in mixer 1-6 line



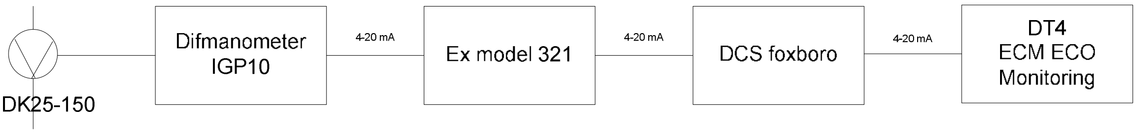
P in mixer 7-8 line



NH3 to mixer 1-6 line

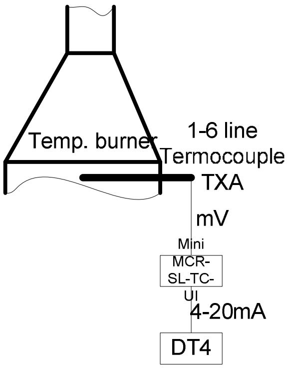


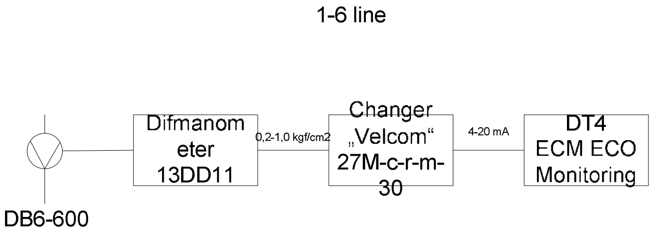
NH3 to mixer 7-8 line

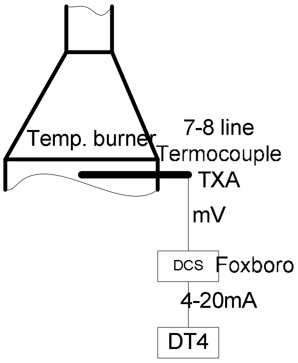


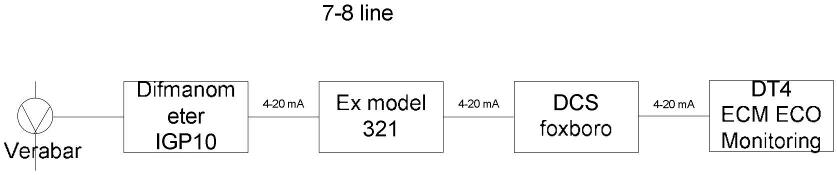
T in burner

Air to mixer









Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further. Maintenance procedures for the ammonia oxidation parameters follow the existing procedures for the operation of the nitric acid plant.

Nitric acid production

Nitric acid concentration is based on two components: nitric acid and water. Standard monitoring method is on-Line refractometry. Measurement of nitric acid (100%) mass volume production per campaign is necessary for calculation of the baseline emissions factor. Nitric acid concentration on all 8 Lines is measured by K-Patents PR-23-GP refractometers.

This analyzer is applying a prism to “return” a generated optical beam back to an LCD detector.

The detector is measuring refraction of monitored liquid based on known refraction of water and nitric acid. The instrument is calibrated for percent concentration of nitric acid. The analyzer is mounted on DIN-flange 2656, PN25 DN80. The optical prism does not require cleaning.

PR-23-GP characteristics:

- Measuring RI is a direct concentration measurement principle. No need to rely or convert magnitudes.
- Digital instrument – no calibration drift
- As it is a robust instrument it is maintenance free
- Dual connectivity if the installation positions allow.
- On-Line data logging, through Ethernet, on whichever web browser.
- No influence by bubbles or particles. It is very common that air enters the process pipeline and still the refractometer measures accurately.

Nitric acid concentration data are in an analog 4-20mA format provided to dataloggers which process these signals further.

In order of being able to calculate total mass volume of nitric acid 100% concentrate produced during the baseline campaign it is necessary to monitor also nitric acid flow and temperature. Measurement of pressure is not necessary for determination of the nitric acid mass volume flow, because nitric acid is in form of liquid and as such it has stabile pressure characteristic.

Signals obtained from the nitric acid flow and temperature measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Nitric acid flow and temperature measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further.

After installation of refractometers there have been occurrences of their failure and following repair service by the manufacturer. For this period starting from 05/10/2007 and ending on 15/09/2008 project uses HNO_3 concentration data provided by the laboratory measurements.

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:

$$Xo=Xn=X$$

where:

Xn: X new
Xo: X 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:

$$Yn=An + (Bn/Bo)*(Yo-Ao)$$

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 “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

Based on the real conditions measured and applied by the AMS for normalization (TSG in °C and PSG in hPa), the stack gas volume flow values are converted to real conditions before the regression analysis using the ideal gas law. The actual gas volume flow rates are derived from gas velocity measurements, therefore, before applying the regression analysis the gas speed is calculated from the volume flow and the duct cross-section and is fed into the calibrating equation. The calibrated values derived from the calibrating equation then converted back to normalized units using the calibrated real conditions (calibrated TSG and PSG). The normalized calibrated stack gas flow rates are further fed into the emission calculation model for further 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 mgN_2O/m_3. The concentration was converted to ppmv to make it compatible with the regression Lines parameters. The nitrous gas concentration values are then calibrated using the provided regression Lines parameters and are input in the model.

6.4 Stack gas Temperature

The stack gas temperature was calibrated by the regression conversion formula

6.5 Stack gas Pressure

The calibration report provides us with a regression Line for the stack gas pressure. We calibrate the readings of the measurements system using the regression formula and applying the values (in kPa).

7. EMISSION REDUCTION CALCULATIONS

Table T 2 illustrates the establishment of historic campaign length based on 5 previous campaigns. Average production in 5 campaigns preceding the baseline campaign was 64 818 tHNO_3 and time duration was on average 238 days. Table contains also information on suppliers of primary catalysts for the line 5.

T 2 Historic campaigns

Line	ACHEMA UKL-5	Production	Start	End	Days	Production per day	Primary Catalyst	Composition
Historic Campaigns	**1** t HNO3	65 664	06 Jun 2003	23 Dec 2003	200	328	Heraeus	N/A *
	2 t HNO3	63 844	23 Dec 2003	24 Aug 2004	245	261	Heraeus	N/A *
	3 t HNO3	58 961	01 Sep 2004	10 May 2005	251	235	Johnson Matthey	N/A *
	4 t HNO3	66 432	12 May 2005	06 Mar 2006	298	223	Johnson Matthey	N/A *
	5 t HNO3	69 189	06 Nov 2006	23 May 2007	198	349	Heraeus	N/A *
Average HNO3 production	t HNO3	**64 818**			**238**	**272**	* Confidential but available for the verification	
Project Campaigns	**BL** t HNO3	55 079	29 Nov 2007	17 Jun 2008	201	274	Umicore	N/A *
	PL t HNO3	58 648	17 Mar 2011	09 Nov 2011	237	247	Umicore	N/A *

The project campaign production value of 58 648 tHNO3 was lower than historic nitric acid production set at level of 64 818 tHNO3.

It is business as usual scenario in Achema UKL-7 plant to keep using primary catalysts from several suppliers and with several compositions. Selection of primary catalysts is determined by technical parameters of their use and price levels offered by suppliers in specific time. Primary catalysts used during the baseline campaign, if other than used in previous campaign/s, did not increase emissions of N2O as confirmed by relevant statements provided to the verifier.

T 3 and Chart C 1 define the length of the baseline campaign. Baseline campaign measurements for this project campaign started on 29/11/2007 and continued through 17/06/2008 when the 55 079 tHNO_3 nitric acid production was reached. The measurement of baseline Nitrous Acid Concentration (NCSG) was carried out until production reached - tHNO_3 .

T 3 Baseline campaign length

ACHEMA UKL-5	Historic Campaings End	Start of Baseline Measurement	End of Baseline Measurement NCSG	End of Baseline Measurement	End of Baseline Campaign
Dates	2007 May 23	2007 Nov 29	2008 Jun 17	2008 Jun 17	2008 Jun 18
Baseline Factor kgN2O/tHNO3	-	-	6.61	6.61	6.61
Production tHNO3		-	55 079	55 079	-
Per Day Production tHNO3	271.9				
Baseline less Historic Production	**(9 739.2)**				
Baseline less Historic Days	**(35.8)**				

C 1 Baseline campaign length

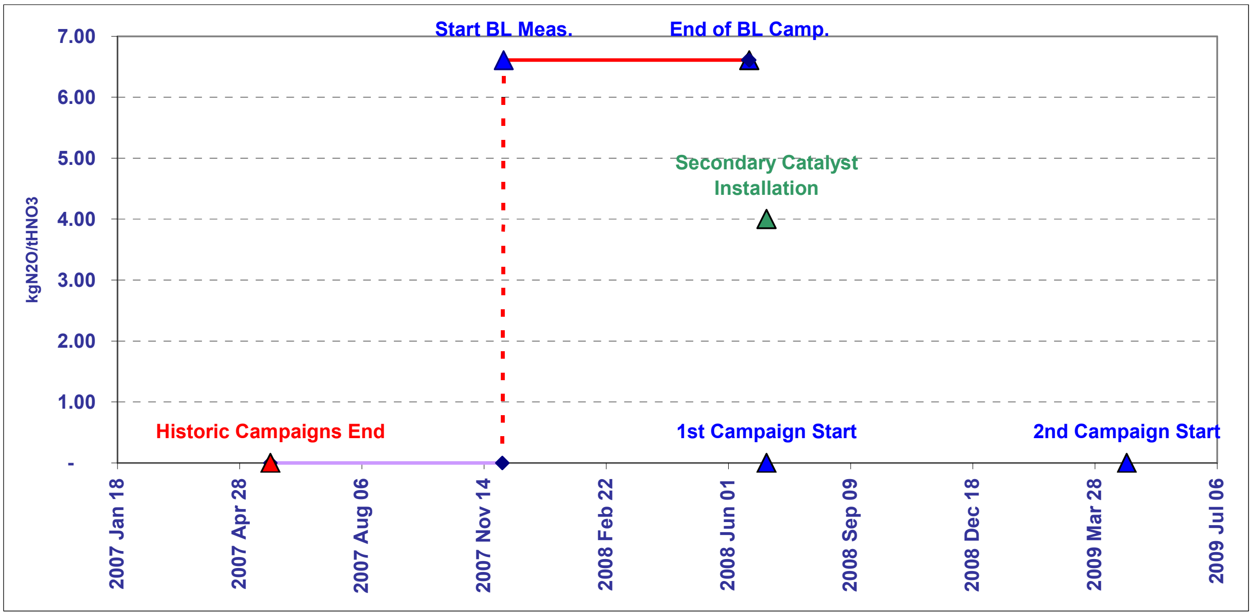


Table T 4 illustrates the calculation of the baseline emission factor on Line 5 using the method as defined in the CDM methodology AM0034 and in the PDD. We have not used overlapping approach allowed by the PDD. Baseline emission factor was determined based on raw data measured from 29/11/2007 through 17/06/2008.

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 N_2O 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 N_2O 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 385 tN_2O.

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

The UNC factor defined by the QAL2 report is 5.450%, which is further modified by an uncertainty of 0.126% due to under-sampling. As a result we have arrived to the baseline emission factor of 6.61 $kgN_2O/tHNO_3$.

Table T 5 shows the calculation of the project emission factor on Line 5 during the project campaign. Project campaign started on 17/03/2011 and went through 09/11/2011.

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

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

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

$$PE_n = VSG * NCSG * 10\text{-}9 * OH\ (tN2O)$$

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 350 tHNO3/day) we have determined the project campaign specific emission factor at value of 2.09 kgN2O/tHNO3.

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

Because the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this 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	AMS in Operation	Nitric Acid Production NCSG
Code	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP		NAP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa	h	t/h
Elimination of extreme values										
Lower limit		0	0	0	0	0	- 50	0		0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000		50
Raw Data Measured Range										
Count	**4 519**	4 571	4 660	4 558	4 701	4 414	4 797	4 698	4 064	4 571
as % of Dataset	*94%*	*95%*	*97%*	*94%*	*97%*	*92%*	*99%*	*97%*	*84%*	*95%*
Minimum		-	0	-	315	-	(0)	0		-
Maximum		15.02	2 289	82 389	6 482	19.73	908	673		15
Mean		12.05	1 239	65 232	5 932	10.24	844	613		12
Standard Deviation		3.12	268	15 041	990	0.81	195	46		3
Total		55 079								55 079
N2O Emissions (VSG * NCSG * OH)	365	t N2O								
Emission Factor	6.27	kgN2O / tHNO3								
Permitted Range										
Minimum					4 500	0	880	0		
Maximum					7 500	11.70	910	800		
Data within the permitted range										
Count	**4 249**		4 211	4 211					4 064	
as % of Operating Hours	***94%***		*93%*	*93%*					*90%*	
Minimum			717	6 728						
Maximum			2 289	78 602						
Mean			1 234	68 731						
Standard Deviation			225	2 256						
N2O Emissions (VSG * NCSG * OH)	383	t N2O								
Emission Factor	6.58	kgN2O / tHNO3								
Data within the confidence interval										
95% Confidence interval										
Lower bound			793	64 309						
Upper bound			1 675	73 153						
Count			4 009	4 063						
as % of Operating Hours			*89%*	*90%*						
Minimum			796	64 317						
Maximum			1 674	73 152						
Mean			1 240	68 711						
Standard Deviation			204	1 796						
N2O Emissions (VSG * NCSG * OH)	**385**	**t N2O**								
Emission Factor (EF_BL)	**6.61**	**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	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa
Elimination of extreme values								
Lower limit		0	0	0	0	0	- 50	0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000
Raw Data Measured Range								
Count	**3 919**	4 559	3 838	3 872	5 275	4 729	5 661	5 620
as % of Dataset	*69%*	*80%*	*67%*	*68%*	*93%*	*83%*	*100%*	*99%*
Minimum		0.59	167	63 479	291	2	0	0
Maximum		16.88	1 306	108 774	6 539	19.69	909	720
Mean		12.86	380	68 825	4 842	10.44	635	538
Standard Deviation		4.56	71	2 180	2 280	1.38	390	233
Total		58 648						
N2O Emissions (VSG * NCSG * OH)	103	t N2O						
Emission Factor	1.75	kgN2O / tHNO3						
Data within the confidence interval								
95% Confidence interval								
Lower bound			242	64 553				
Upper bound			519	73 097				
Count			3 611	3 752				
as % of Operating Hours			*92%*	*96%*				
Minimum			242	64 622				
Maximum			519	73 080				
Mean			373	68 677				
Standard Deviation			57	1 879				
N2O Emissions (VSG * NCSG * OH)	**100**	**t N2O**						
Actual Project Emission Factor (EF_PActual)	**1.71**	**kgN2O / tHNO3**						
Abatement Ratio	**74.1%**							
Moving Average Emission Factor Correction	**Actual Factors**	**Moving Average Rule**						
1	1.68	1.68						
2	2.90	2.90						
3	2.07	2.22						
4	1.71	2.09						
5	-							
Project Emission Factor (EF_P)	**2.09**	**kgN2O / tHNO3**						
Abatement Ratio	**68.4%**							

MONITORING REPORT

PROJECT: ACHEMA UKL nitric acid plant N_2O abatement project
LINE: Line 6
MONITORING PERIOD:
FROM: 01/10/2010

TO: 10/08/2011

Prepared by:

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Table of Contents

1. EXECUTIVE SUMMARY

This monitoring report determines baseline emission factor for the Line 6 of ACHEMA UKL nitric acid plant and quantity of emission reduction generated during the third project campaign on Line 6.

The first project campaign on Line 6 started on 21/07/2008. Secondary catalyst was installed on 25/07/2008. Total quantity of emission reductions generated during the third project period from 01/10/2010 through 10/08/2011 on Line 6 is **214 833 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	10.34	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	4.03	kgN2O/tHNO3
Nitric Acid Produced in the Baseline Campaign	NAP_BL	60 850	tHNO3
Nitric Acid Produced in the NCSG Baseline Campaign	NAP_BL_NCSG	60 850	tHNO3
Nitric Acid Produced in the Project Campaign	NAP_P	109 827	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**214 833**	**tCOe**
*ER=(EF_BL-EF_P)*NAP_P*GWP/1000*			
Abatement Ratio		**76.1%**	

EMISSION REDUCTION PER YEAR			
Year	2009	2010	2011
Date From		01 Oct 2010	01 Jan 2011
Date To		31 Dec 2010	10 Aug 2011
Nitric Acid Production		31 515	78 822
Emission Reduction		**61 361**	**153 471**
*ER_YR = ER * NAP_P_YR / NAP_P*			

Baseline emission factor established for the Line 6 during baseline measurement carried from 11/01/2008 through 21/07/2008 is 10.34 kgN_2O/tHNO_3.

