SECOND MONITORING REPORT

PROJECT: **ACHEMA UKL-7 plant N_2O abatement project**

Prepared by:

VERTIS

VERTIS FINANCE

October 18, 2010

Monitoring periods

Line 1

Project campaign 1

FROM:	04/11/2008
TO:	10/05/2010
ERUs	221,400

Line 4

Project campaign 2

FROM:	07/05/2009
TO:	06/05/2010
ERUs	104,372

Line 6

Project campaign 2

FROM:	27/04/2009
TO:	25/11/2009
ERUs	116,735

Line 6

Project campaign 3

FROM:	27/11/2009
TO:	20/09/2010
ERUs	143,005

MONITORING REPORT

PROJECT: ACHEMA UKL nitric acid plant N_2O abatement project
LINE: Line 1
MONITORING PERIOD:
FROM: 04/11/2008

TO: 10/05/2010

Prepared by:

VERTIS

VERTIS FINANCE

www.vertisfinance.com

Table of Contents

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 first project campaign on Line 1.

The first project campaign on Line 1 started on 04/11/2008, when the secondary catalyst was installed. Total quantity of emission reductions generated during the first project period from 04/11/2008 through 10/05/2010 on Line 1 is **221 400 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	9.63	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	2.10	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	94 846	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**221 400**	**tCOe**
*ER=(EF_BL-EF_P)*NAP_P*GWP/1000*			
Abatement Ratio		**78.2%**	

EMISSION REDUCTION PER YEAR			
Year	2008	2009	2010
Date from	04 Nov 2008	01 Jan 2009	01 Jan 2010
Date to	31 Dec 2008	31 Dec 2009	10 May 2010
Nitric Acid Production	1 913	55 103	37831
Emission Reduction	**4 465**	**128 626**	**88309**
*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 first project campaign after installation of secondary catalysts on Line 1, which started on 04/11/2008 and went through 10/05/2010 with secondary catalyst installed and commissioned on 30/10/2008, is 2.10 $kgN_2O/tHNO_3$.

During the project campaign 94 846 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 five campaigns), has not been used as a cap on the length of the baseline campaign because of shorter project 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 nth 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 this campaign was first project campaign on Line 1 there has been no moving average emission factor established yet for 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.

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)

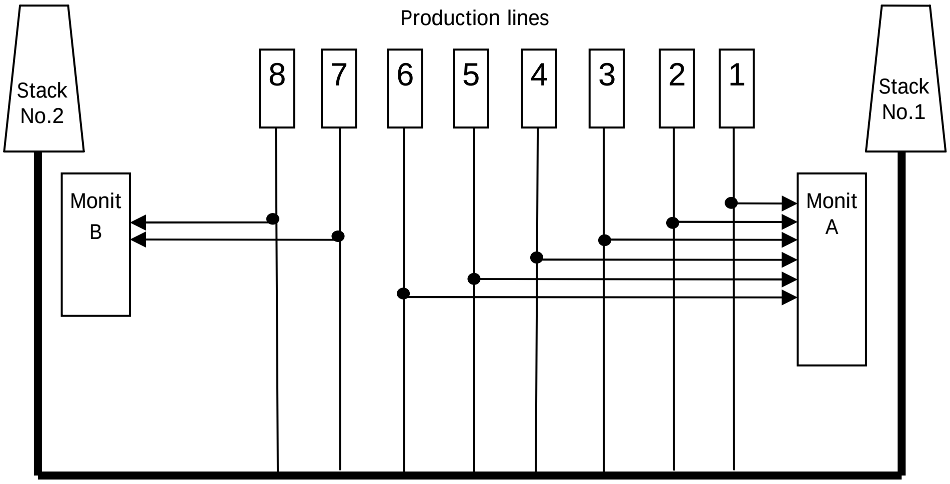
5. MONITORING PLAN

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.

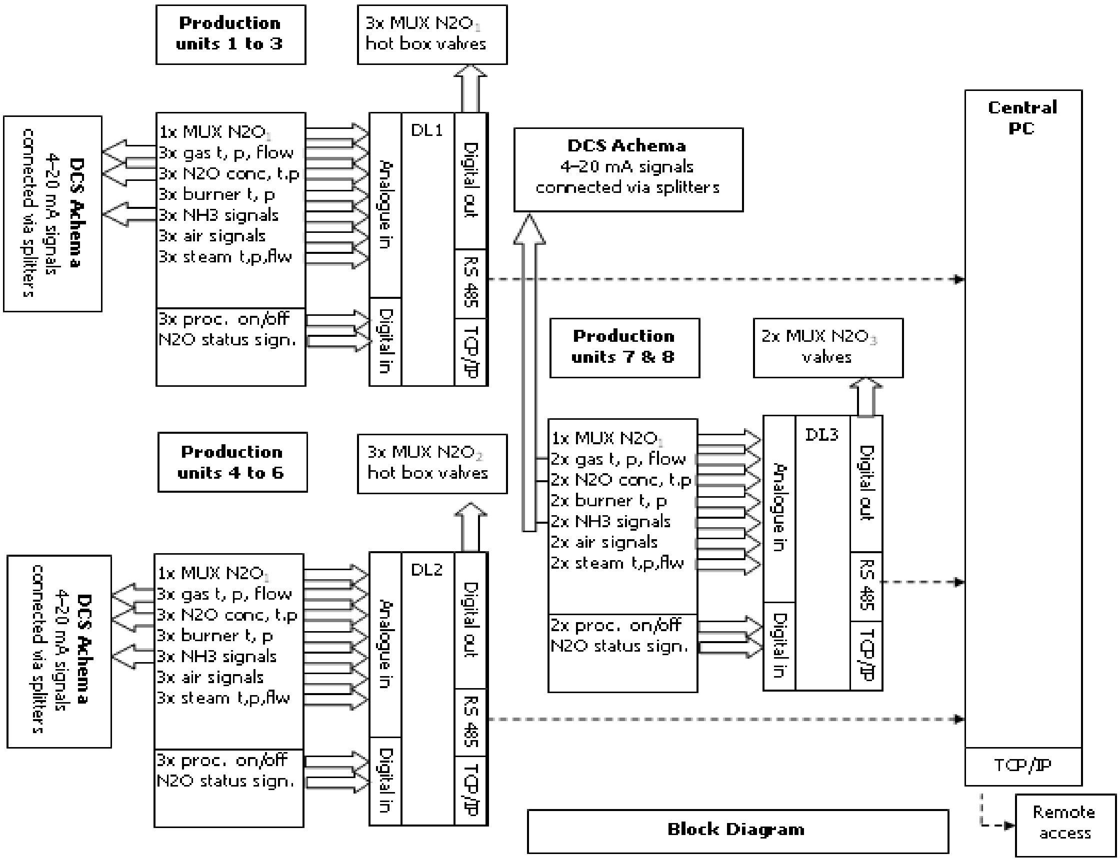
Monitoring System (MS) for purpose of this monitoring plan means:

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.

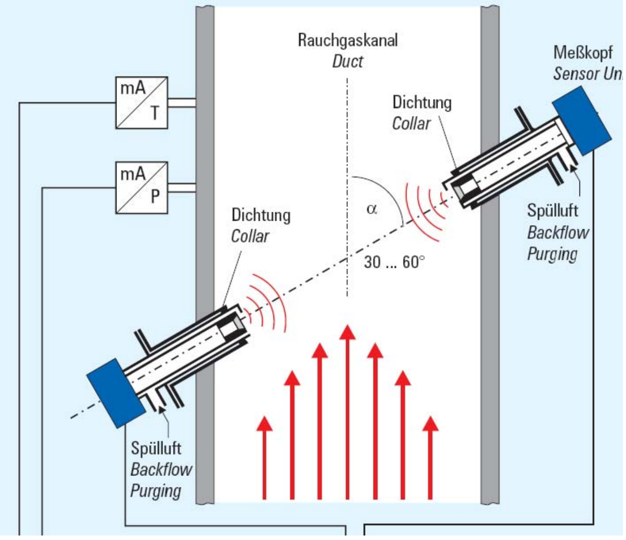
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

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.

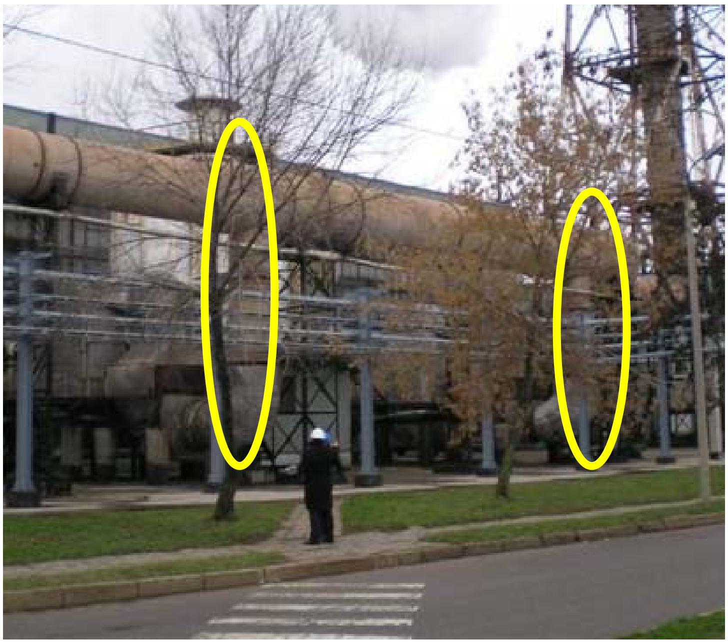
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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=L1_Flow_N2O*(273.15/(273.15+L1_Temp))*(L1_Press/101.325)*((100-L1_Humi)/100)

where Humi (water content)=

(L1_Flow_steam*1.2436)/(L1_Flow_N2O*(273.15/(273.15+L1_Temp))*(L1_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.