Project emission factor during the third project campaign after installation of secondary catalysts on Line 6, which started on 01/10/2010 and went through 10/08/2011 with secondary catalyst installed and commissioned on 25/07/2008, is 4.03 kgN_2O/tHNO_3.

During the project campaign 109 827 tonnes of nitric acid was produced.

2. DESCRIPTION OF THE PROJECT ACTIVITY

Purpose of the Project (the “Project”) is the reduction of nitrous oxide (N_2O) emissions from nitric acid production Lines at the UKL-7 nitric acid plant of AB Achema (“Achema” or “the Company”). The Company is situated in Jonava, Lithuania.

Achema has installed and operates secondary N_2O reduction catalysts underneath the primary catalyst precious metal catching and catalytic gauzes package in the ammonium burners of the UKL-7 nitric acid plant.

This monitoring report contains information on Line 6 emission reductions including information on baseline emission factor setting for the Line 6.

The separate treatment of 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 requirements 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 6 has been established on the Line-specific basis. Campaign used for baseline measurements on the line 6 has been carried out from 11/01/2008 through 21/07/2008.

N_2O concentration and gas volume flow are monitored by monitoring system complying with requirements of the European Norm 14181.

Monitoring system provides separate readings for N_2O 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 N_2O 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 N_2O concentration of stack gas (NCSG))

The average mass of N_2O emissions per hour is estimated as product of the NCSG and VSG. The N_2O emissions per campaign are estimates product of N_2O 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 N_2O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N_2O 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 N_2O emission factor per tonne of nitric acid produced in the baseline period (EFBL) 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

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from the Line 6 tail gas duct at sampling point located after expansion turbine and transported by sample Line to the Monitoring room A, where the analyzer is located.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis.

N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production lines. N_2O concentration is measured by 3 concentration meters on a switched basis.

N_2O concentration measured data are sent from the analyzer on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

3.1.2 Tail gas flow rate, pressure and temperature

Tail gas flow, pressure and temperature is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section. Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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 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 5 campaigns), has been used as a cap on the length of the baseline campaign.

4. PROJECT EMISSIONS

During the first project campaign on line 6 the tail gas volume flow in the stack of the nitric acid plant as well as N_2O concentration have been measured on the 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 N_2O 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

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

where:

Variable	Definition
VSG	Mean stack gas volume flow rate for the project campaign (m^3/h)
NCSG	Mean concentration of N_2O in the stack gas for the project campaign (mgN_2O/m^3)
PE_n	Total N_2O emissions of the n^{th} project campaign (tN_2O)
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 the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this campaign.

4.2 Minimum project emission factor

The minimum average emission factor established factor will be established after 10th project campaign.

4.3 Project Campaign Length

Project campaign production of nitric acid has been below defined nameplate capacity and thus all NAP produced from date of installation of secondary catalysts has been used for calculation of emission reductions.

Because the nitric acid production during the project was higher than the baseline, all of the baseline NCSG values were used to determine the baseline emission factor.

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 N_2O:

$$ER = (EFBL – EFP) * NAP *GWPN_2O\ (tCO_2e)$$

Where:

Variable	**Definition**
ER	Emission reductions of the project for the specific campaign (tCO_2e)
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 ($tN_2O/tHNO_3$)
EFP	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of $EF_{ma,n}$ and EF_n)

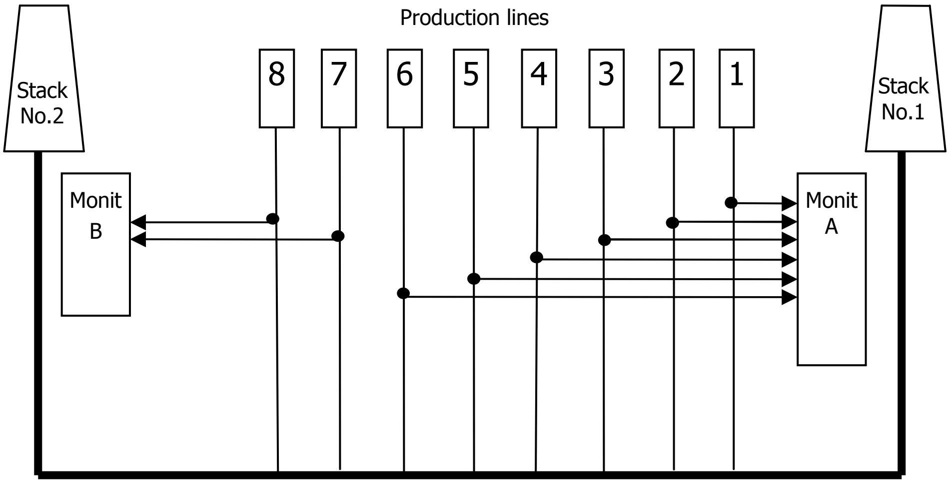
5. MONITORING PLAN

Purpose of the monitoring plan

The purpose of the monitoring plan is to describe the system used to monitor emissions of N_2O from the plant in such a way that is compliant with the prescriptions of the AM0034/Version 02.

Plant description

The UKL-7 nitric acid plant comprises 8 production Lines numbered from 1 through 8, each with its own burner, absorption column and expansion turbine. Each production Line represents a separate nitric acid production unit independent from each other. The tail gasses from each Line are after expansion turbines led to a common stack bus and vented through two interconnected stacks.



Primary catalyst is changed at different times thus it is necessary to measure the emissions from each Line individually. This means that eight separate sets of monitoring equipment are installed to measure tail gas flow, nitric acid production, nitric acid concentration, and the operating conditions. N_2O concentration in the tail gas is measured by 3 switched concentration meters.

Monitoring System architecture

Methodology AM0034/Version 02 requires installation of an N_2O monitoring system that includes both a gas volume flow meter to determine the tail gas mass volume flow and an infrared gas analyser to determine the concentration of N_2O.

But tail gas N_2O concentration meter and tail gas volume flow meter alone are not sufficient for a JI project purposes. In order of being able to calculate the baseline emission factor expressed as tonnage of N_2O in t CO_2e per 1 tonne of HNO_3 (100%), it is necessary to include also HNO_3 measurement, and in order of being able to document normal operating conditions it is necessary to include also operating conditions measurement.

Because of this we use the term Monitoring System (MS) to describe entire monitoring system directly and indirectly used for the JI purposes, while Automated Measurement System (AMS) covers only N_2O emissions and tail gas mass volume part of the MS.

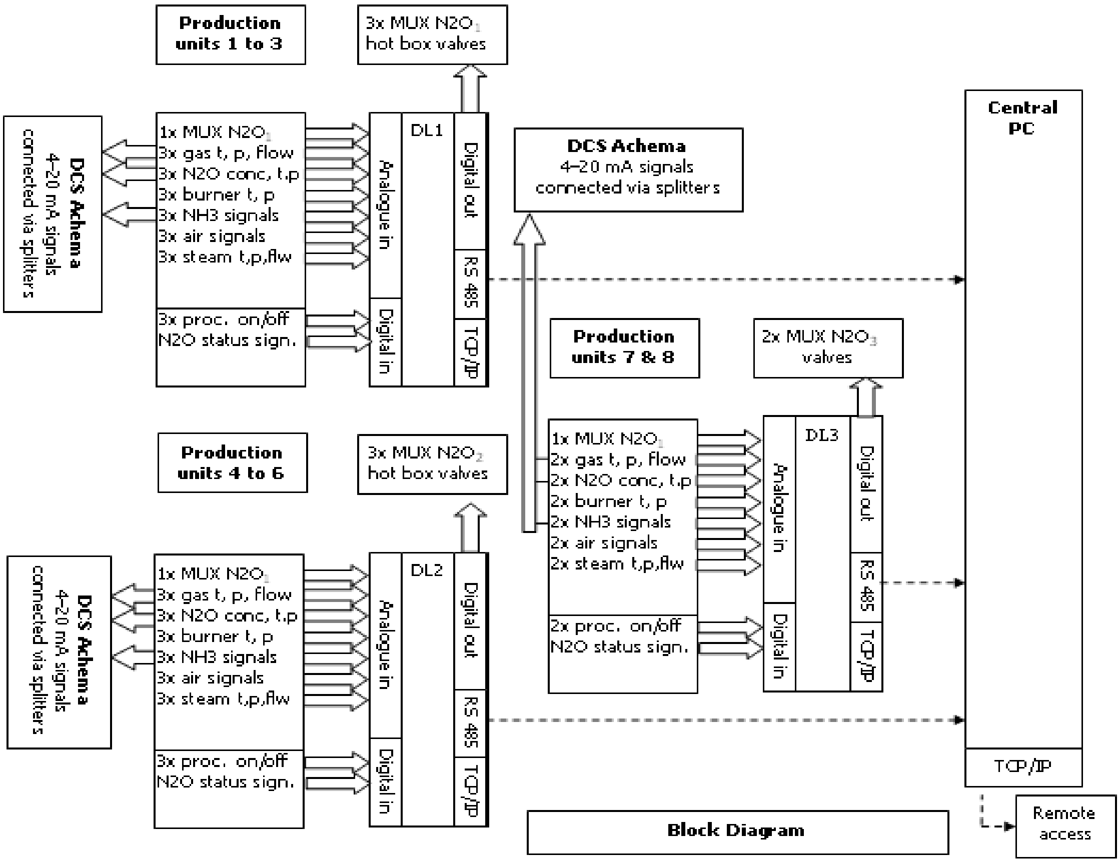
Monitoring System (MS) for purpose of this monitoring plan means:

monitoring system measuring operational conditions;
Ammonia volume flow
Ammonia temperature
Ammonia pressure
Primary air volume flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

nitric acid 100% concentrate production;
Nitric acid concentration
Nitric acid flow
Nitric acid temperature

and newly installed measurement devices for measurement of N2O concentration and tail gas flow, temperature and pressure (AMS)
N_2O concentration in the stack
Stack volume flow rate
Stack gas temperature
Stack gas pressure

Incorporation of the AMS into the MS by interfacing already existing and newly installed measurement devices is documented by the diagram below.



N_2O automated measurement system

Main purpose of the N_2O automated measurement system (AMS) is to measure total mass of N_2O emitted during particular campaigns (both baseline and project). In order of calculation of total mass of N_2O emitted during particular campaign it is necessary to measure on an extractive basis the N_2O concentration in a tail gas and on a non-extractive basis tail gas flow, pressure and temperature.

N_2O concentration

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from respective tail gas ducts at sampling points located after expansion turbines and transported by heated sample lines to the Monitoring room A located next to the main production hall. This applies to 2 concentration meters measuring lines 1-3 and lines 4-6. lines 7-8 are measured by third concentration meter located at the other side of the production hall (Monitoring room B) physically closer to respective production lines 7 and 8.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis. Correction of dry basis ppmV value to real wet tail

gas conditions based on steam flow injected into the system is part of both - the project emissions calculations and baseline emission factor calculations.

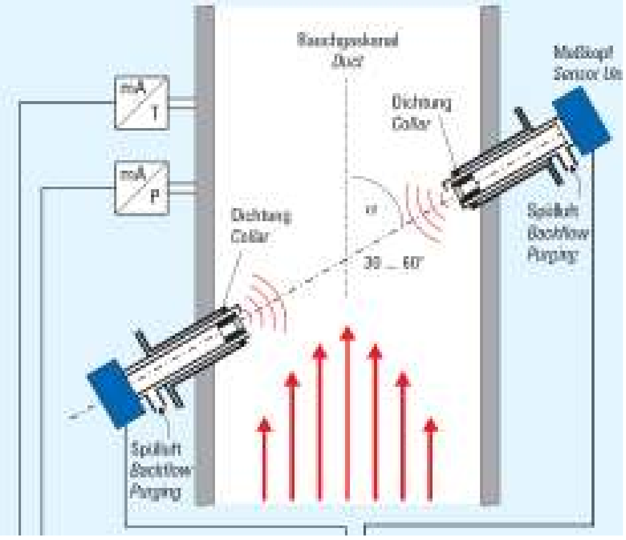
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production Lines. N_2O concentration is measured by 3 concentration meters on a switched basis. Tail gas samples are automatically switched. Under-sampling uncertainty is part of both - the project emissions calculations and baseline emission factor calculations.

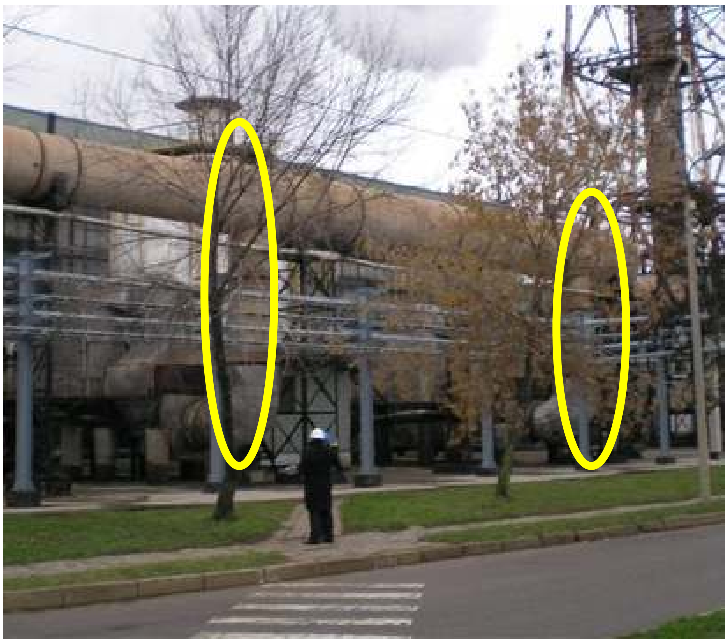
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas flow, pressure and temperature

Tail gas flow is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section.



The tail gas ducts do not allow any optimum location to perform the flow monitoring. The only possible location is the quite short vertical tube behind the 90° “knee”.



Since the flow is not really laminar, a classical Pitot tube one point solution wouldn't allow good results. The ultrasonic system is under these conditions superior to differential pressure. Cross duct monitoring is more accurate than a couple of discrete point averaged pressure.

Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas steam injection elimination

Steam injected into the Achema UKL-7 tail gas for purpose of increasing the turbine output is eliminated from the tail gas mass flow calculation by following formulae:

flow - STVF= Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325)*((100-Humi)/100)

where Humi (water content)=

(Flow_steam*1.2436)/(Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325))*100+0.6

where 1.2436 is the conversion factor from kg/h to Nm3/h and 0.6% is a value of humidity present in a flue gas permanently without steam injection

The Flow_steam parameter necessary for calculation of the water content in the dataloggers is provided in the kg/h unit.

Achema measures steam flow in kg/h using formula Q=C*sqrt(dp) , where C is flow constant which is already integrated using an orifice plate sizing program. The orifice plate calculation for injection steam has been done for temperature 250˚C and pressure 6 bar.

Flow steam in kg/h measured by using the constant steam T and P values is then recalculated to actual steam T and P values valid for relevant hours and as result the STVF value cleaned of the steam injected is used for further emission reductions calculations.

EN14181 compliance

As required by the AM0034/Version 02 methodology the N_2O automated measurement system (AMS) complies with requirements of the technical norm EN14181. N_2O AMS consists from the N_2O concentration meter and integrated flowmeter (F, T, P). Both measurement devices are QAL1 certified (concentration meter for the N_2O measurand specifically) and after full commissioning of the monitoring system there was the QAL2 test carried out by an independent laboratory certified according to ISO17025.

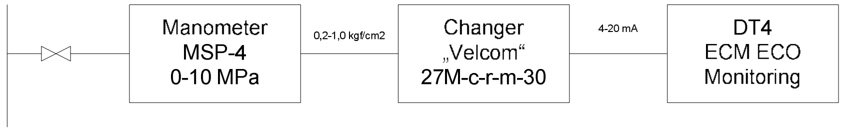
Operating conditions

For purpose of the baseline emissions factor setting it is necessary to monitor and report operating conditions in all 8 burners. Namely:

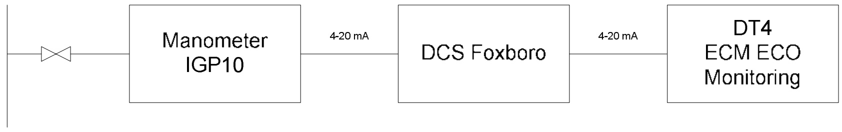
Ammonia flow
Ammonia temperature
Ammonia pressure
Primary air flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

All these parameters are measured by the plant monitoring system as presented on diagrams below:

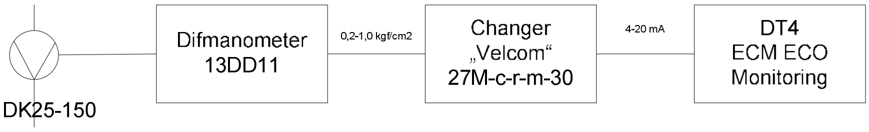
P in mixer 1-6 line



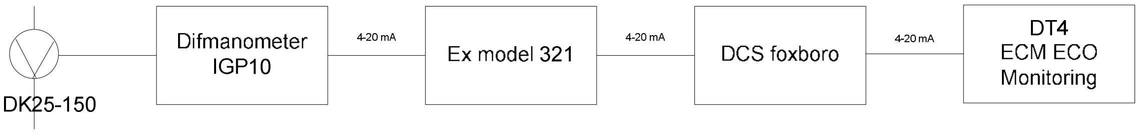
P in mixer 7-8 line

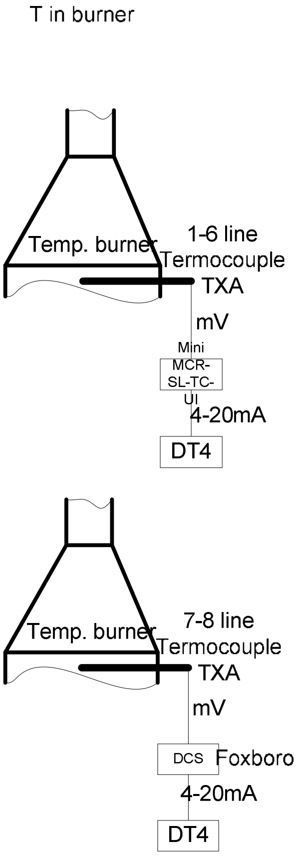


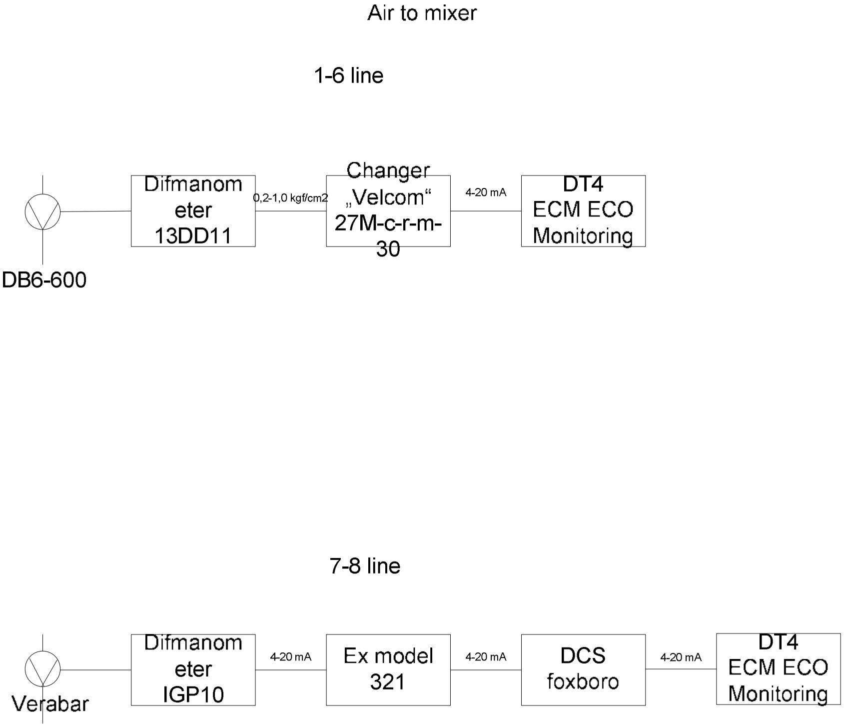
NH3 to mixer 1-6 line



NH3 to mixer 7-8 line







Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further. Maintenance procedures for the ammonia oxidation parameters follow the existing procedures for the operation of the nitric acid plant.

Nitric acid production

Nitric acid concentration is based on two components: nitric acid and water. Standard monitoring method is on-Line refractometry. Measurement of nitric acid (100%) mass volume production per campaign is necessary for calculation of the baseline emissions factor. Nitric acid concentration on all 8 Lines is measured by K-Patents PR-23-GP refractometers.

This analyzer is applying a prism to “return” a generated optical beam back to an LCD detector.

The detector is measuring refraction of monitored liquid based on known refraction of water and nitric acid. The instrument is calibrated for percent concentration of nitric acid. The analyzer is mounted on DIN-flange 2656, PN25 DN80. The optical prism does not require cleaning.

PR-23-GP characteristics:

Measuring RI is a direct concentration measurement principle. No need to rely or convert magnitudes.
Digital instrument – no calibration drift
As it is a robust instrument it is maintenance free
Dual connectivity if the installation positions allow.
On-Line data logging, through Ethernet, on whichever web browser.
No influence by bubbles or particles. It is very common that air enters the process pipeline and still the refractometer measures accurately.

Nitric acid concentration data are in an analog 4-20mA format provided to dataloggers which process these signals further.

In order of being able to calculate total mass volume of nitric acid 100% concentrate produced during the baseline campaign it is necessary to monitor also nitric acid flow and temperature. Measurement of pressure is not necessary for determination of the nitric acid mass volume flow, because nitric acid is in form of liquid and as such it has stabile pressure characteristic.

Signals obtained from the nitric acid flow and temperature measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Nitric acid flow and temperature measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further.

After installation of refractometers there have been occurrences of their failure and following repair service by the manufacturer. For this period starting from 05/10/2007 and ending on 08/09/2008 project uses HNO_3 concentration data provided by the laboratory measurements.

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
X_o: X 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:

$$Yn=An + (Bn/Bo)*(Yo-Ao)$$

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 “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

Based on the real conditions measured and applied by the AMS for normalization (TSG in °C and PSG in hPa), the stack gas volume flow values are converted to real conditions before the regression analysis using the ideal gas law. The actual gas volume flow rates are derived from gas velocity measurements, therefore, before applying the regression analysis the gas speed is calculated from the volume flow and the duct cross-section and is fed into the calibrating equation. The calibrated values derived from the calibrating equation then converted back to normalized units using the calibrated real conditions (calibrated TSG and PSG). The normalized calibrated stack gas flow rates are further fed into the emission calculation model for further 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 mgN_2O/m_3. The concentration was converted to ppmv to make it compatible with the regression Lines parameters. The nitrous gas concentration values are then calibrated using the provided regression Lines parameters and are input in the model.

6.4 Stack gas Temperature

The stack gas temperature was calibrated by the regression conversion formula

6.5 Stack gas Pressure

The calibration report provides us with a regression Line for the stack gas pressure. We calibrate the readings of the measurements system using the regression formula and applying the values (in kPa).

7. EMISSION REDUCTION CALCULATIONS

Table T 2 illustrates the establishment of historic campaign length based on 5 previous campaigns. Average production in 5 campaigns preceding the baseline campaign was 61 599 $tHNO_3$ and time duration was on average 241 days. Table contains also information on suppliers of primary catalysts for the line 6.

T 2 Historic campaigns

Line	ACHEMA UKL-6	Production	Start	End	Days	Production per day	Primary Catalyst	Composition
Historic Campaigns	**1** t HNO3	62 918	28 Aug 2003	25 Mar 2004	210	300	Heraeus	N/A *
	2 t HNO3	61 366	01 Apr 2004	02 Feb 2005	307	200	Johnson Matthey	N/A *
	3 t HNO3	64 872	26 Jul 2005	10 Mar 2006	227	286	Johnson Matthey	N/A *
	4 t HNO3	55 693	10 Mar 2006	29 Nov 2006	264	211	Umicore	N/A *
	5 t HNO3	63 148	29 Nov 2006	12 Jun 2007	195	324	Heraeus	N/A *
Average HNO3 production	t HNO3	**61 599**			**241**	**256**	* Confidential but available for the verification	
Project Campaigns	**BL** t HNO3	60 850	11 Jan 2008	21 Jul 2008	192	317	Heraeus	N/A *
	PL t HNO3	109 827	01 Oct 2010	10 Aug 2011	314	350	Heraeus	N/A *

The project campaign production value of 110 337 tHNO3 was higher than historic nitric acid production set at level of 61 599 tHNO3.

It is business as usual scenario in Achema UKL-7 plant to keep using primary catalysts from several suppliers and with several compositions. Selection of primary catalysts is determined by technical parameters of their use and price levels offered by suppliers in specific time. Primary catalysts used during the baseline campaign, if other than used in previous campaign/s, did not increase emissions of N2O as confirmed by relevant statements provided to the verifier.

T 3 and Chart C 1 define the length of the baseline campaign. Baseline campaign measurements for this project campaign started on 11/01/2008 and continued through 21/07/2008 when the 60 850 $tHNO_3$ nitric acid production was reached. The measurement of baseline Nitrous Acid Concentration (NCSG) was carried out until production reached - $tHNO_3$.

T 3 Baseline campaign length

ACHEMA UKL-6	Historic Campaings End	Start of Baseline Measurement	End of Baseline Measurement NCSG	End of Baseline Measurement	End of Baseline Campaign
Dates	2007 Jun 12	2008 Jan 11	2008 Jul 21	2008 Jul 21	2008 Jul 22
Baseline Factor kgN2O/tHNO3	-	-	10.34	10.34	10.34
Production tHNO3		-	60 850	60 850	-
Per Day Production tHNO3	256.0				
Baseline less Historic Production	**(749.3)**				
Baseline less Historic Days	**(2.9)**				

C 1 Baseline campaign length

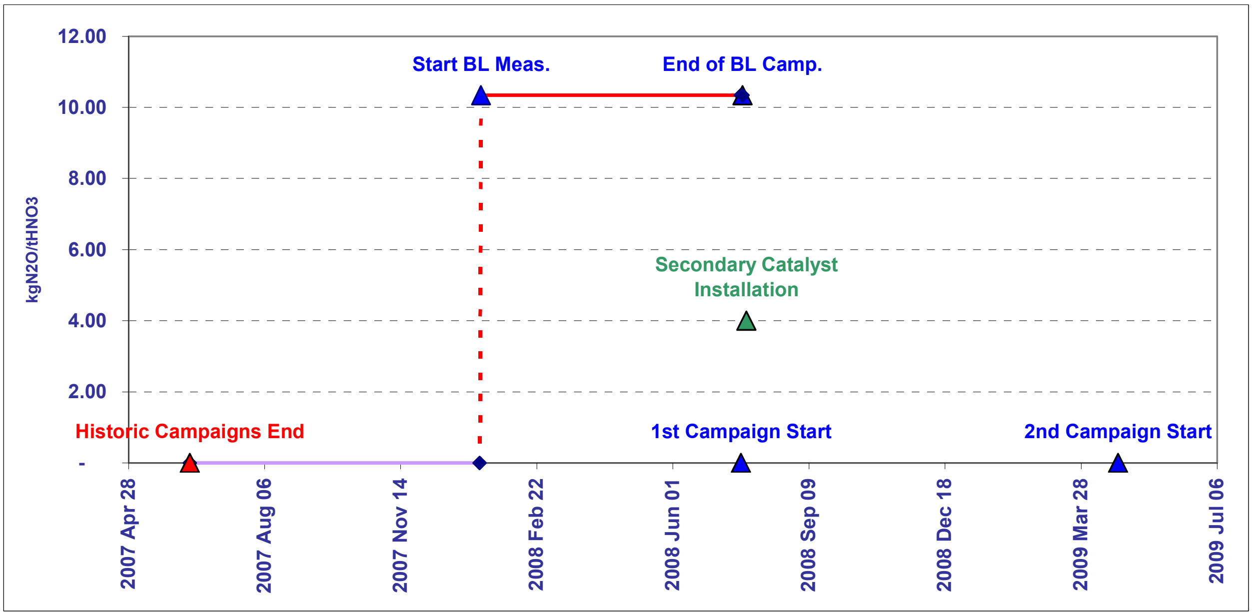


Table T 4 illustrates the calculation of the baseline emission factor on Line 6 using the method as defined in the CDM methodology AM0034 and in the PDD. We have not used overlapping approach allowed by the PDD. Baseline emission factor was determined based on raw data measured from 11/01/2008 through 21/07/2008.

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 N_2O 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 N_2O 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 667 tN_2O.

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

The UNC factor defined by the QAL2 report is 5.620%, which is further modified by an uncertainty of 0.105% due to under-sampling. As a result we have arrived to the baseline emission factor of 10.34 $kgN_2O/tHNO_3$.

Table T 5 shows the calculation of the project emission factor on Line 6 during the project campaign. Project campaign started on 01/10/2010 and went through 10/08/2011.

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

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

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

$PE_n = VSG * NCSG * 10\text{-}9 * OH\ (tN2O)$

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 350 tHNO3/day) we have determined the project campaign specific emission factor at value of 4.03 kgN2O/tHNO3.

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

Because the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this campaign.

T 4 Baseline emission factor

BASELINE EMISSION FACTOR										
Code **Unit**	**Operating Hours** **OH** **h**	**Nitric Acid Production** **NAP** **t/h**	**N2O Concentration** **NCSG** **mg N2O/Nm3**	**Gas Volume Flow** **VSG** **Nm3/h**	**Ammonia Flow Rate** **AFR** **Nm3/h**	**Ammonia to Air Ratio** **AIFR** **%**	**Oxidation Temperature** **OT** **°C**	**Oxidation Pressure** **OP** **kPa**	**AMS in Operation** **h**	**Nitric Acid Production NCSG** **NAP** **t/h**
Elimination of extreme values										
Lower limit		0	0	0	0	0	- 50	0		0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000		50
Raw Data Measured Range										
Count	**4 233**	4 363	4 494	4 290	4 324	4 361	4 585	4 564	3 944	4 363
as % of Dataset	*92%*	*95%*	*98%*	*93%*	*94%*	*95%*	*100%*	*99%*	*86%*	*95%*
Minimum		-	1	2	568	-	(1)	0		-
Maximum		16.37	2 303	117 970	6 423	15.58	905	634		16
Mean		13.95	1 422	99 960	6 050	10.50	833	583		14
Standard Deviation		3.18	416	17 673	456	1.70	201	44		3
Total		60 850								60 850
N2O Emissions (VSG * NCSG * OH)	602	t N2O								
Emission Factor	9.33	kgN2O / tHNO3								
Permitted Range										
Minimum					4 500	0	880	0		
Maximum					7 500	11.70	910	800		
Data within the permitted range										
Count	**4 116**		4 015	4 015					3 944	
as % of Operating Hours	***97%***		*95%*	*95%*					*93%*	
Minimum			7	10 156						
Maximum			2 074	110 925						
Mean			1 456	103 058						
Standard Deviation			312	2 541						
N2O Emissions (VSG * NCSG * OH)	635	t N2O								
Emission Factor	9.85	kgN2O / tHNO3								
Data within the confidence interval										
95% Confidence interval										
Lower bound			844	98 078						
Upper bound			2 068	108 039						
Count			3 695	3 991						
as % of Operating Hours			*87%*	*94%*						
Minimum			997	98 180						
Maximum			2 062	108 018						
Mean			1 528	103 105						
Standard Deviation			201	1 728						
N2O Emissions (VSG * NCSG * OH)	**667**	**t N2O**								
Emission Factor (EF_BL)	**10.34**	**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	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa
Elimination of extreme values								
Lower limit		0	0	0	0	0	- 50	0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000
Raw Data Measured Range								
Count	**7 103**	7 478	6 969	7 070	7 528	7 110	7 528	7 501
as % of Dataset	*94%*	*99%*	*93%*	*94%*	*100%*	*94%*	*100%*	*100%*
Minimum		-	90	61	142	0	20	0
Maximum		17.82	528	101 511	7 714	19.73	903	703
Mean		14.75	422	90 039	6 174	10.34	847	609
Standard Deviation		2.56	53	5 782	857	0.22	182	39
Total		110 337						
N2O Emissions (VSG * NCSG * OH)	270	t N2O						
Emission Factor	2.44	kgN2O / tHNO3						
Data within the confidence interval								
95% Confidence interval								
Lower bound			319	78 706				
Upper bound			525	101 373				
Count			6 686	7 011				
as % of Operating Hours			*94%*	*99%*				
Minimum			319	78 814				
Maximum			524	100 878				
Mean			425	90 399				
Standard Deviation			48	2 951				
N2O Emissions (VSG * NCSG * OH)	**273**	**t N2O**						
Actual Project Emission Factor (EF_PActual)	**2.48**	**kgN2O / tHNO3**						
Abatement Ratio	**76.1%**							
Moving Average Emission Factor Correction	**Actual Factors**	**Moving Average Rule**						
1	4.94	4.94						
2	4.39	4.67						
3	4.31	4.55						
4	2.48	4.03						
5	-							
Project Emission Factor (EF_P)	**4.03**	**kgN2O / tHNO3**						
Abatement Ratio	**61.1%**							

MONITORING REPORT

PROJECT: ACHEMA UKL nitric acid plant N_2O abatement project
LINE: Line 7
MONITORING PERIOD:
FROM: 10/12/2010

TO: 30/08/2011

Prepared by:

VERTIS

VERTIS FINANCE

www.vertisfinance.com

Table of Contents

1. EXECUTIVE SUMMARY

This monitoring report determines baseline emission factor for the Line 7 of ACHEMA UKL nitric acid plant and quantity of emission reduction generated during the fourth project campaign on Line 7.