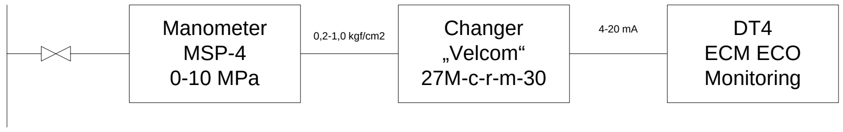
Operating conditions

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

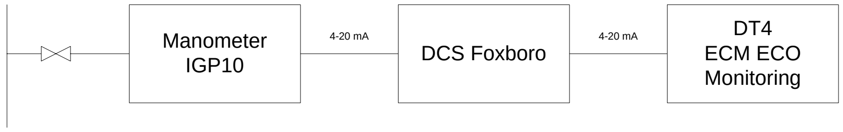
Ammonia flow
Ammonia temperature
Ammonia pressure
Primary air flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

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

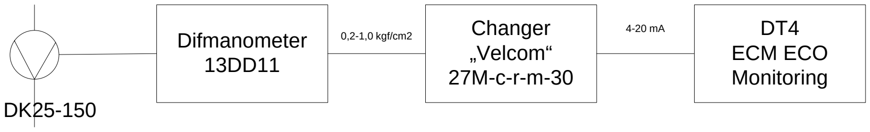
P in mixer 1-6 line



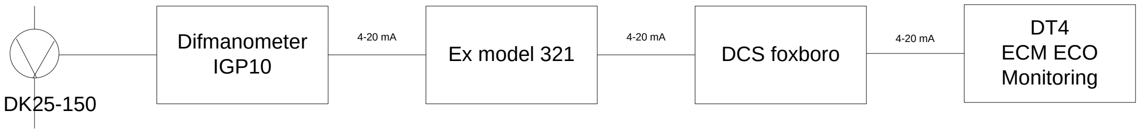
P in mixer 7-8 line

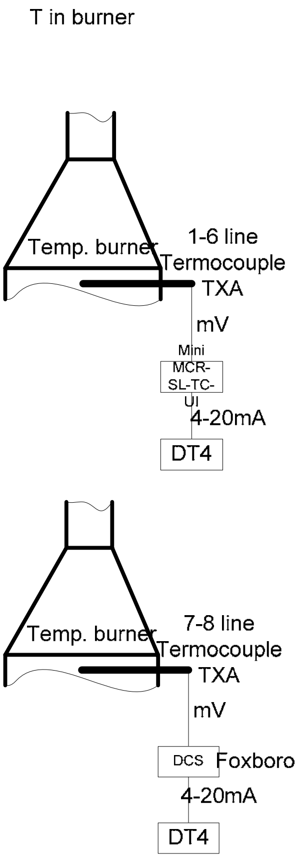


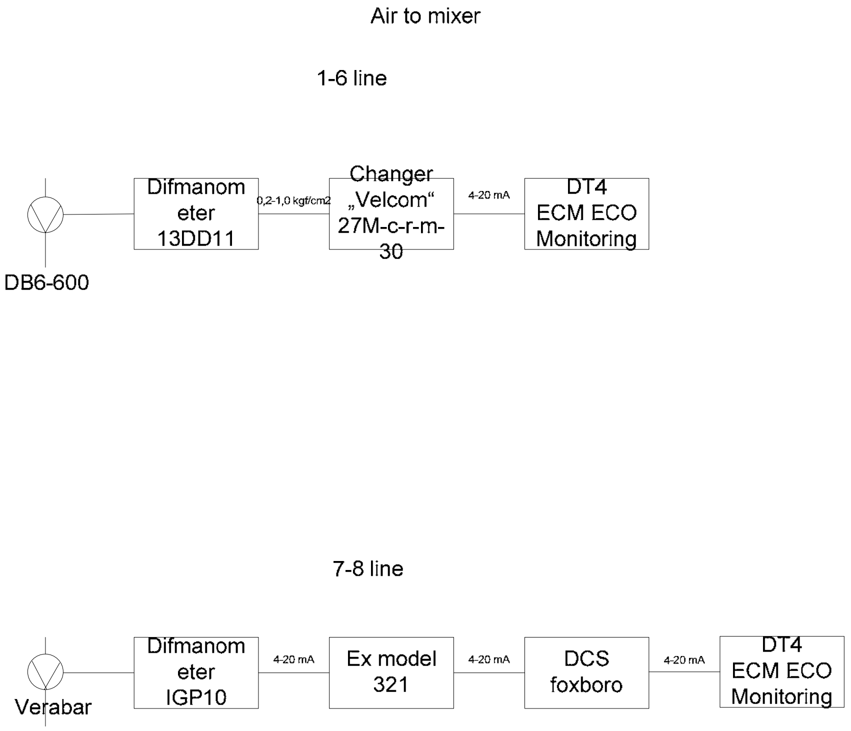
NH3 to mixer 1-6 line



NH3 to mixer 7-8 line





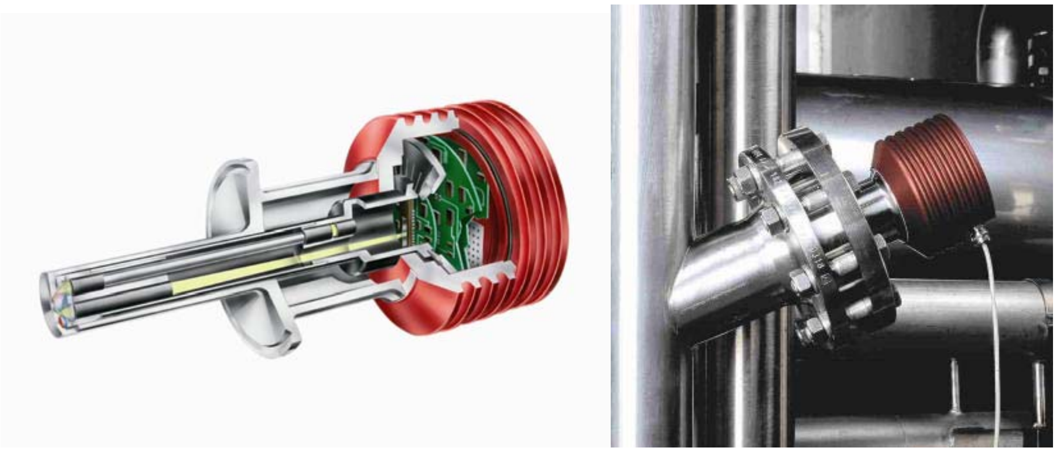


Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, 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 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:

$$X_o = X_n = X$$

where:

X_n: X new
Y_o: Y old

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

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

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	90/5/5
	2 t HNO3	-	29 Apr 2005	24 Oct 2005	178	-	Heraeus	61/4/35
	3 t HNO3	58 648	24 Oct 2005	20 Sep 2006	331	177	Johnson Matthey	90/5/5
	4 t HNO3	65 266	21 Sep 2006	24 Jul 2007	306	213	Umicore	95/5
	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**		
Project Campaigns	**BL** t HNO3	60 691	14 Mar 2008	21 Oct 2008	221	275	Johnson Matthey	n.a.
	PL t HNO3	94 846	04 Nov 2008	10 May 2010	552	172	Johnson Matthey	n.a.

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

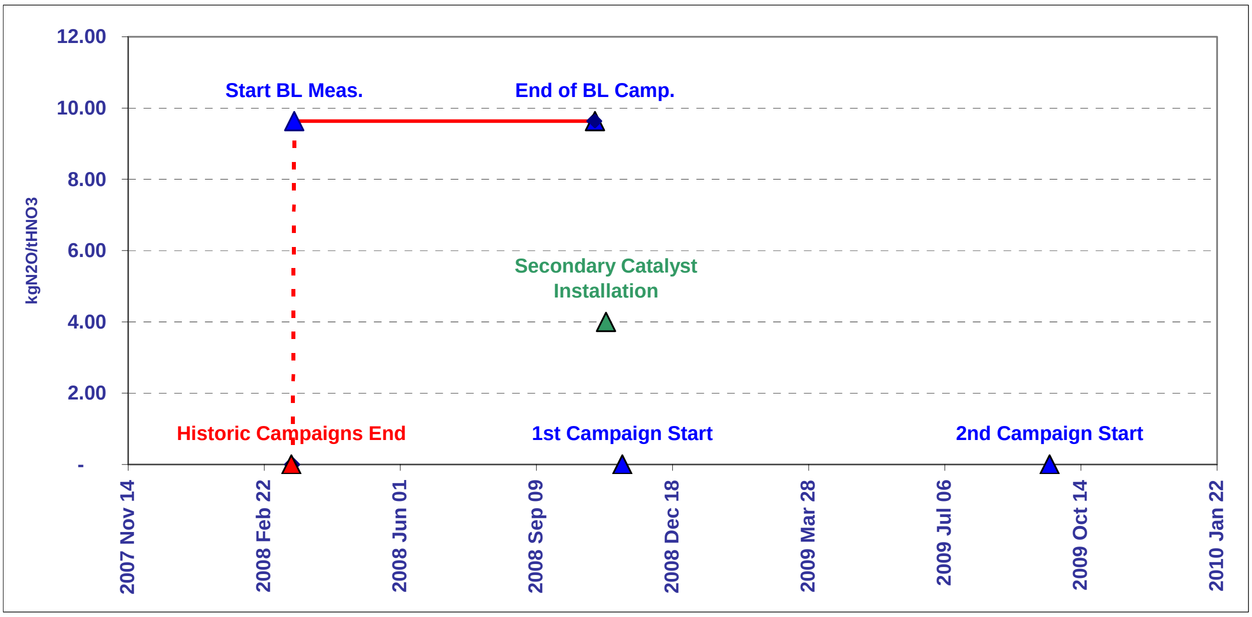


Table T 4 illustrates the calculation of the baseline emission factor on Line 1 using the method as defined in the CDM methodology AM0034 and in the PDD. We have not used overlapping approach allowed by the PDD. Baseline emission factor was determined based on raw data measured from 14/03/2008 through 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 04/11/2008 and went through 10/05/2010.

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 2.10 kgN2O/tHNO3.

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

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

T 4 Baseline emission factor

BASELINE EMISSION FACTOR										
Parameter	Operating Hours	Nitric Acid Production	N2O Concentration	Gas Volume Flow	Ammonia Flow Rate	Ammonia to Air Ratio	Oxidation Temperature	Oxidation Pressure	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	12.50	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	**6 329**	8 471	6 624	6 374	13 249	9 724	13 236	11 726
as % of Dataset	*48%*	*64%*	*50%*	*48%*	*100%*	*73%*	*100%*	*89%*
Minimum		-	0	57	-	-	(0)	0
Maximum		17.32	831	84 931	7 506	20.00	905	672
Mean		11.20	402	72 568	3 278	10.23	435	396
Standard Deviation		4.94	123	8 893	2 713	3.03	437	260
Total		94 846						

N2O Emissions (VSG * NCSG * OH)	185	t N2O
Emission Factor	1.95	kgN2O / tHNO3

Data within the confidence interval

	NCSG	VSG
95% Confidence interval		
Lower bound	161	55 137
Upper bound	642	89 999
Count	5 991	6 282
as % of Operating Hours	*95%*	*99%*
Minimum	181	60 346
Maximum	642	85 717
Mean	427	73 626
Standard Deviation	59	3 156

N2O Emissions (VSG * NCSG * OH)	**199**	**t N2O**
Actual Project Emission Factor (EF_PActual)	**2.10**	**kgN2O / tHNO3**
Abatement Ratio	**78.2%**	

Moving Average Emission Factor Correction	**Actual Factors**	**Moving Average Rule**
1	2.10	2.10
2	-	
3	-	

Project Emission Factor (EF_P)	**2.10**	**kgN2O / tHNO3**
Abatement Ratio	**78.2%**	

MONITORING REPORT

PROJECT: ACHEMA UKL nitric acid plant N_2O abatement project
LINE: Line 4
MONITORING PERIOD:
FROM: 07/05/2009

TO: 06/05/2010

Prepared by:

VERTIS

VERTIS FINANCE

www.vertisfinance.com

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 second project campaign on Line 4.

Total quantity of emission reductions generated during the second project period from 07/05/2009 through 06/05/2010 on Line 4 is **104 372 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	7.73	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	2.57	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	65 249	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**104 372**	**tCOe**
*ER=(EF_BL-EF_P)*NAP_P*GWP/1000*			
Abatement Ratio		**69.4%**	

EMISSION REDUCTION PER YEAR			
Year	2008	2009	2010
Date From		07 May 2009	01 Jan 2010
Date To		31 Dec 2009	06 May 2010
Nitric Acid Production		42 744	22505
Emission Reduction		**68 373**	**35999**
*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 second project campaign after installation of secondary catalysts on Line 4, which started on 07/05/2009 and went through 06/05/2010 with secondary catalyst installed and commissioned on 06/10/2008, is 2.57 kgN_2O/tHNO_3.

During the project campaign 65 249 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 five campaigns), has not been used as a cap on the length of the baseline campaign because of shorter project 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

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

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.

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)

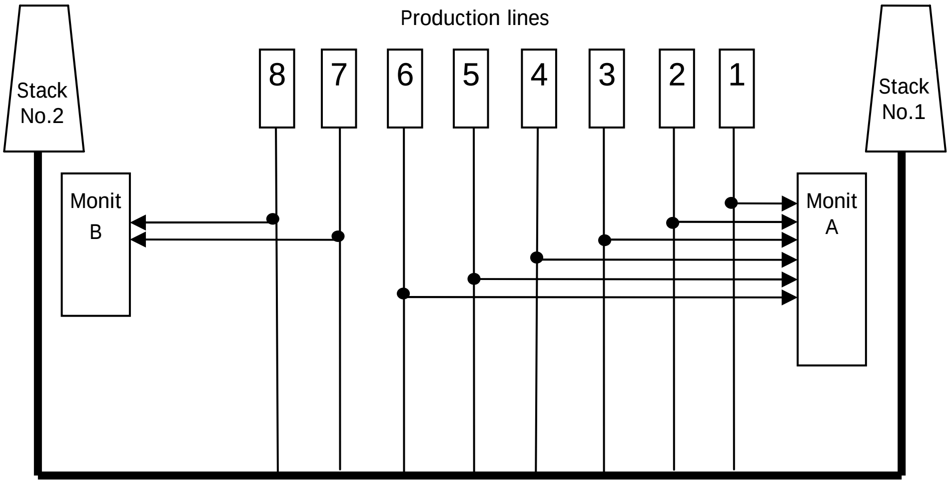
5. MONITORING PLAN

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.

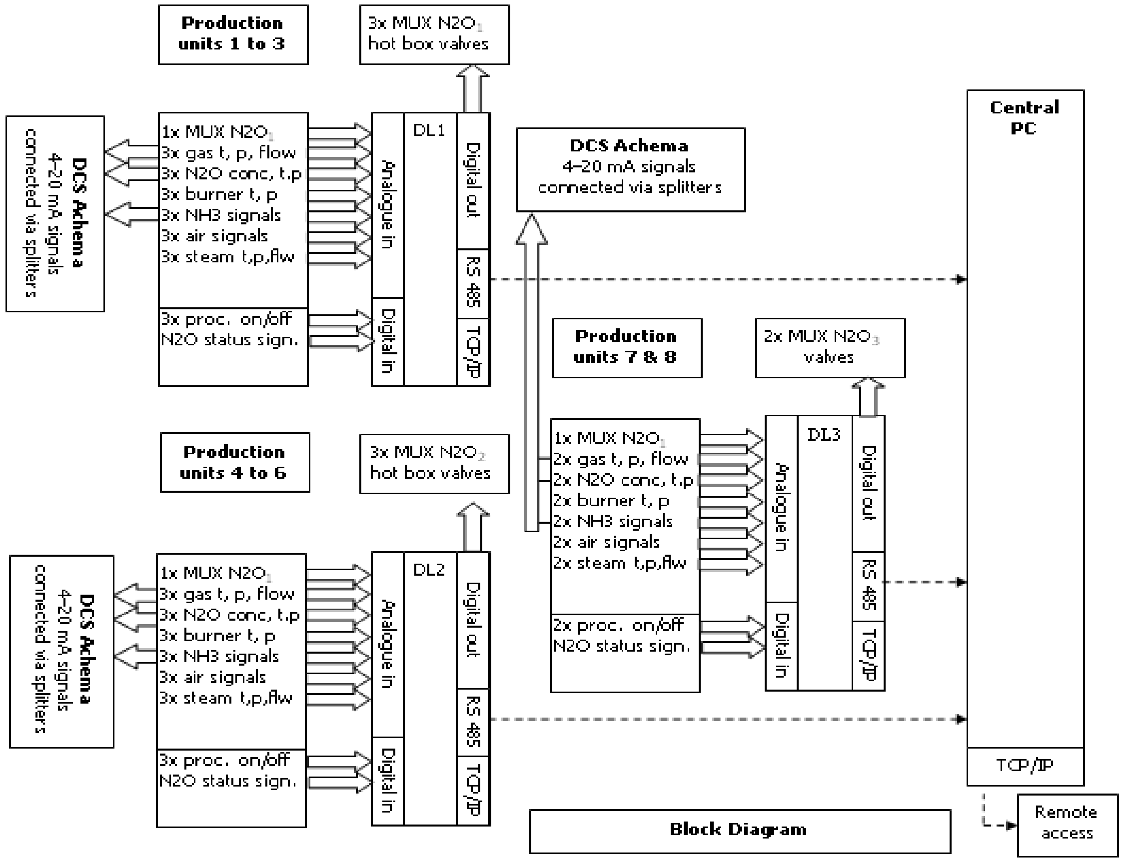
Monitoring System (MS) for purpose of this monitoring plan means:

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.

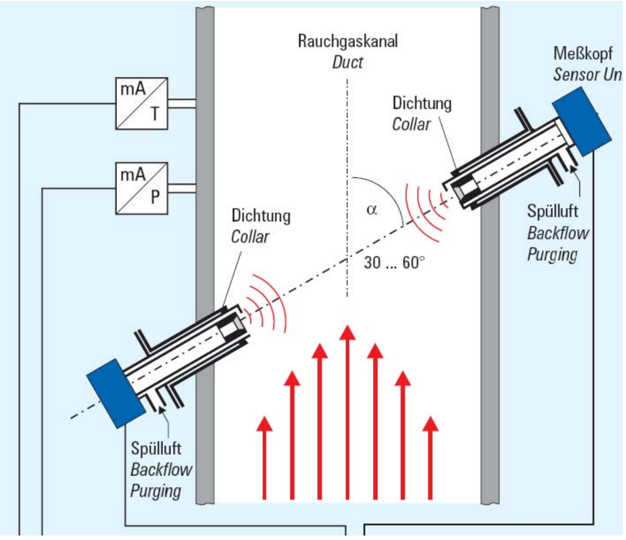
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

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.

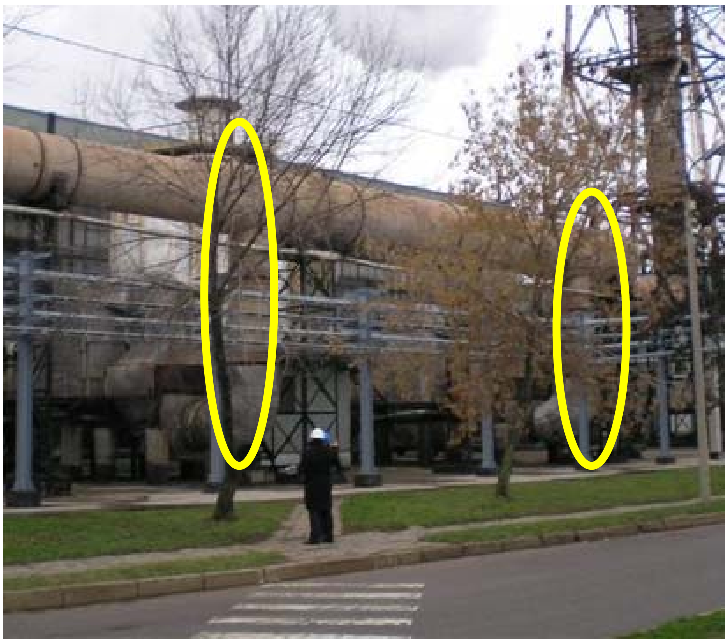
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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=L1_Flow_N2O*(273.15/(273.15+L1_Temp))*(L1_Press/101.325)*((100-L1_Humi)/100)

where Humi (water content)=

(L1_Flow_steam*1.2436)/(L1_Flow_N2O*(273.15/(273.15+L1_Temp))*(L1_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.