The first project campaign on Line 7 started on 28/03/2008. Secondary catalyst was installed on 03/07/2008. Total quantity of emission reductions generated during the fourth project period from 10/12/2010 through 30/08/2011 on Line 7 is **163 985 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	9.09	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	2.01	kgN2O/tHNO3
Nitric Acid Produced in the Baseline Campaign	NAP_BL	55 626	tHNO3
Nitric Acid Produced in the NCSG Baseline Campaign	NAP_BL_NCSG	55 626	tHNO3
Nitric Acid Produced in the Project Campaign	NAP_P	74 715	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**163 985**	**tCOe**
*ER=(EF_BL-EF_P)*NAP_P*GWP/1000*			
Abatement Ratio		**87.7%**	

EMISSION REDUCTION PER YEAR			
Year	2009	2010	2011
Date From		10 Dec 2010	01 Jan 2011
Date To		31 Dec 2010	30 Aug 2011
Nitric Acid Production		6 843	67 872
Emission Reduction		**15 019**	**148 966**
*ER_YR = ER * NAP_P_YR / NAP_P*			

Baseline emission factor established for the Line 7 during baseline measurement carried from 12/09/2007 through 27/03/2008 is 9.09 kgN_2O/tHNO_3.

Project emission factor during the fourth project campaign after installation of secondary catalysts on Line 7, which started on 10/12/2010 and went through 30/08/2011 with secondary catalyst installed and commissioned on 03/07/2008, is 2.01 kgN_2O/tHNO_3.

During the project campaign 74 715 tonnes of nitric acid was produced.

2. DESCRIPTION OF THE PROJECT ACTIVITY

Purpose of the Project (the “Project”) is the reduction of nitrous oxide (N_2O) emissions from nitric acid production Lines at the UKL-7 nitric acid plant of AB Achema (“Achema” or “the Company”). The Company is situated in Jonava, Lithuania.

Achema has installed and operates secondary N_2O reduction catalysts underneath the primary catalyst precious metal catching and catalytic gauzes package in the ammonium burners of the UKL-7 nitric acid plant.

This monitoring report contains information on Line 7 emission reductions including information on baseline emission factor setting for the Line 7.

The separate treatment of 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 requirements 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 7 has been established on the Line-specific basis. Campaign used for baseline measurements on the line 7 has been carried out from 12/09/2007 through 27/03/2008.

N_2O concentration and gas volume flow are monitored by monitoring system complying with requirements of the European Norm 14181.

Monitoring system provides separate readings for N_2O 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 N_2O 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 N_2O concentration of stack gas (NCSG))

The average mass of N_2O emissions per hour is estimated as product of the NCSG and VSG. The N_2O emissions per campaign are estimates product of N_2O 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 N_2O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N_2O 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 N_2O emission factor per tonne of nitric acid produced in the baseline period (EFBL) 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

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from the Line 7 tail gas duct at sampling point located after expansion turbine and transported by sample Line to the Monitoring room B, where the analyzer is located.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis.

N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production lines. N_2O concentration is measured by 3 concentration meters on a switched basis.

N_2O concentration measured data are sent from the analyzer on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

3.1.2 Tail gas flow rate, pressure and temperature

Tail gas flow, pressure and temperature is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section. Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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 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 5 campaigns), has been used as a cap on the length of the baseline campaign.

4. PROJECT EMISSIONS

During the first project campaign on line 7 the tail gas volume flow in the stack of the nitric acid plant as well as N_2O concentration have been measured on the 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 N_2O 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

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

where:

Variable	**Definition**
VSG	Mean stack gas volume flow rate for the project campaign (m^3/h)
NCSG	Mean concentration of N_2O in the stack gas for the project campaign (mgN_2O/m^3)
PE_n	Total N_2O emissions of the n^{th} project campaign (tN_2O)
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 the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this campaign.

4.2 Minimum project emission factor

The minimum average emission factor established factor will be established after 10th project campaign.

4.3 Project Campaign Length

Project campaign production of nitric acid has been below defined nameplate capacity and thus all NAP produced from date of installation of secondary catalysts has been used for calculation of emission reductions.

Because the nitric acid production during the project was higher than the baseline, all of the baseline NCSG values were used to determine the baseline emission factor.

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 N_2O:

$$ER = (EFBL – EFP) * NAP *GWPN_2O \ (tCO_2e)$$

Where:

Variable	**Definition**
ER	Emission reductions of the project for the specific campaign (tCO_2e)
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 ($tN_2O/tHNO_3$)
EFP	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of $EF_{ma,n}$ and EF_n)

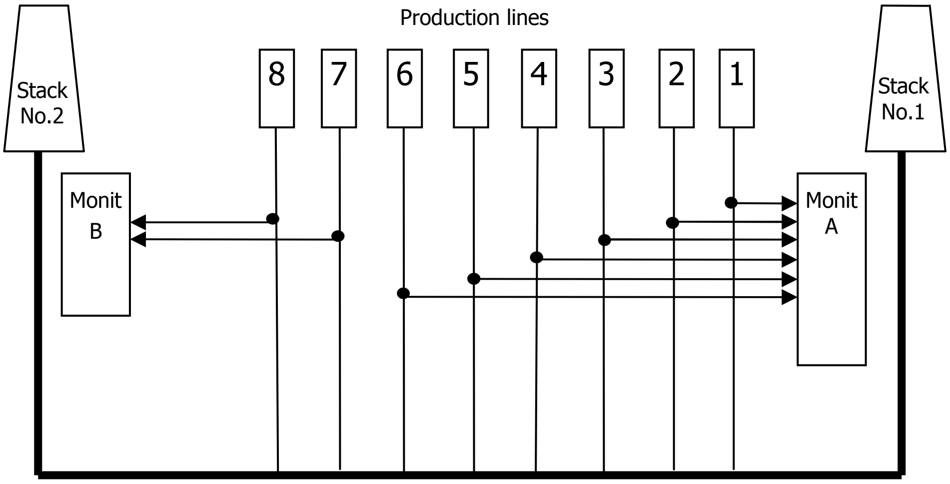
5. MONITORING PLAN

Purpose of the monitoring plan

The purpose of the monitoring plan is to describe the system used to monitor emissions of N_2O from the plant in such a way that is compliant with the prescriptions of the AM0034/Version 02.

Plant description

The UKL-7 nitric acid plant comprises 8 production Lines numbered from 1 through 8, each with its own burner, absorption column and expansion turbine. Each production Line represents a separate nitric acid production unit independent from each other. The tail gasses from each Line are after expansion turbines led to a common stack bus and vented through two interconnected stacks.



Primary catalyst is changed at different times thus it is necessary to measure the emissions from each Line individually. This means that eight separate sets of monitoring equipment are installed to measure tail gas flow, nitric acid production, nitric acid concentration, and the operating conditions. N_2O concentration in the tail gas is measured by 3 switched concentration meters.

Monitoring System architecture

Methodology AM0034/Version 02 requires installation of an N_2O monitoring system that includes both a gas volume flow meter to determine the tail gas mass volume flow and an infrared gas analyser to determine the concentration of N_2O.

But tail gas N_2O concentration meter and tail gas volume flow meter alone are not sufficient for a JI project purposes. In order of being able to calculate the baseline emission factor expressed as tonnage of N_2O in t CO_2e per 1 tonne of HNO_3 (100%), it is necessary to include also HNO_3 measurement, and in order of being able to document normal operating conditions it is necessary to include also operating conditions measurement.

Because of this we use the term Monitoring System (MS) to describe entire monitoring system directly and indirectly used for the JI purposes, while Automated Measurement System (AMS) covers only N_2O emissions and tail gas mass volume part of the MS.

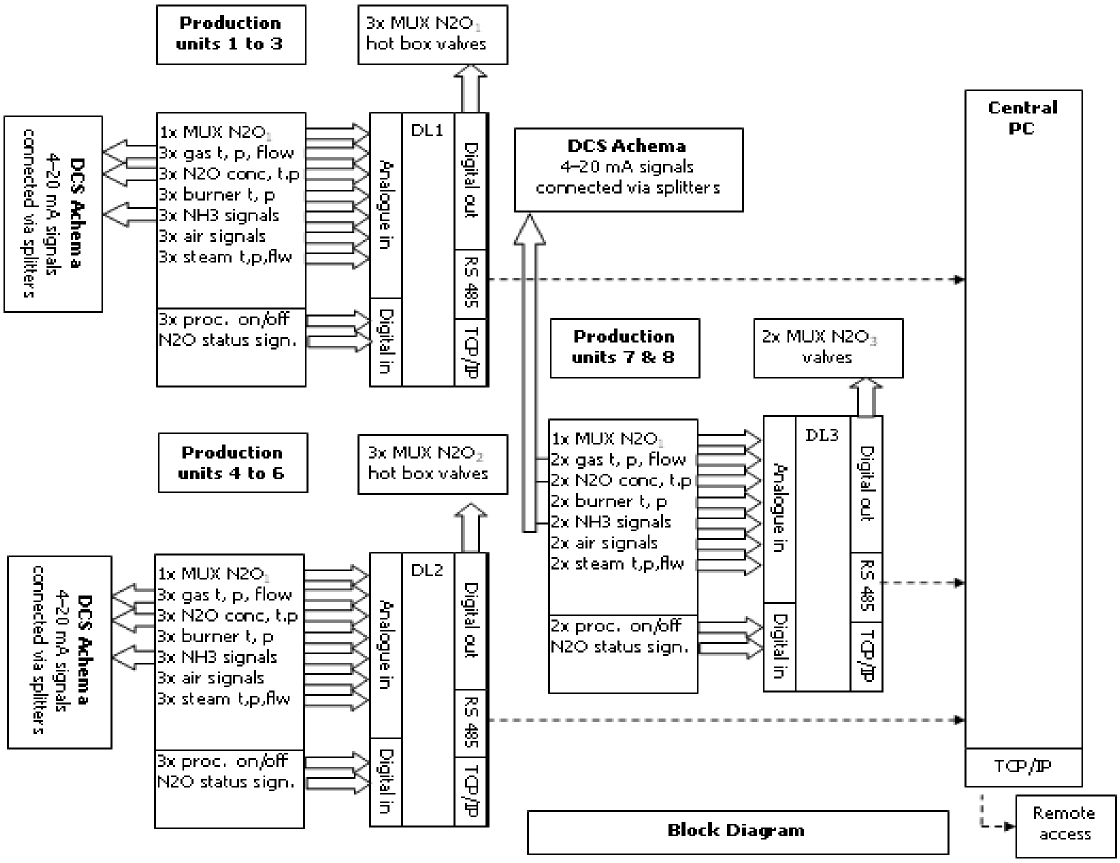
Monitoring System (MS) for purpose of this monitoring plan means:

monitoring system measuring operational conditions;
Ammonia volume flow
Ammonia temperature
Ammonia pressure
Primary air volume flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

nitric acid 100% concentrate production;
Nitric acid concentration
Nitric acid flow
Nitric acid temperature

and newly installed measurement devices for measurement of N2O concentration and tail gas flow, temperature and pressure (AMS)
N_2O concentration in the stack
Stack volume flow rate
Stack gas temperature
Stack gas pressure

Incorporation of the AMS into the MS by interfacing already existing and newly installed measurement devices is documented by the diagram below.



N_2O automated measurement system

Main purpose of the N_2O automated measurement system (AMS) is to measure total mass of N_2O emitted during particular campaigns (both baseline and project). In order of calculation of total mass of N_2O emitted during particular campaign it is necessary to measure on an extractive basis the N_2O concentration in a tail gas and on a non-extractive basis tail gas flow, pressure and temperature.

N_2O concentration

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from respective tail gas ducts at sampling points located after expansion turbines and transported by heated sample lines to the Monitoring room A located next to the main production hall. This applies to 2 concentration meters measuring lines 1-3 and lines 4-6. lines 7-8 are measured by third concentration meter located at the other side of the production hall (Monitoring room B) physically closer to respective production lines 7 and 8.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis. Correction of dry basis ppmV value to real wet tail

gas conditions based on steam flow injected into the system is part of both - the project emissions calculations and baseline emission factor calculations.

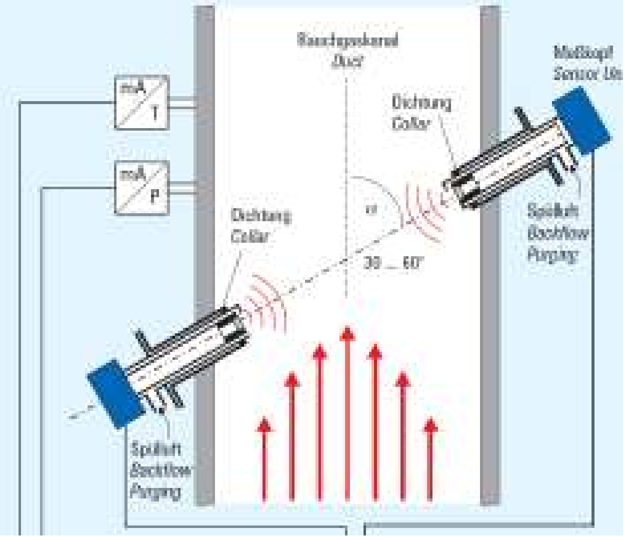
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production Lines. N_2O concentration is measured by 3 concentration meters on a switched basis. Tail gas samples are automatically switched. Under-sampling uncertainty is part of both - the project emissions calculations and baseline emission factor calculations.

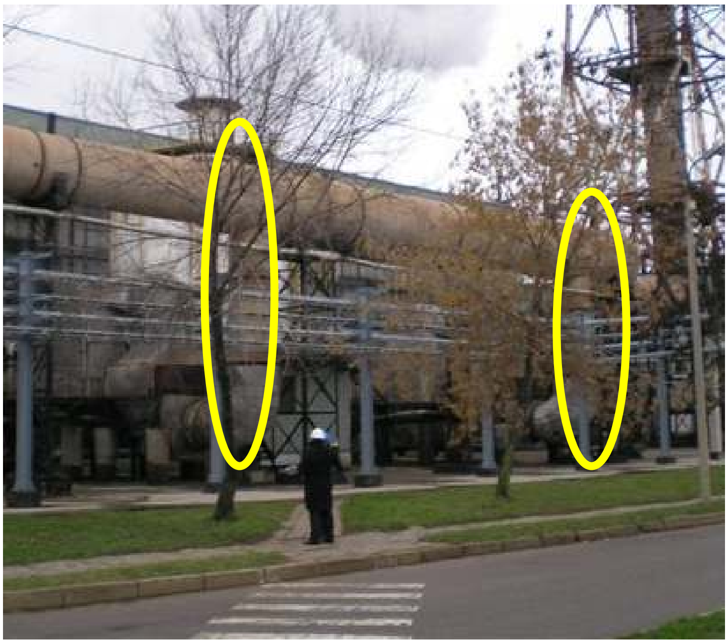
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas flow, pressure and temperature

Tail gas flow is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section.



The tail gas ducts do not allow any optimum location to perform the flow monitoring. The only possible location is the quite short vertical tube behind the 90° “knee”.



Since the flow is not really laminar, a classical Pitot tube one point solution wouldn't allow good results. The ultrasonic system is under these conditions superior to differential pressure. Cross duct monitoring is more accurate than a couple of discrete point averaged pressure.

Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas steam injection elimination

Steam injected into the Achema UKL-7 tail gas for purpose of increasing the turbine output is eliminated from the tail gas mass flow calculation by following formulae:

flow - STVF= Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325)*((100-Humi)/100)

where Humi (water content)=

(Flow_steam*1.2436)/(Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325))*100+0.6

where 1.2436 is the conversion factor from kg/h to Nm3/h and 0.6% is a value of humidity present in a flue gas permanently without steam injection

The Flow_steam parameter necessary for calculation of the water content in the dataloggers is provided in the kg/h unit.

Achema measures steam flow in kg/h using formula Q=C*sqrt(dp) , where C is flow constant which is already integrated using an orifice plate sizing program. The orifice plate calculation for injection steam has been done for temperature 250˚C and pressure 6 bar.

Flow steam in kg/h measured by using the constant steam T and P values is then recalculated to actual steam T and P values valid for relevant hours and as result the STVF value cleaned of the steam injected is used for further emission reductions calculations.

EN14181 compliance

As required by the AM0034/Version 02 methodology the N_2O automated measurement system (AMS) complies with requirements of the technical norm EN14181. N_2O AMS consists from the N_2O concentration meter and integrated flowmeter (F, T, P). Both measurement devices are QAL1 certified (concentration meter for the N_2O measurand specifically) and after full commissioning of the monitoring system there was the QAL2 test carried out by an independent laboratory certified according to ISO17025.

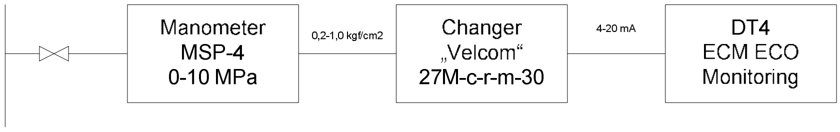
Operating conditions

For purpose of the baseline emissions factor setting it is necessary to monitor and report operating conditions in all 8 burners. Namely:

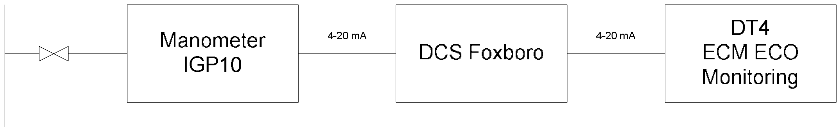
- Ammonia flow
- Ammonia temperature
- Ammonia pressure
- Primary air flow
- Primary air temperature
- Primary air pressure
- Oxidation temperature
- Oxidation pressure

All these parameters are measured by the plant monitoring system as presented on diagrams below:

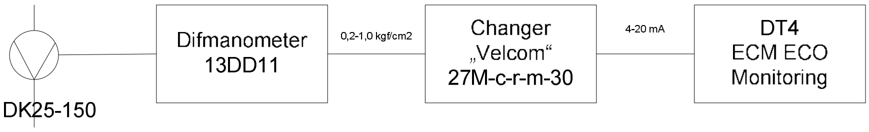
P in mixer 1-6 line



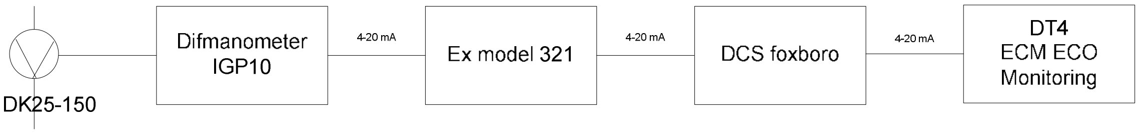
P in mixer 7-8 line



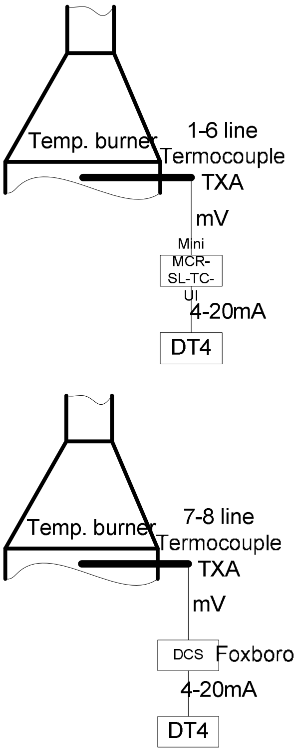
NH3 to mixer 1-6 line



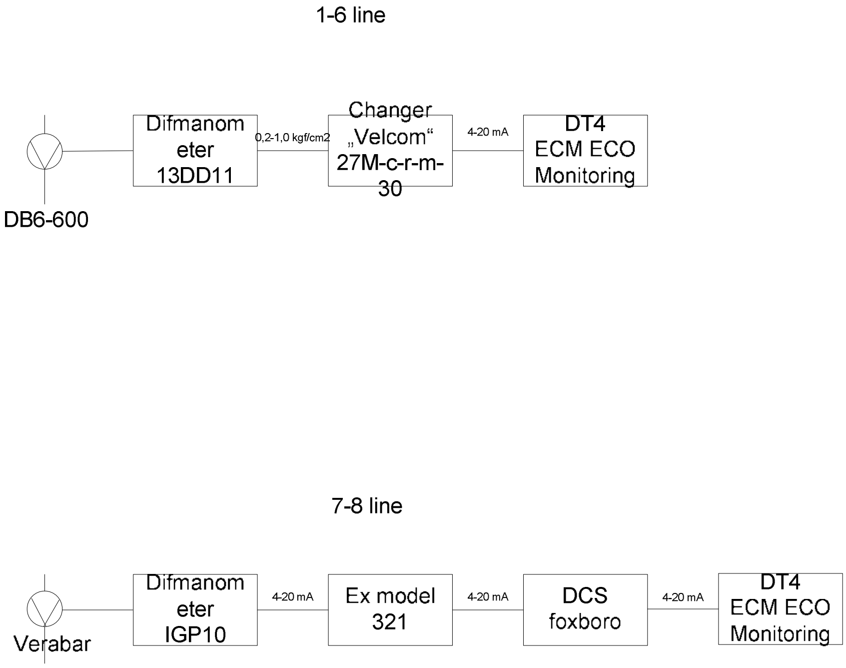
NH3 to mixer 7-8 line



T in burner



Air to mixer



Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further. Maintenance procedures for the ammonia oxidation parameters follow the existing procedures for the operation of the nitric acid plant.

Nitric acid production

Nitric acid concentration is based on two components: nitric acid and water. Standard monitoring method is on-Line refractometry. Measurement of nitric acid (100%) mass volume production per campaign is necessary for calculation of the baseline emissions factor. Nitric acid concentration on all 8 Lines is measured by K-Patents PR-23-GP refractometers.

This analyzer is applying a prism to “return” a generated optical beam back to an LCD detector.

The detector is measuring refraction of monitored liquid based on known refraction of water and nitric acid. The instrument is calibrated for percent concentration of nitric acid. The analyzer is mounted on DIN-flange 2656, PN25 DN80. The optical prism does not require cleaning.

PR-23-GP characteristics:

Measuring RI is a direct concentration measurement principle. No need to rely or convert magnitudes.
Digital instrument – no calibration drift
As it is a robust instrument it is maintenance free
Dual connectivity if the installation positions allow.
On-Line data logging, through Ethernet, on whichever web browser.
No influence by bubbles or particles. It is very common that air enters the process pipeline and still the refractometer measures accurately.

Nitric acid concentration data are in an analog 4-20mA format provided to dataloggers which process these signals further.

In order of being able to calculate total mass volume of nitric acid 100% concentrate produced during the baseline campaign it is necessary to monitor also nitric acid flow and temperature. Measurement of pressure is not necessary for determination of the nitric acid mass volume flow, because nitric acid is in form of liquid and as such it has stabile pressure characteristic.

Signals obtained from the nitric acid flow and temperature measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Nitric acid flow and temperature measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further.

After installation of refractometers there have been occurrences of their failure and following repair service by the manufacturer. For this period starting from 04/05/2008 and ending on 18/08/2008 project uses HNO_3 concentration data provided by the laboratory measurements.

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
X_o: X 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:

$$Yn=An + (Bn/Bo)*(Yo-Ao)$$

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 “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

Based on the real conditions measured and applied by the AMS for normalization (TSG in °C and PSG in hPa), the stack gas volume flow values are converted to real conditions before the regression analysis using the ideal gas law. The actual gas volume flow rates are derived from gas velocity measurements, therefore, before applying the regression analysis the gas speed is calculated from the volume flow and the duct cross-section and is fed into the calibrating equation. The calibrated values derived from the calibrating equation then converted back to normalized units using the calibrated real conditions (calibrated TSG and PSG). The normalized calibrated stack gas flow rates are further fed into the emission calculation model for further 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 mgN_2O/m_3. The concentration was converted to ppmv to make it compatible with the regression Lines parameters. The nitrous gas concentration values are then calibrated using the provided regression Lines parameters and are input in the model.

6.4 Stack gas Temperature

The stack gas temperature was calibrated by the regression conversion formula

6.5 Stack gas Pressure

The calibration report provides us with a regression Line for the stack gas pressure. We calibrate the readings of the measurements system using the regression formula and applying the values (in kPa).

7. EMISSION REDUCTION CALCULATIONS

Table T 2 illustrates the establishment of historic campaign length based on 5 previous campaigns. Average production in 5 campaigns preceding the baseline campaign was 64 274 $tHNO_3$ and time duration was on average 218 days. Table contains also information on suppliers of primary catalysts for the line 7.

T 2 Historic campaigns

Line	ACHEMA UKL-7	Production	Start	End	Days	Production per day	Primary Catalyst	Composition
Historic Campaigns	**1** t HNO3	57 671	10 Sep 2004	16 Mar 2005	187	308	Heraeus	N/A *
	2 t HNO3	70 015	16 Mar 2005	07 Nov 2005	236	297	Johnson Matthey	N/A *
	3 t HNO3	55 426	08 Nov 2005	20 May 2006	193	287	Heraeus	N/A *
	4 t HNO3	67 588	24 May 2006	04 Jan 2007	225	300	Johnson Matthey	N/A *
	5 t HNO3	70 670	04 Jan 2007	11 Sep 2007	250	283	Umicore	N/A *
Average HNO3 production	t HNO3	**64 274**			**218**	**295**	* Confidential but available for the verification	
Project Campaigns	**BL** t HNO3	55 626	12 Sep 2007	27 Mar 2008	197	282	Heraeus	N/A *
	PL t HNO3	74 715	10 Dec 2010	30 Aug 2011	263	284	Heraeus	N/A *

The project campaign production value of 74 715 tHNO3 was higher than historic nitric acid production set at level of 64 274 tHNO3.

It is business as usual scenario in Achema UKL-7 plant to keep using primary catalysts from several suppliers and with several compositions. Selection of primary catalysts is determined by technical parameters of their use and price levels offered by suppliers in specific time. Primary catalysts used during the baseline campaign, if other than used in previous campaign/s, did not increase emissions of N2O as confirmed by relevant statements provided to the verifier.

T 3 and Chart C 1 define the length of the baseline campaign. Baseline campaign measurements for this project campaign started on 12/09/2007 and continued through 27/03/2008 when the 55 626 $tHNO_3$ nitric acid production was reached. The measurement of baseline Nitrous Acid Concentration (NCSG) was carried out until production reached - $tHNO_3$.

T 3 Baseline campaign length

ACHEMA UKL-7	Historic Campaings End	Start of Baseline Measurement	End of Baseline Measurement NCSG	End of Baseline Measurement	End of Baseline Campaign
Dates	2007 Sep 11	2007 Sep 12	2008 Mar 27	2008 Mar 27	2008 Mar 28
Baseline Factor kgN2O/tHNO3	-	-	9.09	9.09	9.09
Production tHNO3		-	55 626	55 626	-
Per Day Production tHNO3	294.6				
Baseline less Historic Production	**(8 647.4)**				
Baseline less Historic Days	**(29.4)**				

C 1 Baseline campaign length

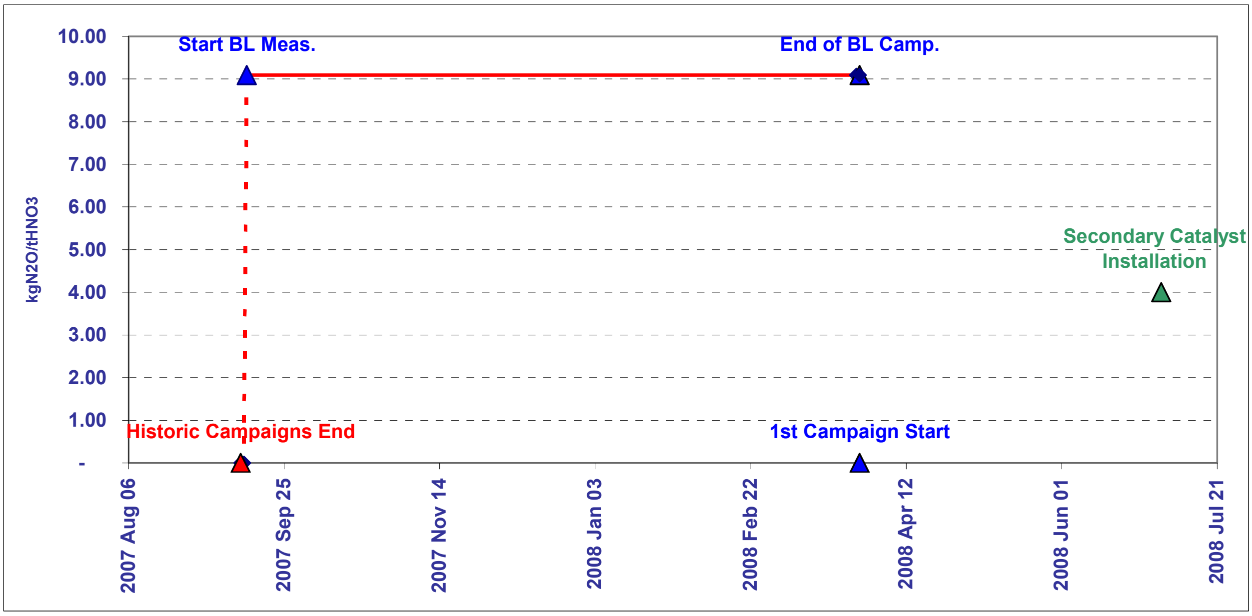


Table T 4 illustrates the calculation of the baseline emission factor on Line 7 using the method as defined in the CDM methodology AM0034 and in the PDD. We have not used overlapping approach allowed by the PDD. Baseline emission factor was determined based on raw data measured from 12/09/2007 through 27/03/2008.

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 N_2O 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 N_2O 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 536 tN_2O.

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

The UNC factor defined by the QAL2 report is 5.640%, which is further modified by an uncertainty of 0.124% due to under-sampling. As a result we have arrived to the baseline emission factor of 9.09 $kgN_2O/tHNO_3$.

Table T 5 shows the calculation of the project emission factor on Line 7 during the project campaign. Project campaign started on 10/12/2010 and went through 30/08/2011.

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

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

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

$$PE_n = VSG * NCSG * 10\text{-}9 * OH \ (tN2O)$$

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 350 tHNO3/day) we have determined the project campaign specific emission factor at value of 2.01 kgN2O/tHNO3.