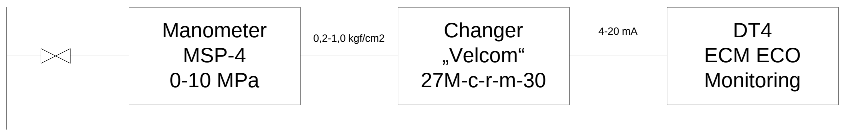
Operating conditions

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

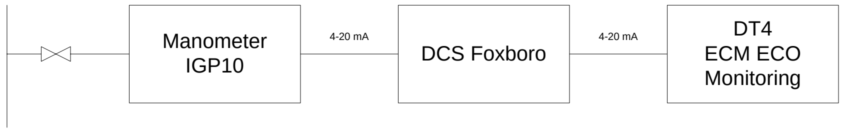
Ammonia flow
Ammonia temperature
Ammonia pressure
Primary air flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

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

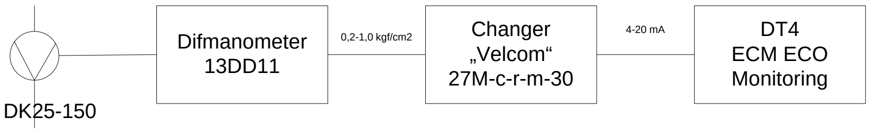
P in mixer 1-6 line



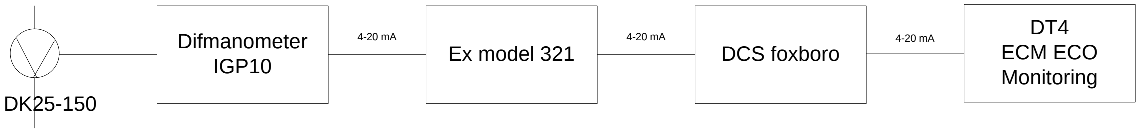
P in mixer 7-8 line



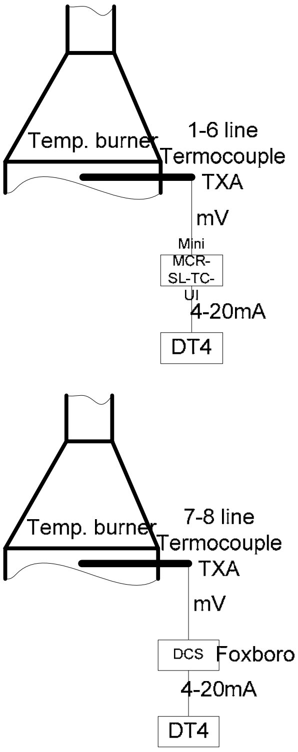
NH3 to mixer 1-6 line



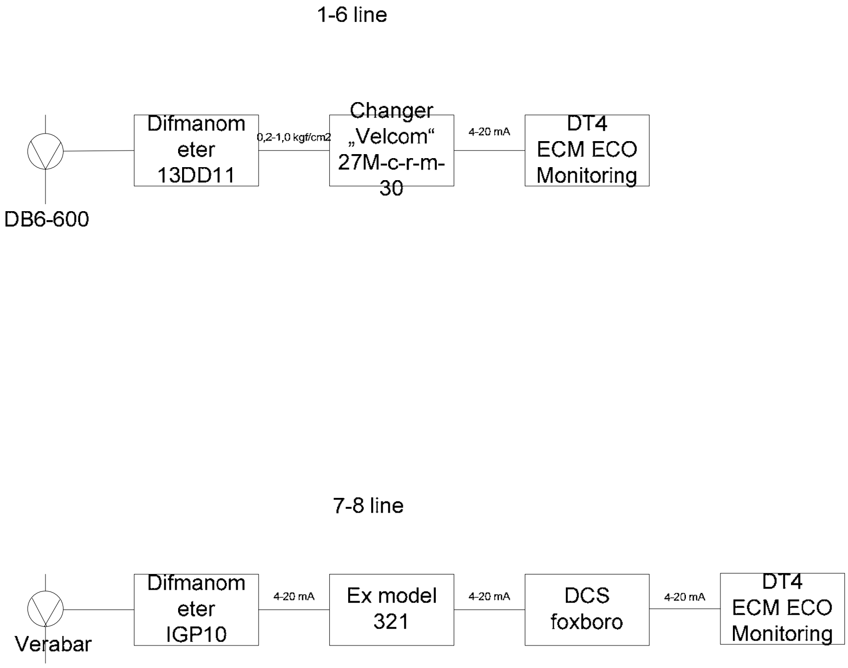
NH3 to mixer 7-8 line



T in burner



Air to mixer

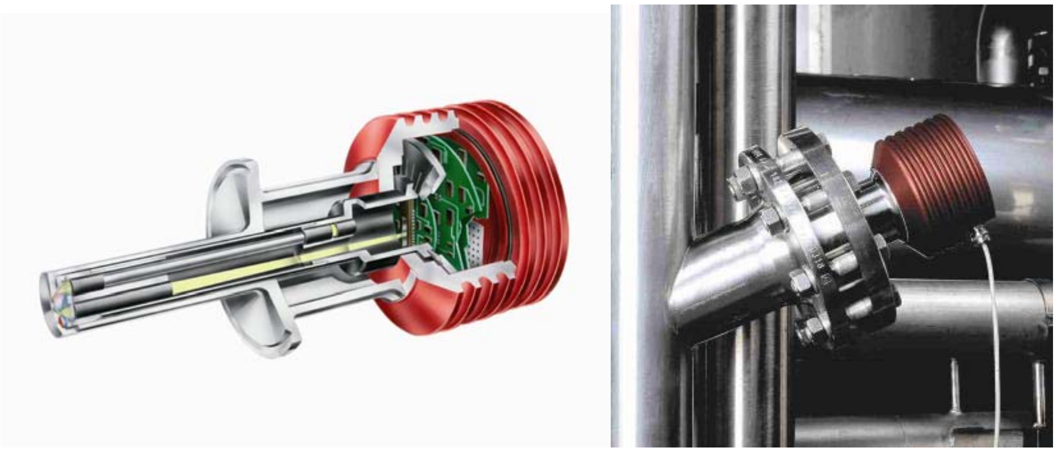


Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, 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:

$$Xo=Xn=X$$

where:

Xn: X new
Yo: Y old

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

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

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	90/5/5
	2 t HNO3	65 420	11 Dec 2003	06 Dec 2004	361	181	Johnson Matthey	90/5/5
	3 t HNO3	66 129	07 Dec 2004	08 Nov 2005	336	197	Umicore	95/5
	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**		
Project Campaigns	**BL** t HNO3	58 683	28 Dec 2007	31 Jul 2008	216	272	Johnson Matthey	n.a.
	PL t HNO3	65 249	07 May 2009	06 May 2010	364	179	Johnson Matthey	n.a.

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

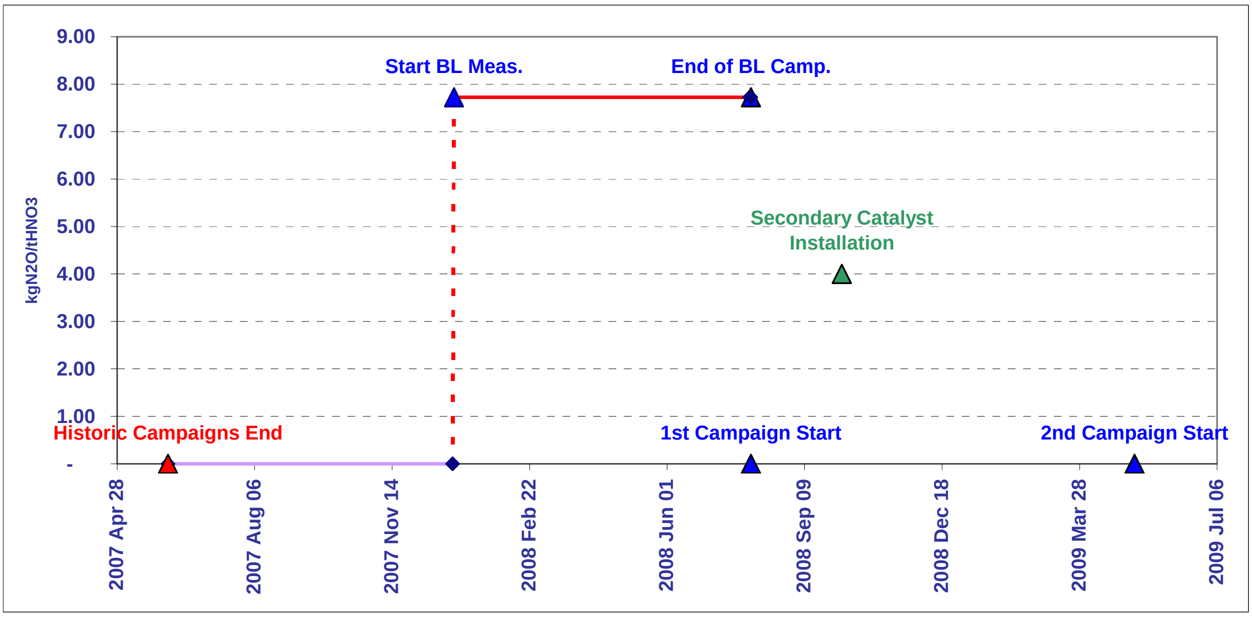


Table T 4 illustrates the calculation of the baseline emission factor on Line 4 using the method as defined in the CDM methodology AM0034 and in the PDD. We have not used overlapping approach allowed by the PDD. Baseline emission factor was determined based on raw data measured from 28/12/2007 through 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 07/05/2009 and went through 06/05/2010.