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

Because the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this 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	AMS in Operation	Nitric Acid Production NCSG
Code	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP		NAP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa	h	t/h
Elimination of extreme values										
Lower limit		0	0	0	0	0	- 50	0		0
Upper Limit		50.00	3 000	150 000	10 000	20.00	1 200	1 000		50
Raw Data Measured Range										
Count	**4 097**	4 238	4 385	4 238	4 708	4 485	4 708	4 708	3 890	4 238
as % of Dataset	*87%*	*90%*	*93%*	*90%*	*100%*	*95%*	*100%*	*100%*	*82%*	*90%*
Minimum		0.00	0	1 728	0	0	33	3		0
Maximum		16.41	1 933	112 864	6 476	18.83	915	667		16
Mean		13.13	1 250	81 347	5 394	9.92	811	590		13
Standard Deviation		4.69	448	24 945	1 806	1.37	228	112		5
Total		55 626								55 626
N2O Emissions (VSG * NCSG * OH)	417	t N2O								
Emission Factor	7.07	kgN2O / tHNO3								
Permitted Range										
Minimum					-	0	880	550		
Maximum					7 500	11.20	910	800		
Data within the permitted range										
Count	**3 145**		2 856	2 856					3 890	
as % of Operating Hours	***77%***		*70%*	*70%*					*95%*	
Minimum			722	57 328						
Maximum			1 933	99 189						
Mean			1 433	89 644						
Standard Deviation			281	5 811						
N2O Emissions (VSG * NCSG * OH)	526	t N2O								
Emission Factor	8.93	kgN2O / tHNO3								
Data within the confidence interval										
95% Confidence interval										
Lower bound			882	78 254						
Upper bound			1 984	101 034						
Count			2 753	2 841						
as % of Operating Hours			*67%*	*69%*						
Minimum			913	78 697						
Maximum			1 933	99 189						
Mean			1 457	89 755						
Standard Deviation			257	5 588						
N2O Emissions (VSG * NCSG * OH)	**536**	**t N2O**								
Emission Factor (EF_BL)	**9.09**	**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	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa
Elimination of extreme values								
Lower limit		0	0	0	0	0	- 50	0
Upper Limit		50.00	3 000	150 000	10 000	20.00	1 200	1 000
Raw Data Measured Range								
Count	**5 272**	5 973	5 238	5 231	6 285	5 372	6 285	6 285
as % of Dataset	*84%*	*95%*	*83%*	*83%*	*100%*	*85%*	*100%*	*100%*
Minimum		0.02	76	64 105	5	0	42	1
Maximum		18.90	559	81 511	8 000	19.31	902	676
Mean		12.51	231	70 207	4 877	10.37	773	555
Standard Deviation		4.69	36	2 311	1 773	0.26	263	162
Total		74 715						
N2O Emissions (VSG * NCSG * OH)	86	t N2O						
Emission Factor	1.15	kgN2O / tHNO3						
Data within the confidence interval								
95% Confidence interval								
Lower bound			161	65 676				
Upper bound			301	74 737				
Count			4 881	4 970				
as % of Operating Hours			*93%*	*94%*				
Minimum			162	65 684				
Maximum			301	74 731				
Mean			225	70 088				
Standard Deviation			26	2 028				
N2O Emissions (VSG * NCSG * OH)	**83**	**t N2O**						
Actual Project Emission Factor (EF_PActual)	**1.11**	**kgN2O / tHNO3**						
Abatement Ratio	**87.7%**							
Moving Average Emission Factor Correction	**Actual Factors**	**Moving Average Rule**						
1	2.18	2.18						
2	2.93	2.93						
3	1.83	2.31						
4	1.11	2.01						
5	-							
Project Emission Factor (EF_P)	**2.01**	**kgN2O / tHNO3**						
Abatement Ratio	**77.9%**							

MONITORING REPORT

PROJECT: ACHEMA UKL nitric acid plant N_2O abatement project
LINE: Line 8
MONITORING PERIOD:
FROM: 09/11/2010

TO: 01/09/2011

Prepared by:

VERTIS

VERTIS FINANCE

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Table of Contents

1. EXECUTIVE SUMMARY

This monitoring report determines baseline emission factor for the Line 8 of ACHEMA UKL nitric acid plant and quantity of emission reduction generated during the fourth project campaign on Line 8.

The first project campaign on Line 8 started on 17/04/2008. Secondary catalyst was installed on 11/06/2008. Total quantity of emission reductions generated during the fourth project period from 09/11/2010 through 01/09/2011 on Line 8 is **111 857 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	7.23	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	3.03	kgN2O/tHNO3
Nitric Acid Produced in the Baseline Campaign	NAP_BL	63 577	tHNO3
Nitric Acid Produced in the NCSG Baseline Campaign	NAP_BL_NCSG	63 577	tHNO3
Nitric Acid Produced in the Project Campaign	NAP_P	85 912	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**111 857**	**tCOe**
*ER=(EF_BL-EF_P)*NAP_P*GWP/1000*			
Abatement Ratio		**80.2%**	

EMISSION REDUCTION PER YEAR			
Year	2009	2010	2011
Date From		09 Nov 2010	01 Jan 2011
Date To		31 Dec 2010	01 Sep 2011
Nitric Acid Production		18 323	67 589
Emission Reduction		**23 856**	**88 001**
*ER_YR = ER * NAP_P_YR / NAP_P*			

Baseline emission factor established for the Line 8 during baseline measurement carried from 01/09/2007 through 15/04/2008 is 7.23 kgN_2O/tHNO_3.

Project emission factor during the fourth project campaign after installation of secondary catalysts on Line 8, which started on 09/11/2010 and went through 01/09/2011 with secondary catalyst installed and commissioned on 11/06/2008, is 3.03 kgN_2O/tHNO_3.

During the project campaign 85 912 tonnes of nitric acid was produced.

2. DESCRIPTION OF THE PROJECT ACTIVITY

Purpose of the Project (the “Project”) is the reduction of nitrous oxide (N_2O) emissions from nitric acid production Lines at the UKL-7 nitric acid plant of AB Achema (“Achema” or “the Company”). The Company is situated in Jonava, Lithuania.

Achema has installed and operates secondary N_2O reduction catalysts underneath the primary catalyst precious metal catching and catalytic gauzes package in the ammonium burners of the UKL-7 nitric acid plant.

This monitoring report contains information on Line 8 emission reductions including information on baseline emission factor setting for the Line 8.

The separate treatment of 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 requirements 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 8 has been established on the Line-specific basis. Campaign used for baseline measurements on the line 8 has been carried out from 01/09/2007 through 15/04/2008.

N_2O concentration and gas volume flow are monitored by monitoring system complying with requirements of the European Norm 14181.

Monitoring system provides separate readings for N_2O 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 N_2O 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 N_2O concentration of stack gas (NCSG))

The average mass of N_2O emissions per hour is estimated as product of the NCSG and VSG. The N_2O emissions per campaign are estimates product of N_2O 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 N_2O emissions per tonne of nitric acid over one full campaign is derived by dividing the total mass of N_2O 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 N_2O emission factor per tonne of nitric acid produced in the baseline period (EFBL) 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

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from the Line 8 tail gas duct at sampling point located after expansion turbine and transported by sample Line to the Monitoring room B, where the analyzer is located.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis.

N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production lines. N_2O concentration is measured by 3 concentration meters on a switched basis.

N_2O concentration measured data are sent from the analyzer on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

3.1.2 Tail gas flow rate, pressure and temperature

Tail gas flow, pressure and temperature is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section. Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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 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 5 campaigns), has been used as a cap on the length of the baseline campaign.

4. PROJECT EMISSIONS

During the first project campaign on line 8 the tail gas volume flow in the stack of the nitric acid plant as well as N_2O concentration have been measured on the 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 N_2O 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

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

where:

Variable	**Definition**
VSG	Mean stack gas volume flow rate for the project campaign (m^3/h)
NCSG	Mean concentration of N_2O in the stack gas for the project campaign (mgN_2O/m^3)
PE_n	Total N_2O emissions of the n^{th} project campaign (tN_2O)
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 the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this campaign.

4.2 Minimum project emission factor

The minimum average emission factor established factor will be established after 10th project campaign.

4.3 Project Campaign Length

Project campaign production of nitric acid has been below defined nameplate capacity and thus all NAP produced from date of installation of secondary catalysts has been used for calculation of emission reductions.

Because the nitric acid production during the project was higher than the baseline, all of the baseline NCSG values were used to determine the baseline emission factor.

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 N_2O:

$$ER = (EFBL - EFP) * NAP * GWPN_2O \ (tCO_2e)$$

Where:

Variable	**Definition**
ER	Emission reductions of the project for the specific campaign (tCO_2e)
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 ($tN_2O/tHNO_3$)
EFP	Emissions factor used to calculate the emissions from this particular campaign (i.e. the higher of $EF_{ma,n}$ and EF_n)

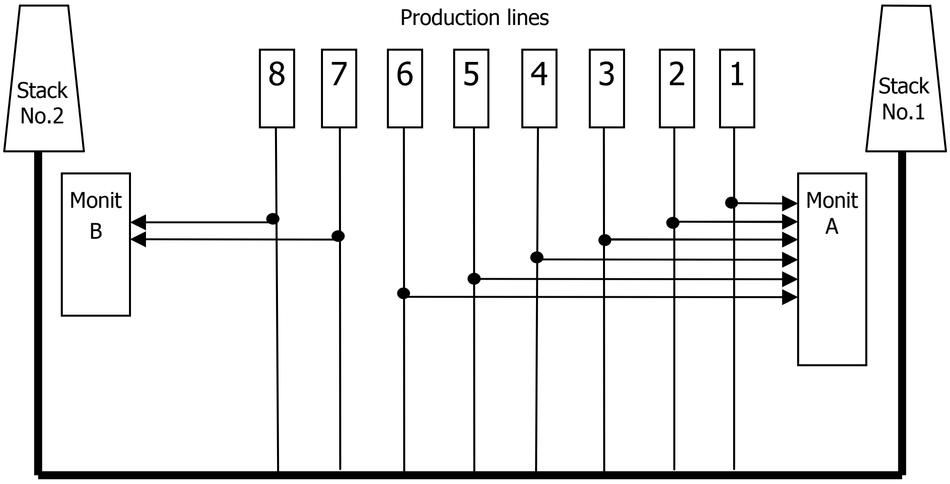
5. MONITORING PLAN

Purpose of the monitoring plan

The purpose of the monitoring plan is to describe the system used to monitor emissions of N_2O from the plant in such a way that is compliant with the prescriptions of the AM0034/Version 02.

Plant description

The UKL-7 nitric acid plant comprises 8 production Lines numbered from 1 through 8, each with its own burner, absorption column and expansion turbine. Each production Line represents a separate nitric acid production unit independent from each other. The tail gasses from each Line are after expansion turbines led to a common stack bus and vented through two interconnected stacks.



Primary catalyst is changed at different times thus it is necessary to measure the emissions from each Line individually. This means that eight separate sets of monitoring equipment are installed to measure tail gas flow, nitric acid production, nitric acid concentration, and the operating conditions. N_2O concentration in the tail gas is measured by 3 switched concentration meters.

Monitoring System architecture

Methodology AM0034/Version 02 requires installation of an N_2O monitoring system that includes both a gas volume flow meter to determine the tail gas mass volume flow and an infrared gas analyser to determine the concentration of N_2O.

But tail gas N_2O concentration meter and tail gas volume flow meter alone are not sufficient for a JI project purposes. In order of being able to calculate the baseline emission factor expressed as tonnage of N_2O in t CO_2e per 1 tonne of HNO_3 (100%), it is necessary to include also HNO_3 measurement, and in order of being able to document normal operating conditions it is necessary to include also operating conditions measurement.

Because of this we use the term Monitoring System (MS) to describe entire monitoring system directly and indirectly used for the JI purposes, while Automated Measurement System (AMS) covers only N_2O emissions and tail gas mass volume part of the MS.

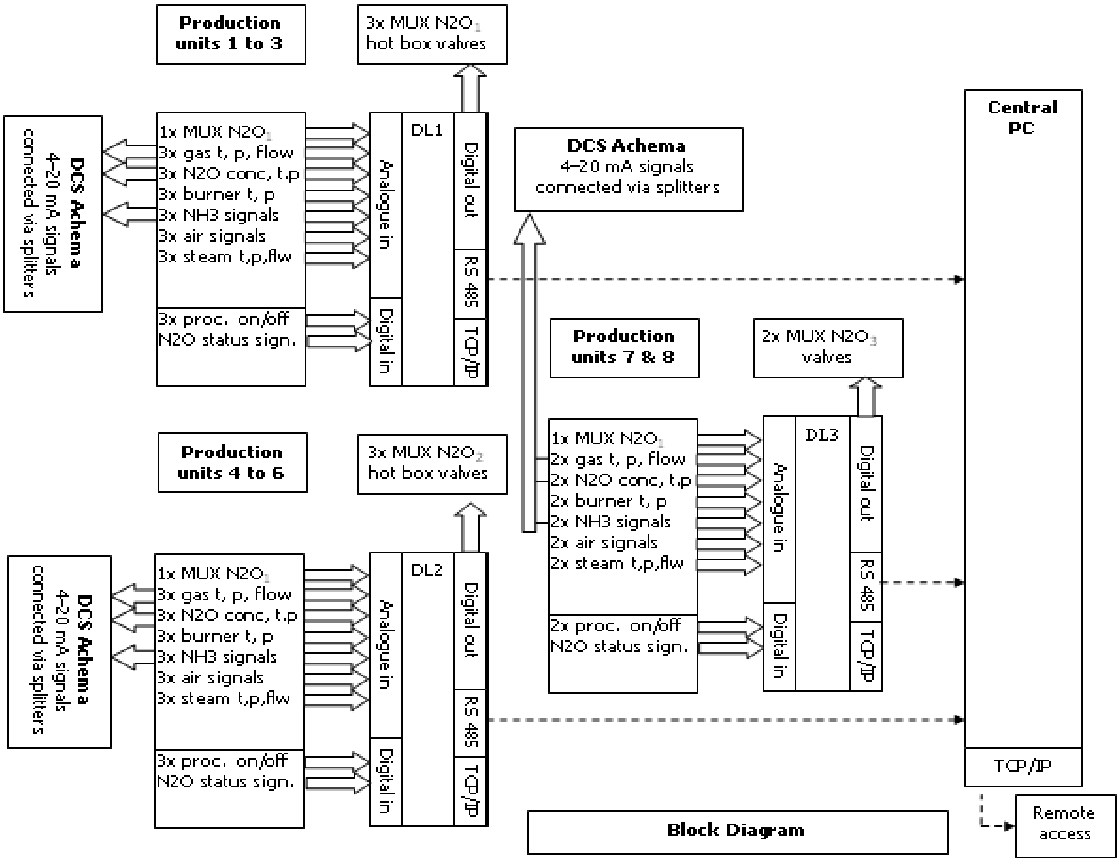
Monitoring System (MS) for purpose of this monitoring plan means:

monitoring system measuring operational conditions;
Ammonia volume flow
Ammonia temperature
Ammonia pressure
Primary air volume flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

nitric acid 100% concentrate production;
Nitric acid concentration
Nitric acid flow
Nitric acid temperature

and newly installed measurement devices for measurement of N2O concentration and tail gas flow, temperature and pressure (AMS)
N_2O concentration in the stack
Stack volume flow rate
Stack gas temperature
Stack gas pressure

Incorporation of the AMS into the MS by interfacing already existing and newly installed measurement devices is documented by the diagram below.



N_2O automated measurement system

Main purpose of the N_2O automated measurement system (AMS) is to measure total mass of N_2O emitted during particular campaigns (both baseline and project). In order of calculation of total mass of N_2O emitted during particular campaign it is necessary to measure on an extractive basis the N_2O concentration in a tail gas and on a non-extractive basis tail gas flow, pressure and temperature.

N_2O concentration

N_2O concentration is measured by extractive measurement system. Tail gas samples are taken from respective tail gas ducts at sampling points located after expansion turbines and transported by heated sample lines to the Monitoring room A located next to the main production hall. This applies to 2 concentration meters measuring lines 1-3 and lines 4-6. lines 7-8 are measured by third concentration meter located at the other side of the production hall (Monitoring room B) physically closer to respective production lines 7 and 8.

Tail gas samples are filtered and conditioned in the condensation dryer (4°C), so N_2O concentration is measured on a dry basis. Correction of dry basis ppmV value to real wet tail

gas conditions based on steam flow injected into the system is part of both - the project emissions calculations and baseline emission factor calculations.

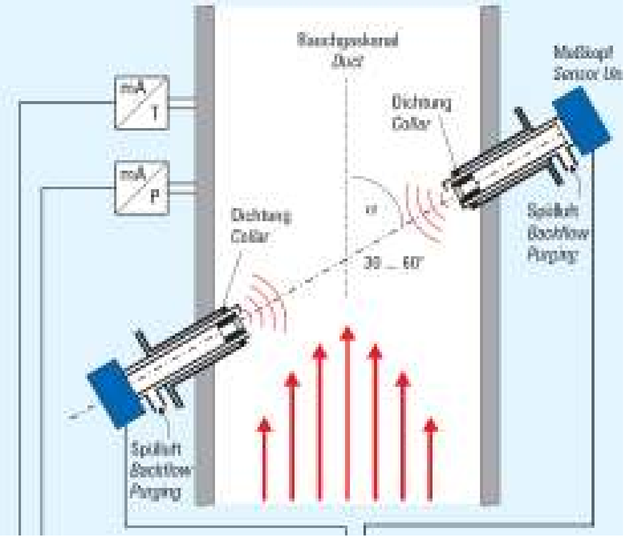
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

Recently there are 8 production Lines. N_2O concentration is measured by 3 concentration meters on a switched basis. Tail gas samples are automatically switched. Under-sampling uncertainty is part of both - the project emissions calculations and baseline emission factor calculations.

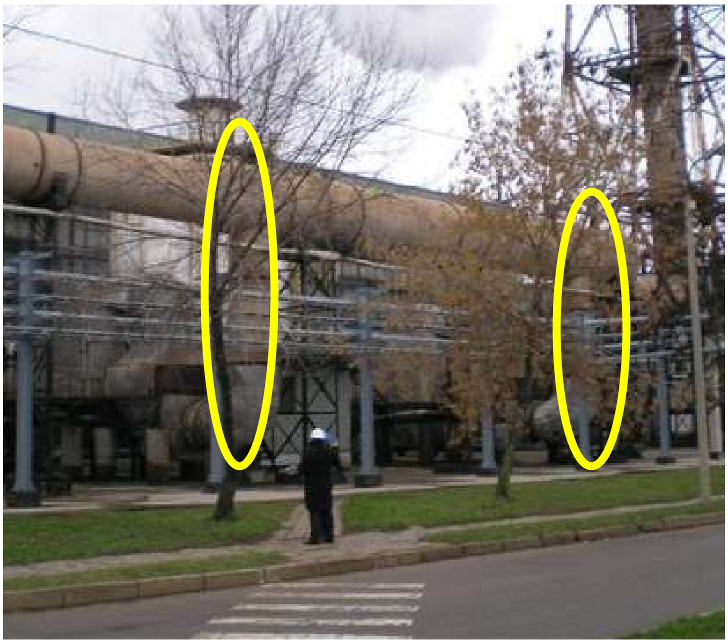
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas flow, pressure and temperature

Tail gas flow is measured by ultrasonic Durag DF-L 200 flowmeters based on ultrasonic pulse fly time across the entire duct cross-section.



The tail gas ducts do not allow any optimum location to perform the flow monitoring. The only possible location is the quite short vertical tube behind the 90° “knee”.



Since the flow is not really laminar, a classical Pitot tube one point solution wouldn't allow good results. The ultrasonic system is under these conditions superior to differential pressure. Cross duct monitoring is more accurate than a couple of discrete point averaged pressure.

Tail gas flow, pressure and temperature measured data are sent from the flow meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

Tail gas steam injection elimination

Steam injected into the Achema UKL-7 tail gas for purpose of increasing the turbine output is eliminated from the tail gas mass flow calculation by following formulae:

flow - STVF= Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325)*((100-Humi)/100)

where Humi (water content)=

(Flow_steam*1.2436)/(Flow_N2O*(273.15/(273.15+Temp))*(Press/101.325))*100+0.6

where 1.2436 is the conversion factor from kg/h to Nm3/h and 0.6% is a value of humidity present in a flue gas permanently without steam injection

The Flow_steam parameter necessary for calculation of the water content in the dataloggers is provided in the kg/h unit.

Achema measures steam flow in kg/h using formula Q=C*sqrt(dp) , where C is flow constant which is already integrated using an orifice plate sizing program. The orifice plate calculation for injection steam has been done for temperature 250˚C and pressure 6 bar.

Flow steam in kg/h measured by using the constant steam T and P values is then recalculated to actual steam T and P values valid for relevant hours and as result the STVF value cleaned of the steam injected is used for further emission reductions calculations.

EN14181 compliance

As required by the AM0034/Version 02 methodology the N_2O automated measurement system (AMS) complies with requirements of the technical norm EN14181. N_2O AMS consists from the N_2O concentration meter and integrated flowmeter (F, T, P). Both measurement devices are QAL1 certified (concentration meter for the N_2O measurand specifically) and after full commissioning of the monitoring system there was the QAL2 test carried out by an independent laboratory certified according to ISO17025.

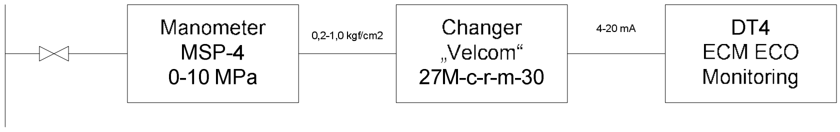
Operating conditions

For purpose of the baseline emissions factor setting it is necessary to monitor and report operating conditions in all 8 burners. Namely:

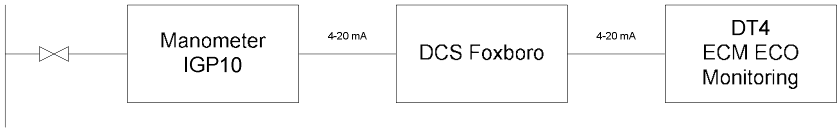
Ammonia flow
Ammonia temperature
Ammonia pressure
Primary air flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

All these parameters are measured by the plant monitoring system as presented on diagrams below:

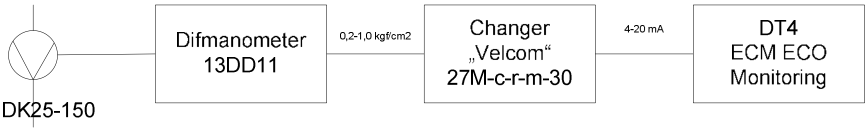
P in mixer 1-6 line



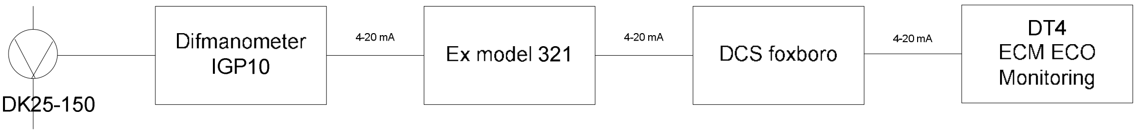
P in mixer 7-8 line

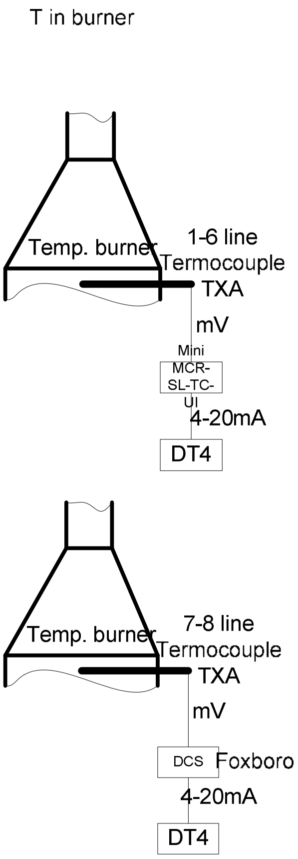


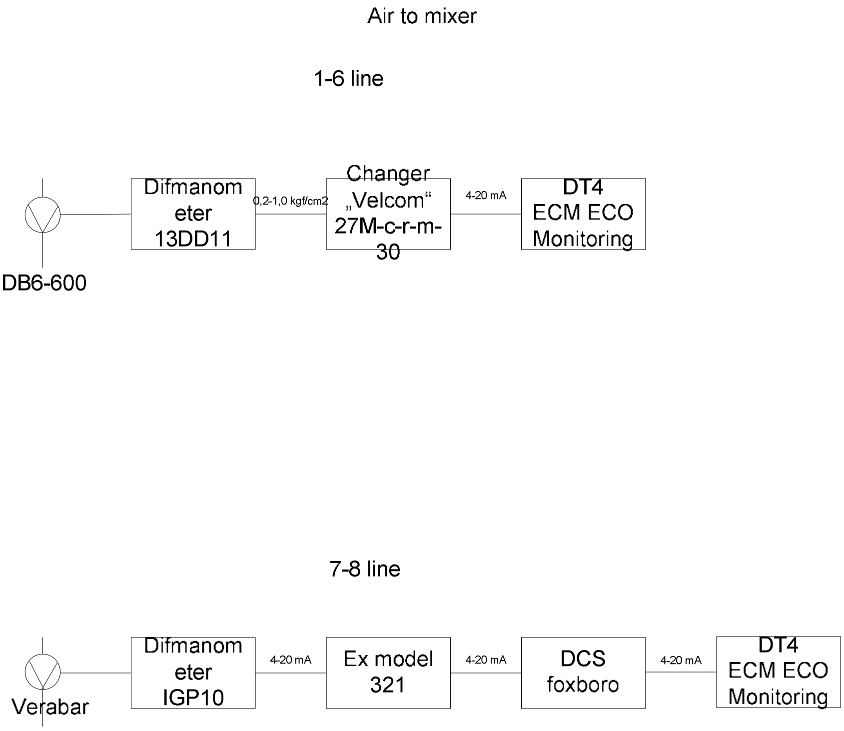
NH3 to mixer 1-6 line



NH3 to mixer 7-8 line







Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further. Maintenance procedures for the ammonia oxidation parameters follow the existing procedures for the operation of the nitric acid plant.

Nitric acid production

Nitric acid concentration is based on two components: nitric acid and water. Standard monitoring method is on-Line refractometry. Measurement of nitric acid (100%) mass volume production per campaign is necessary for calculation of the baseline emissions factor. Nitric acid concentration on all 8 Lines is measured by K-Patents PR-23-GP refractometers.

This analyzer is applying a prism to “return” a generated optical beam back to an LCD detector.

The detector is measuring refraction of monitored liquid based on known refraction of water and nitric acid. The instrument is calibrated for percent concentration of nitric acid. The analyzer is mounted on DIN-flange 2656, PN25 DN80. The optical prism does not require cleaning.

PR-23-GP characteristics:

- Measuring RI is a direct concentration measurement principle. No need to rely or convert magnitudes.
- Digital instrument – no calibration drift
- As it is a robust instrument it is maintenance free
- Dual connectivity if the installation positions allow.
- On-Line data logging, through Ethernet, on whichever web browser.
- No influence by bubbles or particles. It is very common that air enters the process pipeline and still the refractometer measures accurately.

Nitric acid concentration data are in an analog 4-20mA format provided to dataloggers which process these signals further.

In order of being able to calculate total mass volume of nitric acid 100% concentrate produced during the baseline campaign it is necessary to monitor also nitric acid flow and temperature. Measurement of pressure is not necessary for determination of the nitric acid mass volume flow, because nitric acid is in form of liquid and as such it has stabile pressure characteristic.

Signals obtained from the nitric acid flow and temperature measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Nitric acid flow and temperature measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, which process them further.

After installation of refractometers there have been occurrences of their failure and following repair service by the manufacturer. For this period starting from 05/10/2007 and ending on 20/10/2008 project uses HNO_3 concentration data provided by the laboratory measurements.

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
X_o: X 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:

$$Yn=An + (Bn/Bo)*(Yo-Ao)$$

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 “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

Based on the real conditions measured and applied by the AMS for normalization (TSG in °C and PSG in hPa), the stack gas volume flow values are converted to real conditions before the regression analysis using the ideal gas law. The actual gas volume flow rates are derived from gas velocity measurements, therefore, before applying the regression analysis the gas speed is calculated from the volume flow and the duct cross-section and is fed into the calibrating equation. The calibrated values derived from the calibrating equation then converted back to normalized units using the calibrated real conditions (calibrated TSG and PSG). The normalized calibrated stack gas flow rates are further fed into the emission calculation model for further 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 mgN_2O/m_3. The concentration was converted to ppmv to make it compatible with the regression Lines parameters. The nitrous gas concentration values are then calibrated using the provided regression Lines parameters and are input in the model.

6.4 Stack gas Temperature

The stack gas temperature was calibrated by the regression conversion formula

6.5 Stack gas Pressure

The calibration report provides us with a regression Line for the stack gas pressure. We calibrate the readings of the measurements system using the regression formula and applying the values (in kPa).

7. EMISSION REDUCTION CALCULATIONS

Table T 2 illustrates the establishment of historic campaign length based on 5 previous campaigns. Average production in 5 campaigns preceding the baseline campaign was 63 620 $tHNO_3$ and time duration was on average 228 days. Table contains also information on suppliers of primary catalysts for the line 8.

T 2 Historic campaigns

Line	ACHEMA UKL-8	Production	Start	End	Days	Production per day	Primary Catalyst	Composition
Historic Campaigns	**1** t HNO3	-	00 Jan 1900	00 Jan 1900	-	n/a	0	N/A *
	2 t HNO3	62 575	10 Dec 2004	17 Aug 2005	250	250	Heraeus	N/A *
	3 t HNO3	63 418	02 Nov 2005	14 Jun 2006	224	283	Umicore	N/A *
	4 t HNO3	63 138	15 Jun 2006	01 Feb 2007	231	273	Johnson Matthey	N/A *
	5 t HNO3	65 347	02 Feb 2007	28 Aug 2007	207	316	Johnson Matthey	N/A *
Average HNO3 production	t HNO3	**63 620**			**228**	**279**	* Confidential but available for the verification	
Project Campaigns	**BL** t HNO3	63 577	01 Sep 2007	15 Apr 2008	227	280	Umicore	N/A *
	PL t HNO3	85 912	09 Nov 2010	01 Sep 2011	296	290	Umicore	N/A *

The project campaign production value of 85 912 tHNO3 was higher than historic nitric acid production set at level of 63 620 tHNO3.

It is business as usual scenario in Achema UKL-7 plant to keep using primary catalysts from several suppliers and with several compositions. Selection of primary catalysts is determined by technical parameters of their use and price levels offered by suppliers in specific time. Primary catalysts used during the baseline campaign, if other than used in previous campaign/s, did not increase emissions of N2O as confirmed by relevant statements provided to the verifier.

T 3 and Chart C 1 define the length of the baseline campaign. Baseline campaign measurements for this project campaign started on 01/09/2007 and continued through 15/04/2008 when the 63 577 $tHNO_3$ nitric acid production was reached. The measurement of baseline Nitrous Acid Concentration (NCSG) was carried out until production reached - $tHNO_3$.

T 3 Baseline campaign length

ACHEMA UKL-8	Historic Campaings End	Start of Baseline Measurement	End of Baseline Measurement NCSG	End of Baseline Measurement	End of Baseline Campaign
Dates	2007 Aug 28	2007 Sep 01	2008 Apr 15	2008 Apr 15	2008 Apr 16
Baseline Factor kgN2O/tHNO3	-	-	7.23	7.23	7.23
Production tHNO3		-	63 577	63 577	-
Per Day Production tHNO3	279.0				
Baseline less Historic Production	**(42.6)**				
Baseline less Historic Days	**(0.2)**				

C 1 Baseline campaign length

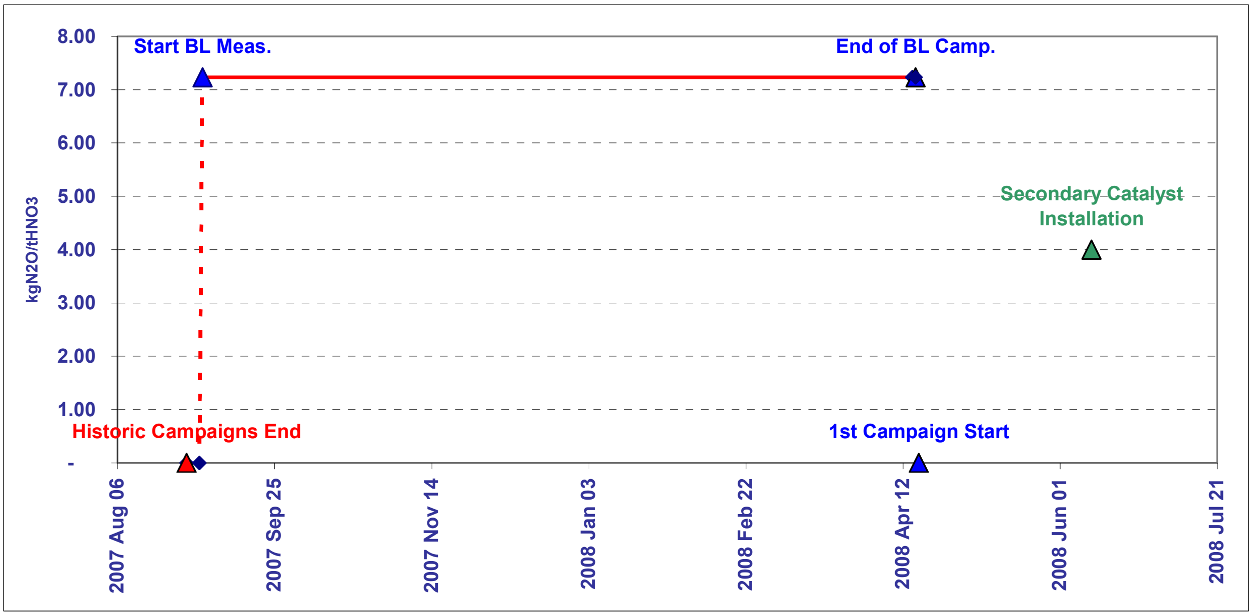


Table T 4 illustrates the calculation of the baseline emission factor on Line 8 using the method as defined in the CDM methodology AM0034 and in the PDD. We have not used overlapping approach allowed by the PDD. Baseline emission factor was determined based on raw data measured from 01/09/2007 through 15/04/2008.

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 N_2O 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 N_2O 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 488 tN_2O.

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

The UNC factor defined by the QAL2 report is 5.890%, which is further modified by an uncertainty of 0.087% due to under-sampling. As a result we have arrived to the baseline emission factor of 7.23 $kgN_2O/tHNO_3$.