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 2.57 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	**4 832**	5 476	4 754	4 810	5 654	5 206	8 727	8 694
as % of Dataset	*55%*	*63%*	*54%*	*55%*	*65%*	*60%*	*100%*	*100%*
Minimum		0.62	2	-	262	3	(23)	15
Maximum		14.97	1 476	88 570	6 419	19.34	916	737
Mean		11.92	487	66 443	5 323	10.21	516	524
Standard Deviation		3.24	185	4 680	1 487	1.16	425	204
Total		65 249						

N2O Emissions (VSG * NCSG * OH)	156	t N2O
Emission Factor	2.39	kgN2O / tHNO3

Data within the confidence interval

95% Confidence interval		NCSG	VSG
Lower bound		124	57 270
Upper bound		850	75 617
Count		4 409	4 744
as % of Operating Hours		*91%*	*98%*
Minimum		199	57 989
Maximum		849	75 605
Mean		480	66 558
Standard Deviation		152	3 137

N2O Emissions (VSG * NCSG * OH)	**154**	**t N2O**
Actual Project Emission Factor (EF_PActual)	**2.37**	**kgN2O / tHNO3**
Abatement Ratio	**69.4%**	

Moving Average Emission Factor Correction	**Actual Factors**	**Moving Average Rule**
1	2.77	2.77
2	2.37	2.57

Project Emission Factor (EF_P)	**2.57**	**kgN2O / tHNO3**
Abatement Ratio	**66.8%**	

MONITORING REPORT

PROJECT: ACHEMA UKL nitric acid plant N_2O abatement project
LINE: Line 6
MONITORING PERIOD:
FROM: 27/04/2009

TO: 25/11/2009

Prepared by:

VERTIS

VERTIS FINANCE

www.vertisfinance.com

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 second project campaign on Line 6.

Total quantity of emission reductions generated during the second project period from 27/04/2009 through 25/11/2009 on Line 6 is **116 735 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	10.34	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	4.66	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	66 297	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**116 735**	**tCOe**
*ER=(EF_BL-EF_P)*NAP_P*GWP/1000*			
Abatement Ratio		**57.6%**	

EMISSION REDUCTION PER YEAR			
Year	2008	2009	2010
Date From		27 Apr 2009	
Date To		25 Nov 2009	
Nitric Acid Production		66 297	
Emission Reduction		**116 735**	
*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 second project campaign after installation of secondary catalysts on Line 6, which started on 27/04/2009 and went through 25/11/2009 with secondary catalyst installed and commissioned on 25/07/2008, is 4.66 kgN_2O/tHNO_3.

During the project campaign 66 297 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 five campaigns), has not been used as a cap on the length of the baseline campaign because of shorter project 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.

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)

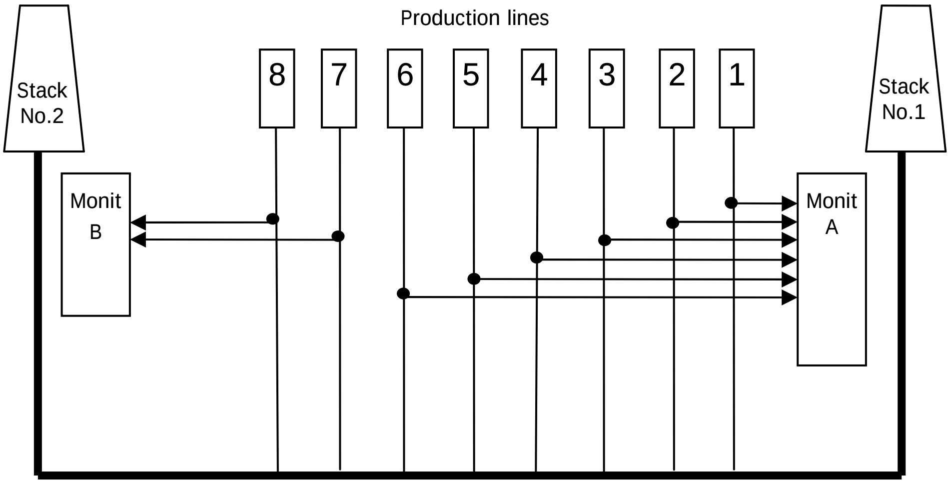
5. MONITORING PLAN

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.

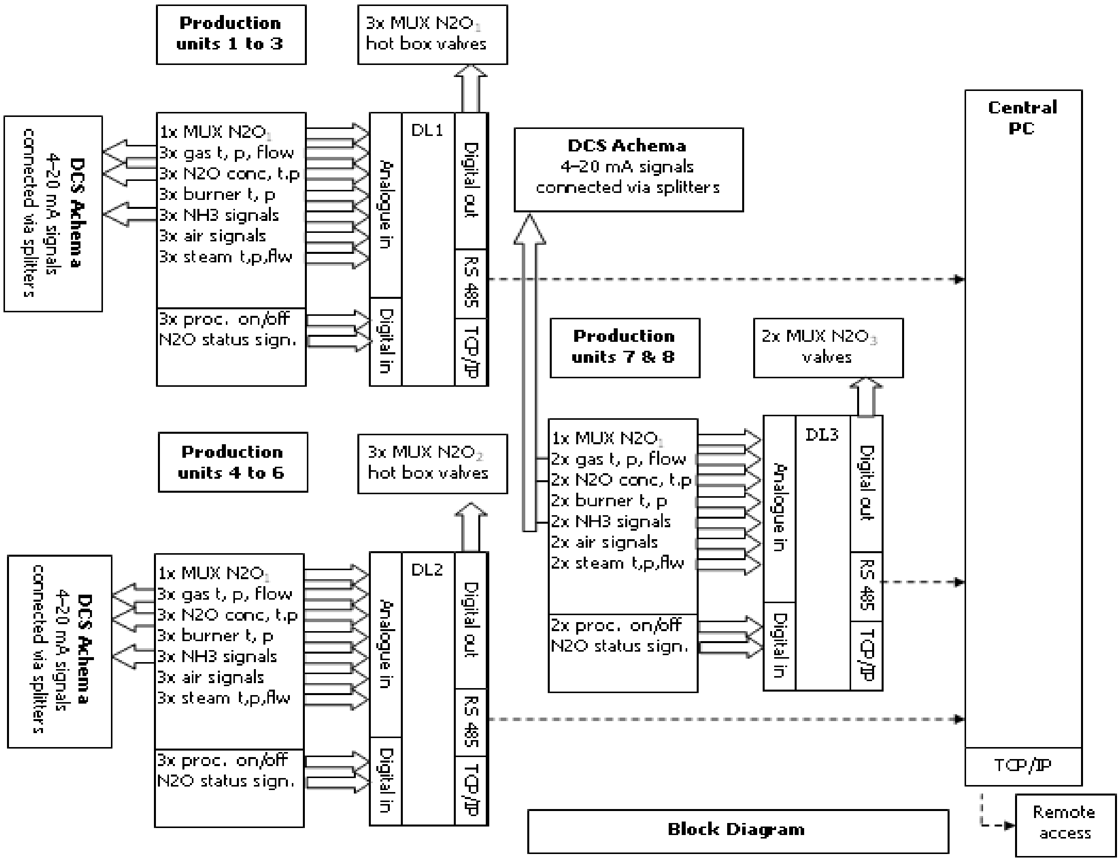
Monitoring System (MS) for purpose of this monitoring plan means:

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.

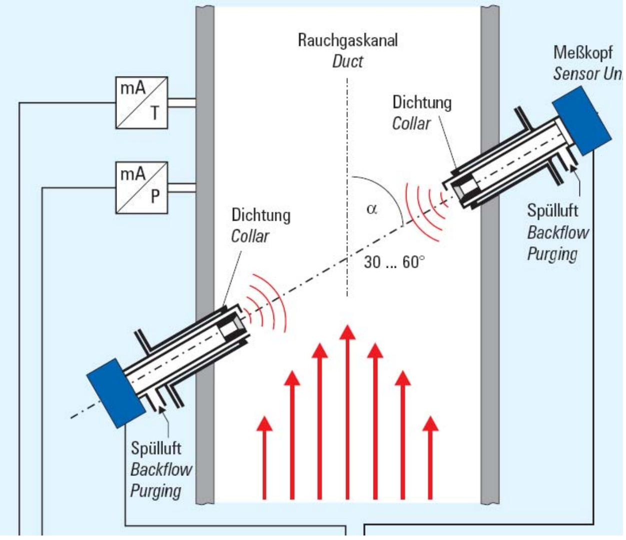
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

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.

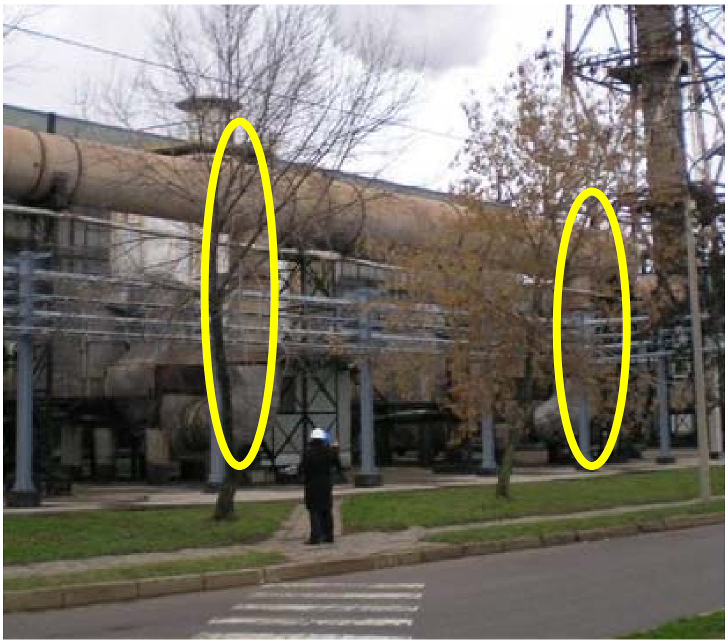
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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=L1_Flow_N2O*(273.15/(273.15+L1_Temp))*(L1_Press/101.325)*((100-L1_Humi)/100)

where Humi (water content)=

(L1_Flow_steam*1.2436)/(L1_Flow_N2O*(273.15/(273.15+L1_Temp))*(L1_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.