Table T 5 shows the calculation of the project emission factor on Line 8 during the project campaign. Project campaign started on 09/11/2010 and went through 01/09/2011.

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

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

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

$$PE_n = VSG * NCSG * 10\text{-}9 * OH \ (tN2O)$$

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 350 tHNO3/day) we have determined the project campaign specific emission factor at value of 3.03 kgN2O/tHNO3.

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

Because the project emission factor measured was lower than the moving average EF of the campaigns on this line so far, we have used the average EF for the calculation of the quantity of emission reductions generated during this campaign.

T 4 Baseline emission factor

BASELINE EMISSION FACTOR *Parameter* *Code* *Unit*	Operating Hours OH h	Nitric Acid Production NAP t/h	N2O Concentration NCSG mg N2O/Nm3	Gas Volume Flow VSG Nm3/h	Ammonia Flow Rate AFR Nm3/h	Ammonia to Air Ratio AIFR %	Oxidation Temperature OT °C	Oxidation Pressure OP kPa	AMS in Operation h	Nitric Acid Production NCSG NAP t/h
Elimination of extreme values										
Lower limit		0	0	0	0	0	- 50	0		0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000		50
Raw Data Measured Range										
Count	**4 719**	4 954	4 801	4 598	4 987	4 663	5 425	5 425	4 129	4 954
as % of Dataset	*87%*	*91%*	*88%*	*84%*	*92%*	*86%*	*100%*	*100%*	*76%*	*91%*
Minimum		0.00	0	4	0	0	27	5		0
Maximum		24.99	1 968	103 514	6 796	14.80	912	654		25
Mean		12.83	1 120	78 981	5 591	10.07	801	564		13
Standard Deviation		5.07	440	16 813	1 520	0.93	245	116		5
Total		63 577								63 577
N2O Emissions (VSG * NCSG * OH)	417	t N2O								
Emission Factor	6.18	kgN2O / tHNO3								
Permitted Range										
Minimum					-	0	880	550		
Maximum					7 500	11.20	910	800		
Data within the permitted range										
Count	**4 453**		3 949	4 131					4 129	
as % of Operating Hours	***94%***		*84%*	*88%*					*87%*	
Minimum			781	-						
Maximum			1 732	96 663						
Mean			1 264	77 635						
Standard Deviation			201	16 881						
N2O Emissions (VSG * NCSG * OH)	463	t N2O								
Emission Factor	6.86	kgN2O / tHNO3								
Data within the confidence interval										
95% Confidence interval										
Lower bound			871	44 549						
Upper bound			1 658	110 722						
Count			3 795	3 949						
as % of Operating Hours			*80%*	*84%*						
Minimum			878	75 503						
Maximum			1 658	96 663						
Mean			1 275	81 213						
Standard Deviation			186	2 729						
N2O Emissions (VSG * NCSG * OH)	**488**	**t N2O**								
Emission Factor (EF_BL)	**7.23**	**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	OH	NAP	NCSG	VSG	AFR	AIFR	OT	OP
Unit	h	t/h	mg N2O/Nm3	Nm3/h	Nm3/h	%	°C	kPa
Elimination of extreme values								
Lower limit		0	0	0	0	0	- 50	0
Upper Limit		50.00	3 000	120 000	10 000	20.00	1 200	1 000
Raw Data Measured Range								
Count	**5 832**	6 889	5 784	5 775	7 083	5 884	7 083	7 083
as % of Dataset	*82%*	*97%*	*81%*	*81%*	*100%*	*83%*	*100%*	*100%*
Minimum		0.02	131	71 261	3	0	19	0
Maximum		18.06	2 004	89 366	6 902	19.43	912	704
Mean		12.47	271	79 167	5 009	10.22	752	624
Standard Deviation		5.53	60	2 911	2 051	0.98	303	89
Total		85 912						
N2O Emissions (VSG * NCSG * OH)	125	t N2O						
Emission Factor	1.46	kgN2O / tHNO3						
Data within the confidence interval								
95% Confidence interval								
Lower bound			153	73 461				
Upper bound			389	84 872				
Count			5 602	5 422				
as % of Operating Hours			*96%*	*93%*				
Minimum			154	73 498				
Maximum			389	84 871				
Mean			267	78 849				
Standard Deviation			45	2 454				
N2O Emissions (VSG * NCSG * OH)	**123**	**t N2O**						
Actual Project Emission Factor (EF_PActual)	**1.43**	**kgN2O / tHNO3**						
Abatement Ratio	**80.2%**							
Moving Average Emission Factor Correction	Actual Factors	Moving Average Rule						
1	4.35	4.35						
2	4.26	4.30						
3	2.06	3.56						
4	1.43	3.03						
5	-							
Project Emission Factor (EF_P)	**3.03**	**kgN2O / tHNO3**						
Abatement Ratio	**58.2%**							

Comparison of the baseline emission factors against N_2O mass limit in the IPPC permit

The N2O cap is defined in the IPPC permit on a yearly basis for the whole UKL-7 plant. The emission can be distributed among lines irregularly, as long as the total emission in each year stays under the yearly limit.

The regulatory emission factor EFReg is defined as the emission factor which would result in hitting the emission cap on a plant level.

We apply a method to attribute EFReg values to each campaign in a way that can be considered fair, and demonstrates a balanced scenario. The yearly N2O caps are allocated to campaigns proportionate to the amount of Nitric Acid they produced compared to other lines during the same year. The total cap of a campaign is the sum of such yearly limits. This way the total amount of plant level limit is always allocated. If each and every campaign would operate with those emission levels, the plant would just hit its yearly N2O caps in each year.

In incomplete years, the initial EFReg values will be high for the first campaigns, but will be lowered and balanced out as new campaigns are finished. These values serve informational purposes, and the real IPPC cap is checked on a plant level.

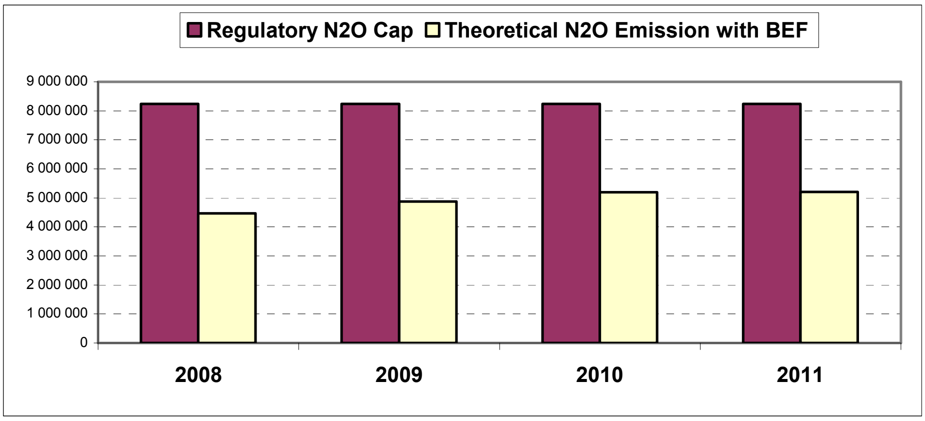
The main indicator of staying under the IPPC limit is the plant level yearly N2O emission calculated with baseline emission factors. Whenever an overflow of N2O emission would occur on plant level in a year, the sum of the product of baseline emission factors and yearly campaign NAP values would immediately indicate this and the projects would not be able to generate more ERU-s in that year.

```
Campaign_N2O_Cap =
      sum( Campaign_NAP[y] / Total_NAP[y] * Plant_N2O_Cap[y]
      for y in [2008,2009,2010,2011] )

Campaign_EFReg = Campaign_N2O_Cap / Campaign_NAP

Plant_N2O_Emission[y] =
      sum( Campaign_BEF[c] * Campaign_NAP[c,y] for c in campaigns )
```

- where Campaign_NAP[y] is the Nitric Acid Produced on a given campaign in year “y”
- Total_NAP is the total production on all lines in that year.
- the campaign EFReg is the campaigns emission cap divided by the campaign’s actual production.
- Plant_N2O_Emission[y] is the theoretical level of N2O emitted in year “y” by using the Baseline Emission Factors of each campaign, and calculating the “sumproduct” of BEF-s and yearly Nitric Acid Production of the lines

Regulatory values		2008	2009	2010	2011
Regulatory N2O Cap	*kgN2O*	8 494 200	9 266 400	9 266 400	9 266 400
Excluding Line 9	*kgN2O*	8 236 800	8 236 800	8 236 800	8 236 800

Plant emissions under baseline conditions		2008	2009	2010	2011
Total Nitric Acid Produced	*tHNO3*	587 784	592 413	617 892	630 205
Theoretical N2O Emission with BEF	*kgN2O*	4 472 161	4 871 985	5 194 928	5 203 230
Weighted average BEF	*kgN2O/tHNO3*	7.61	8.22	8.41	8.26
Critical BEF to reach cap with actual NAP	*kgN2O/tHNO3*	14.01	13.90	13.33	13.07
N2O emission overflow	*kgN2O*	**0**	**0**	**0**	**0**



Nitric acid produced during project campaigns					2008	2009	2010	2011
Line	Campaign	BEF	Start	End	NAP			
1	0	9.63	14 Mar 2008	21 Oct 2008	60 691			
2	0	7.92	09 Nov 2007	20 May 2008	28 951			
3	0	4.42	01 Feb 2008	30 Jun 2008	42 999			
4	0	7.20	28 Dec 2007	31 Jul 2008	57 815			
5	0	6.61	29 Nov 2007	17 Jun 2008	47 192			
6	0	10.34	11 Jan 2008	21 Jul 2008	60 850			
7	0	7.85	12 Sep 2007	27 Mar 2008	26 856			
8	0	6.61	02 Sep 2007	15 Apr 2008	34 716			
1	1	9.63	04 Nov 2008	10 May 2010	1 913	55 103	37 831	
2	1	7.92	07 Nov 2008	16 Jan 2009	12 151	241		
3	1	4.42	04 Jul 2008	27 Aug 2008	13 520			
4	1	7.20	06 Oct 2008	28 Apr 2009	11 753	27 403		
5	1	6.61	02 Jul 2008	22 Apr 2009	39 871	20 358		
6	1	10.34	25 Jul 2008	21 Apr 2009	41 416	26 902		
7	1	7.85	03 Jul 2008	22 Oct 2008	31 445			
8	1	6.61	11 Jun 2008	26 Nov 2008	45 181			
1	2	9.63	13 Sep 2010	21 Aug 2011			36 738	72 938
2	2	9.51	16 Jan 2009	12 Oct 2009		61 628		
3	2	5.45	27 Aug 2008	16 Jun 2009	24 950	31 372		
4	2	7.73	07 May 2009	06 May 2010		42 744	22 505	
5	2	6.61	23 Apr 2009	14 Jan 2010		66 630	4 642	
6	2	10.34	27 Apr 2009	25 Nov 2009		66 297		
7	2	9.09	29 Jan 2009	01 Nov 2009		58 897		
8	2	6.96	09 Dec 2008	20 Nov 2009	5 513	53 779		
1	3							
2	3	9.51	13 Oct 2009	21 Oct 2010		17 444	68 634	
3	3	5.45	17 Jun 2009	16 Nov 2010		35 016	49 304	
4	3	7.73	03 Aug 2010	09 Mar 2011			38 627	20 608
5	3	6.61	12 Aug 2010	17 Mar 2011			48 928	27 358
6	3	10.34	27 Nov 2009	20 Sep 2010		9 863	76 524	
7	3	9.09	03 Nov 2009	08 Dec 2010		8 079	63 581	
8	3	6.96	21 Nov 2009	25 Oct 2010		10 657	76 105	
1	4							
2	4	9.51	22 Oct 2010	12 May 2011			25 426	41 966
3	4	5.46	19 Nov 2010	25 Aug 2011			12 366	70 693
4	4	7.73	16 Mar 2011	05 Oct 2011				61 337
5	4	6.61	17 Mar 2011	09 Nov 2011				58 648
6	4	10.34	01 Oct 2010	10 Aug 2011			31 515	78 822
7	4	9.09	10 Dec 2010	30 Aug 2011			6 843	67 872
8	4	7.23	09 Nov 2010	01 Sep 2011			18 323	67 589
1	5							
2	5	9.51	13 May 2011	08 Dec 2011				62 374
3	5							
4	5							
5	5							
6	5							
7	5							
8	5							

NAP Proportionate Regulatory Emission Factor			
NAP	N2O Cap	EFReg	N2O with BEF
60 691	850 482	14.01	584 454
28 951	405 704	14.01	229 295
42 999	602 557	14.01	190 055
57 815	810 180	14.01	416 268
47 192	661 323	14.01	311 942
60 850	852 711	14.01	629 190
26 856	376 347	14.01	210 822
34 716	486 487	14.01	229 473
94 846	1 297 246	13.68	913 370
12 392	173 627	14.01	98 145
13 520	189 455	14.01	59 757
39 157	545 713	13.94	281 927
60 229	841 780	13.98	398 114
68 318	954 414	13.97	706 407
31 445	440 647	14.01	246 842
45 181	633 132	14.01	298 644
109 676	1 443 042	13.16	1 056 183
61 628	856 864	13.90	586 082
56 322	785 819	13.95	306 953
65 249	894 308	13.71	504 375
71 273	988 299	13.87	471 111
66 297	921 776	13.90	685 507
58 897	818 894	13.90	535 374
59 291	824 982	13.91	412 669
0			
86 079	1 157 471	13.45	818 607
84 321	1 144 113	13.57	459 548
59 235	784 262	13.24	457 886
76 285	1 009 796	13.24	504 247
86 387	1 157 237	13.40	893 243
71 660	959 892	13.40	651 388
86 762	1 162 695	13.40	603 866
0			
67 392	887 442	13.17	640 901
83 058	1 088 795	13.11	453 498
61 337	801 675	13.07	474 134
58 648	766 528	13.07	387 661
110 337	1 450 320	13.14	1 140 887
74 715	978 311	13.09	679 160
85 912	1 127 640	13.13	621 141
0			
62 374	815 234	13.07	593 179
0			
0			
0			
0			
0			
0			

All the EFReg values are green, which indicates that none of the campaigns resulted in excess emission relative to others given their production levels and the plant IPPC limit, and the regulatory emission factor is higher than the baseline emission factor of the campaigns.

The summary table “Plant emission under baseline conditions” contain yearly emission figures, and as all of the “Theoretical N2O Emission with BEF” stay under the yearly caps (made visible by the chart), none of the IPPC limits were ever violated. By taking the currently finished campaigns into account, all the ERU-s can be claimed so far.

Description of the undersampling UNC inclusion

We want the quantify the additional uncertainty the undersampling causes. The undersampling has two sources: the time during which the measurement head is purged and switches between lines and the number of lines it monitors.

Each record in the excel is the average of a one hour observation. The sampling frequency required by the methodology is two seconds, so the number of samples we would have under ideal circumstances would be:

*samples_ideal = 60*60/2 = 1800*

The AMS measures for 240 seconds then it is purged for 60 seconds during which time it also switches lines. So the number of samples with purging is reduced:

*samples_purged = samples_ideal * 240/(60+240) = 1440*

Furthermore lines (1,2,3), (4,5,6) and (7,8) are measured together, which brings the sample of a line down to 720 or 480 for 2 or 3 lines respectively.

samples_per_line = samples_purged / line_count

What we want to measure is the uncertainty of the ERU-s which is based on mean value of nitric acid concentration, so we need the uncertainty of the mean itself.

The deviation of the mean of a sample is given by the following formula sd(mean(x)) = sd(x)/sqrt(n), so for nitric acid concentration it is:

mean_ncsg_deviation = ncsg_deviation / sqrt(ncsg_observation_count)

Where the deviation of that of the hourly NCSG samples and observation count is the number of records that survived statistical elimination.

Since uncertainty is expressed as a percentage, we use the percentage deviation:

mean_ncsg_deviation_percent = mean_ncsg_deviation / mean_ncsg

The above is the deviation of what we have with as many samples as there are with undersampling, the ideal deviation would be less than that proportional to the difference in sample count:

*mean_ncsg_deviation_percent_ideal = mean_ncsg_deviation_percent * sqrt(sample_purged / samples_ideal)*

The additional uncertainty is the increment in the percent deviation compared to the ideal value:

additional_uncertainty = mean_ncsg_deviation_percent - mean_ncsg_deviation_percent_ideal

We combine this uncertainty with the AMS uncertainty determined in the QAL2 report using the square root sum formula:

combined_uncertainty = sqrt(ams_uncertainty^2 + additional_uncertainty^2)