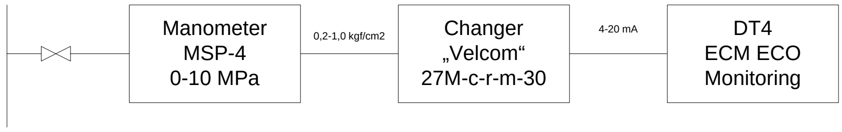
Operating conditions

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

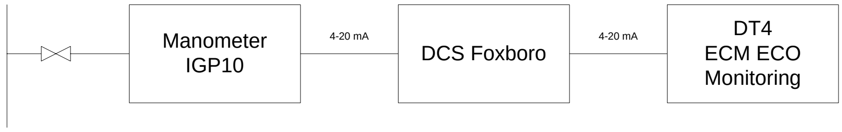
Ammonia flow
Ammonia temperature
Ammonia pressure
Primary air flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

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

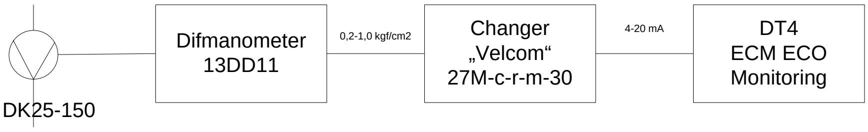
P in mixer 1-6 line



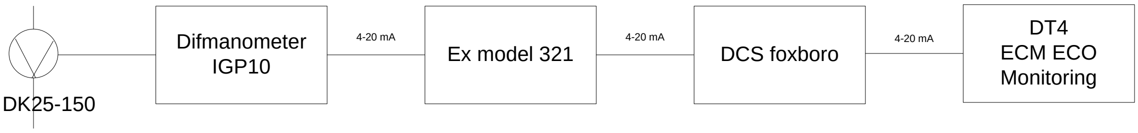
P in mixer 7-8 line



NH3 to mixer 1-6 line

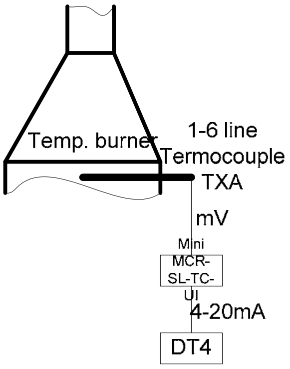


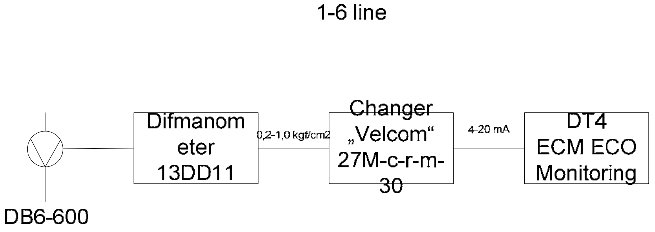
NH3 to mixer 7-8 line

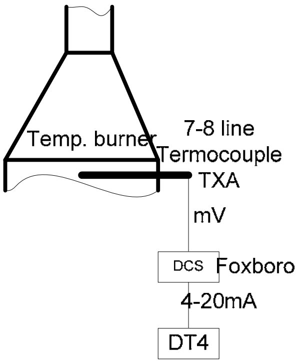


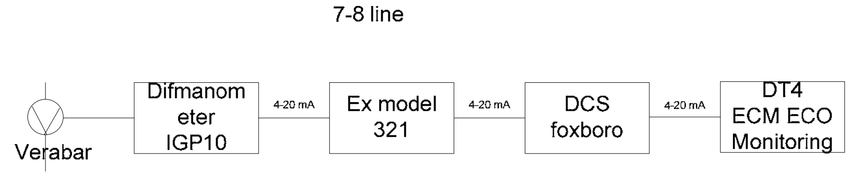
T in burner

Air to mixer







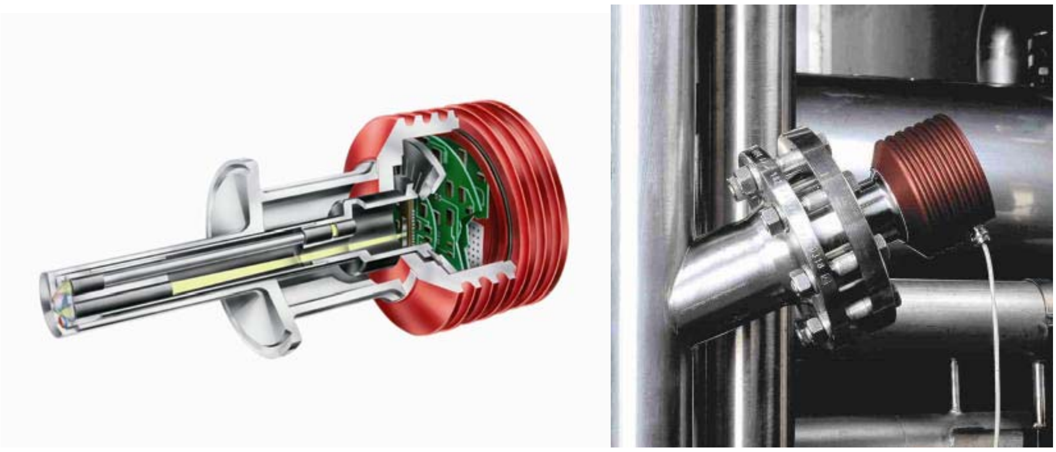


Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, 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 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:

$$Xo=Xn=X$$

where:

Xn: X new
Yo: Y old

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

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

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).The calibration AST test report on July 24, 2009 determined that the pressure transmitter was broken. Later communication with the laboratory Airtec performing the AST test in the plant concluded that a constant average pressure of 103.38 hPa has to be used from the beginning of the failure period (April 27, 2009) until the transmitter was replaced on December 29, 2009, which includes the whole second campaign.

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	90/5/5
	2 t HNO3	61 366	01 Apr 2004	02 Feb 2005	307	200	Johnson Matthey	90/5/5
	3 t HNO3	64 872	26 Jul 2005	10 Mar 2006	227	286	Johnson Matthey	90/5/5
	4 t HNO3	55 693	10 Mar 2006	29 Nov 2006	264	211	Umicore	90/5
	5 t HNO3	63 148	29 Nov 2006	12 Jun 2007	195	324	Heraeus	63/4/33
Average HNO3 production	t HNO3	**61 599**			**241**	**256**		
Project Campaigns	**BL** t HNO3	60 850	11 Jan 2008	21 Jul 2008	192	317	Heraeus	63/4/33
	PL t HNO3	66 297	27 Apr 2009	25 Nov 2009	212	313	Heraeus	63/4/33

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

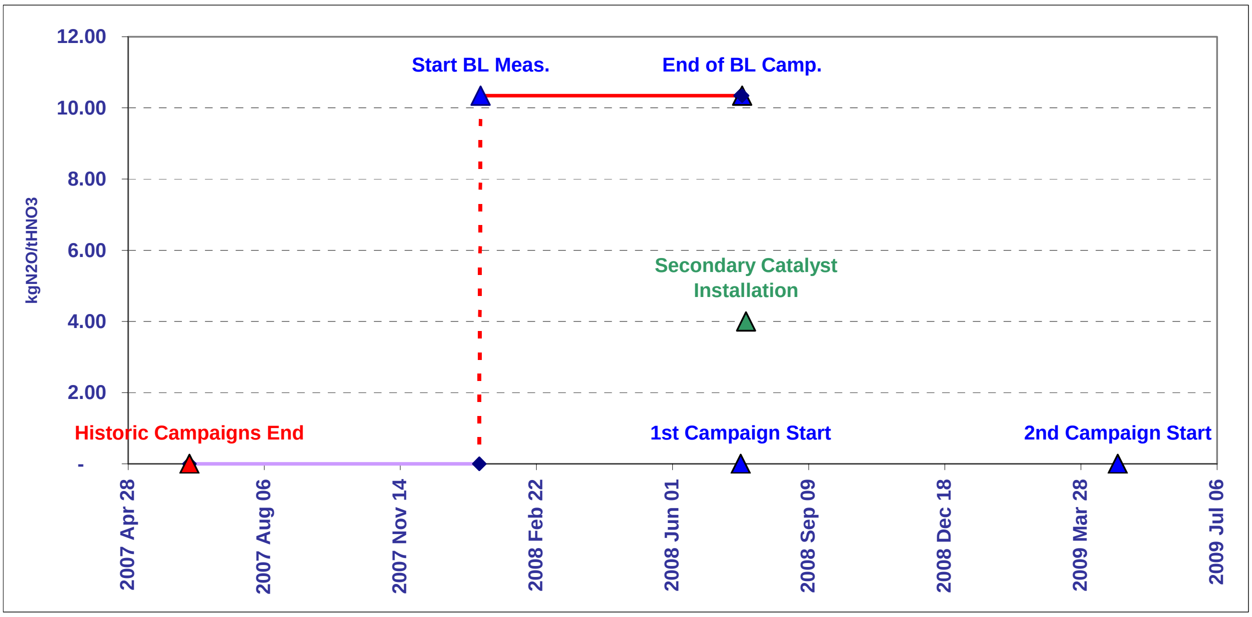


Table T 4 illustrates the calculation of the baseline emission factor on Line 6 using the method as defined in the CDM methodology AM0034 and in the PDD. We have not used overlapping approach allowed by the PDD. Baseline emission factor was determined based on raw data measured from 11/01/2008 through 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 27/04/2009 and went through 25/11/2009.

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 4.66 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	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	**4 233**	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	**4 463**	4 668	4 375	4 388	5 081	4 451	5 081	5 053
as % of Dataset	*88%*	*92%*	*86%*	*86%*	*100%*	*87%*	*100%*	*99%*
Minimum		0.66	0	100 275	126	2	49	3
Maximum		16.52	1 010	119 614	6 642	10.64	904	638
Mean		14.20	620	105 623	5 703	10.44	829	574
Standard Deviation		3.08	101	1 595	1 763	0.18	198	40
Total		66 297						

N2O Emissions (VSG * NCSG * OH)	292	t N2O
Emission Factor	4.41	kgN2O / tHNO3

Data within the confidence interval		
95% Confidence interval		
Lower bound	423	102 497
Upper bound	818	108 748
Count	4 009	4 206
as % of Operating Hours	*90%*	*94%*
Minimum	423	102 502
Maximum	818	108 744
Mean	617	105 642
Standard Deviation	97	1 335

N2O Emissions (VSG * NCSG * OH)	**291**	**t N2O**
Actual Project Emission Factor (EF_PActual)	**4.39**	**kgN2O / tHNO3**
Abatement Ratio	**57.6%**	

Moving Average Emission Factor Correction		**Actual Factors**	**Moving Average Rule**
	1	4.94	4.94
	2	4.39	4.66
	3	-	

Project Emission Factor (EF_P)	**4.66**	**kgN2O / tHNO3**
Abatement Ratio	**54.9%**	

MONITORING REPORT

PROJECT: ACHEMA UKL nitric acid plant N_2O abatement project
LINE: Line 6
MONITORING PERIOD:
FROM: 27/11/2009

TO: 20/09/2010

Prepared by:

VERTIS

VERTIS FINANCE

www.vertisfinance.com

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.

Total quantity of emission reductions generated during the third project period from 27/11/2009 through 20/09/2010 on Line 6 is **143 005 ERUs**.

T 1 Emission reduction calculations

EMISSION REDUCTION			
Baseline Emission Factor	EF_BL	10.34	kgN2O/tHNO3
Project Campaign Emission Factor	EF_P	5.00	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	86 387	tHNO3
GWP	GWP	310	tCO2e/tN2O
Emission Reduction	**ER**	**143 005**	**tCOe**
ER=(EF_BL-EF_P)*NAP_P*GWP/1000			
Abatement Ratio		**51.7%**	

EMISSION REDUCTION PER YEAR			
Year	2008	2009	2010
Date From		27 Nov 2009	01 Jan 2010
Date To		31 Dec 2009	20 Sep 2010
Nitric Acid Production		9 863	76524
Emission Reduction		**16 327**	**126678**
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$_2$O/tHNO$_3$.

Project emission factor during the third project campaign after installation of secondary catalysts on Line 6, which started on 27/11/2009 and went through 20/09/2010 with secondary catalyst installed and commissioned on 25/07/2008, is 5.00 kgN$_2$O/tHNO$_3$.

During the project campaign 86 387 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 five campaigns), has not been used as a cap on the length of the baseline campaign because of shorter project 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 higher than the moving average EF of the campaigns on this line so far, we have used the actual project 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.

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)

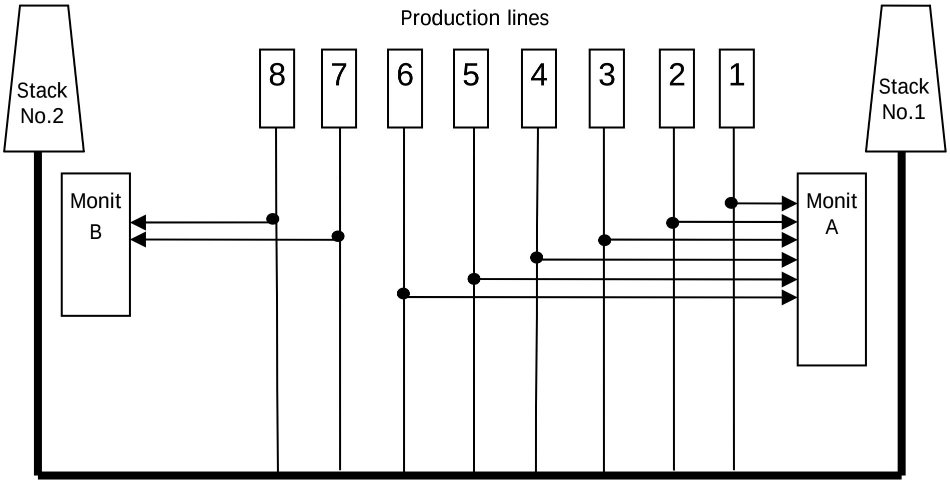
5. MONITORING PLAN

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.

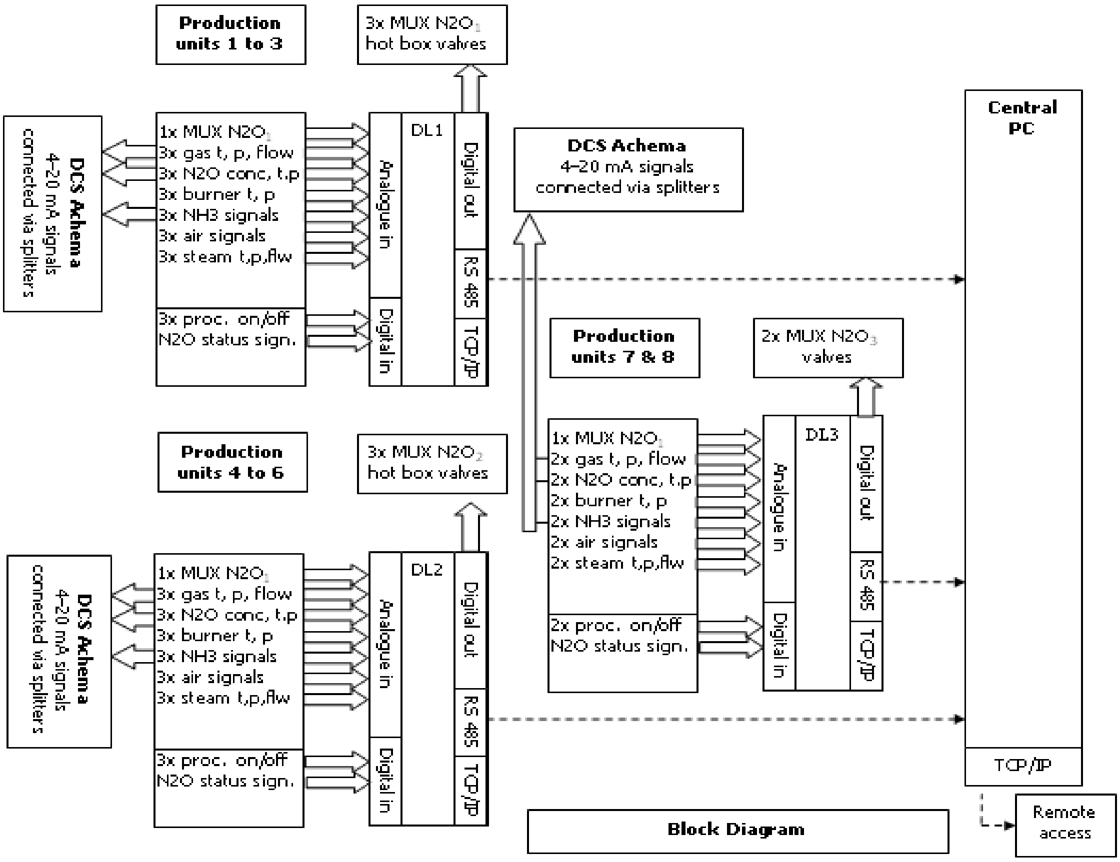
Monitoring System (MS) for purpose of this monitoring plan means:

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.

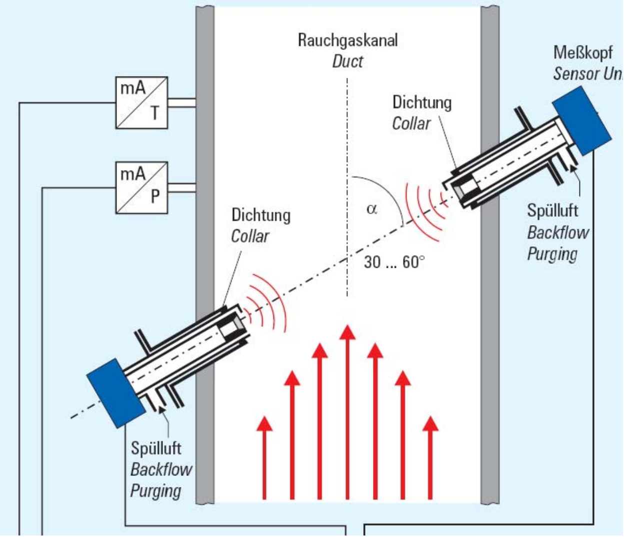
N_2O concentration is measured by concentration infrared absorption principle meters Xentra 4900 using GFX monitoring technology.

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.

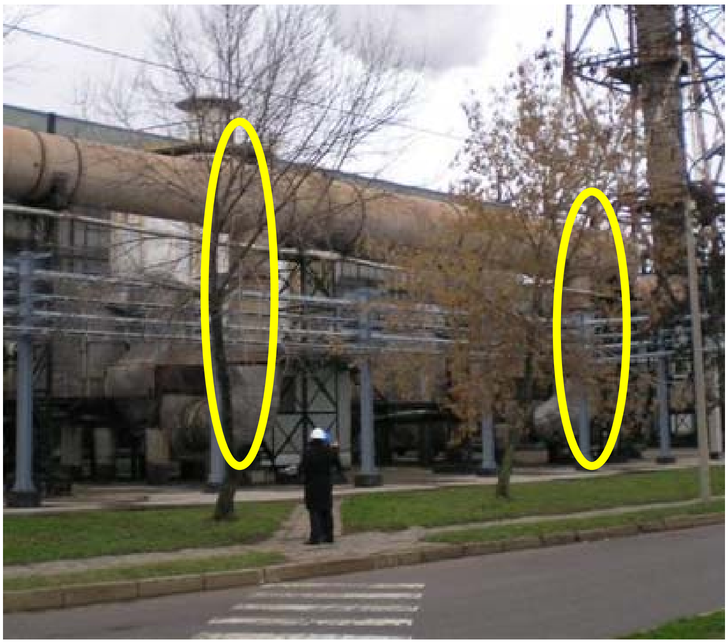
N_2O concentration measured data are sent from the concentration meter on a 2 sec basis in a form of 4-20mA signal to the datalogger and processed further.

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=L1_Flow_N2O*(273.15/(273.15+L1_Temp))*(L1_Press/101.325)*((100-L1_Humi)/100)

where Humi (water content)=

(L1_Flow_steam*1.2436)/(L1_Flow_N2O*(273.15/(273.15+L1_Temp))*(L1_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.

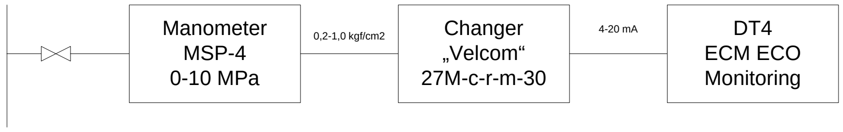
Operating conditions

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

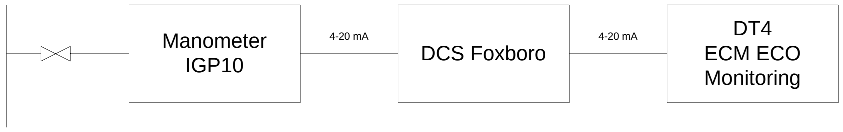
Ammonia flow
Ammonia temperature
Ammonia pressure
Primary air flow
Primary air temperature
Primary air pressure
Oxidation temperature
Oxidation pressure

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

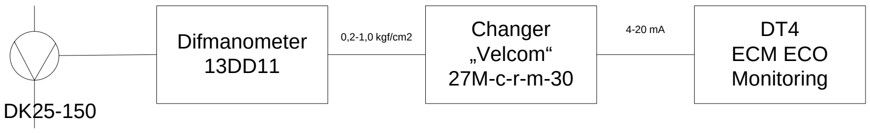
P in mixer 1-6 line



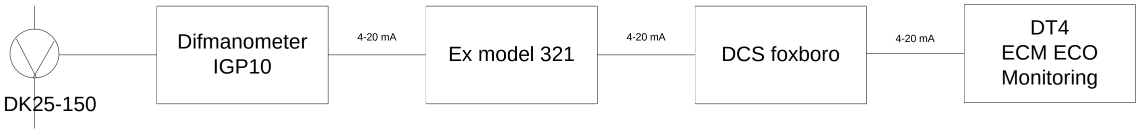
P in mixer 7-8 line



NH3 to mixer 1-6 line



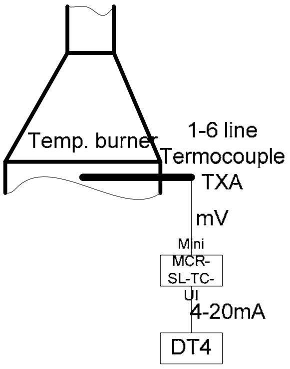
NH3 to mixer 7-8 line

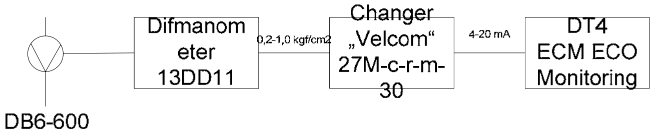


T in burner

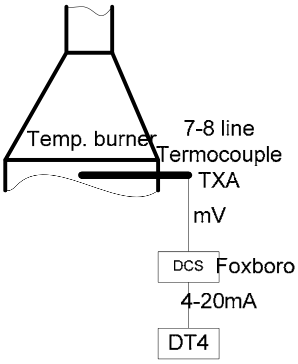
Air to mixer

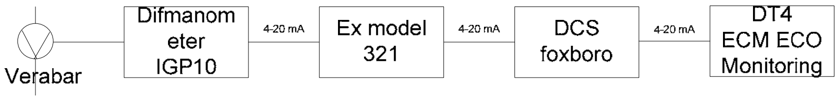
1-6 line





7-8 line



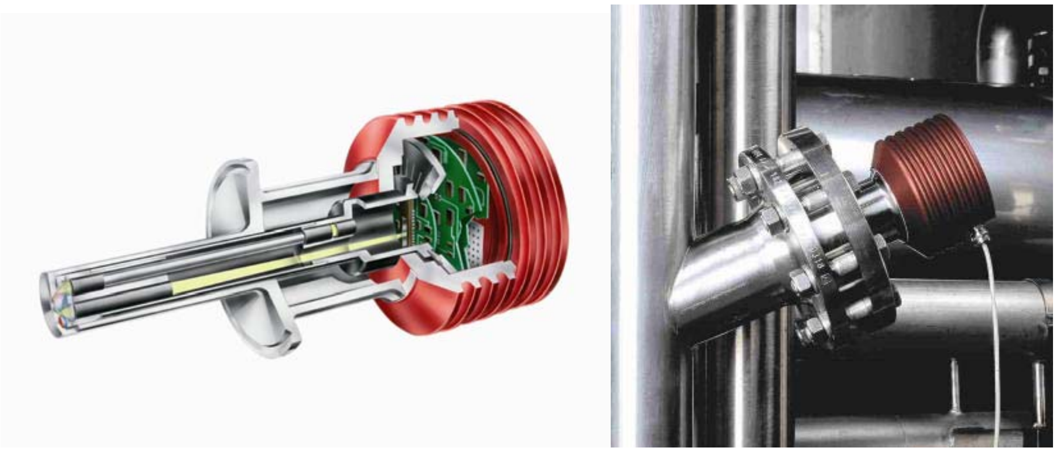


Signals obtained from these measurement devices from production Lines 1-6 are converted from pneumatic to 4-20mA analog signals. Operating conditions measurement devices installed in production Lines 7-8 provide the 4-20mA signals which are digitalized and provided to the monitoring system dataloggers, 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:

$$Xo=Xn=X$$

where:

Xn: X new
Yo: Y old

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

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

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).The calibration AST test report on July 24, 2009 determined that the pressure transmitter was broken. Later communication with the laboratory Airtec performing the AST test in the plant concluded that a constant average pressure of 103.38 hPa has to be used from the beginning of the failure period (April 27, 2009) until the transmitter was replaced on December 29, 2009. From December 30, 2009 through September 20, 2010 (end of the third campaign) we have applied usual QAL2 calculations.

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	90/5/5
	2 t HNO3	61 366	01 Apr 2004	02 Feb 2005	307	200	Johnson Matthey	90/5/5
	3 t HNO3	64 872	26 Jul 2005	10 Mar 2006	227	286	Johnson Matthey	90/5/5
	4 t HNO3	55 693	10 Mar 2006	29 Nov 2006	264	211	Umicore	90/5
	5 t HNO3	63 148	29 Nov 2006	12 Jun 2007	195	324	Heraeus	63/4/33
Average HNO3 production	t HNO3	**61 599**			**241**	**256**		
Project Campaigns	**BL** t HNO3	60 850	11 Jan 2008	21 Jul 2008	192	317	Heraeus	63/4/33
	PL t HNO3	86 387	27 Nov 2009	20 Sep 2010	297	291	Heraeus	63/4/33

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

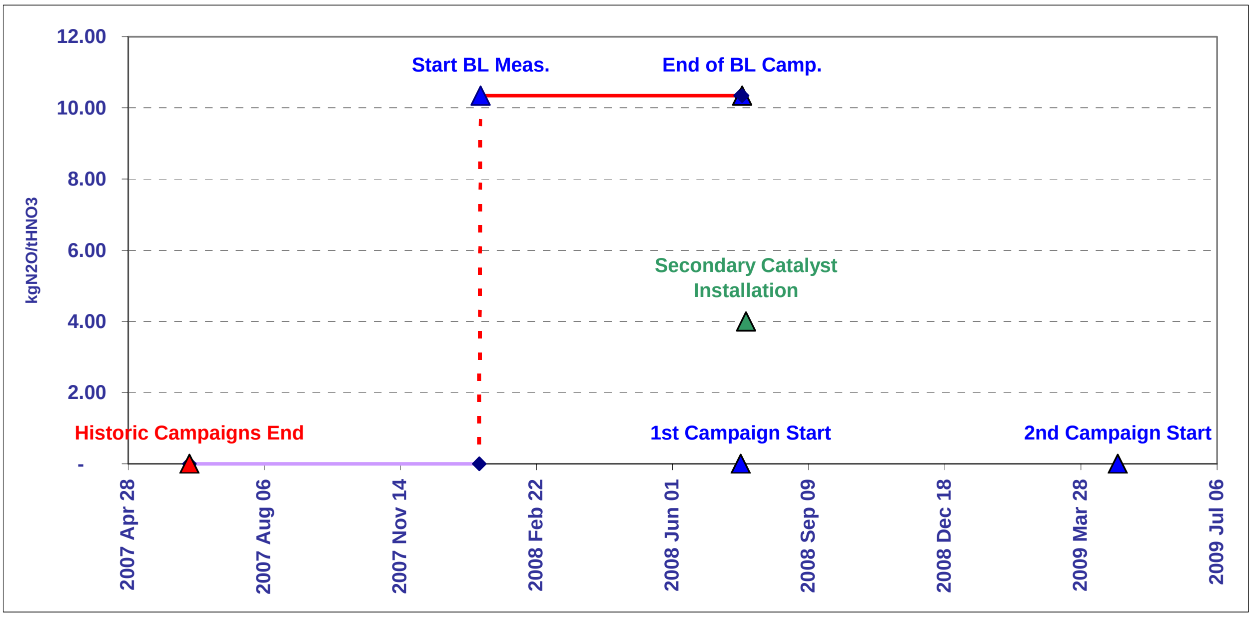


Table T 4 illustrates the calculation of the baseline emission factor on Line 6 using the method as defined in the CDM methodology AM0034 and in the PDD. We have not used overlapping approach allowed by the PDD. Baseline emission factor was determined based on raw data measured from 11/01/2008 through 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 27/11/2009 and went through 20/09/2010.

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 5.00 kgN2O/tHNO3.

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

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

T 4 Baseline emission factor

BASELINE EMISSION FACTOR	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	**4 233**	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	**5 459**	7 089	5 421	5 677	7 129	5 609	7 129	7 104
as % of Dataset	*77%*	*99%*	*76%*	*80%*	*100%*	*79%*	*100%*	*100%*
Minimum		-	1	2	31	1	13	0
Maximum		18.64	1 427	116 339	8 000	19.94	1 100	696
Mean		12.19	772	101 316	5 004	10.17	718	568
Standard Deviation		5.42	166	20 603	2 465	1.17	342	119
Total		86 387						
N2O Emissions (VSG * NCSG * OH)	427	t N2O						
Emission Factor	4.94	kgN2O / tHNO3						
Data within the confidence interval								
95% Confidence interval								
Lower bound			446	60 934				
Upper bound			1 097	141 699				
Count			4 758	5 453				
as % of Operating Hours			*87%*	*100%*				
Minimum			453	67 499				
Maximum			1 097	116 339				
Mean			750	105 434				
Standard Deviation			120	3 155				
N2O Emissions (VSG * NCSG * OH)	**432**	**t N2O**						
Actual Project Emission Factor (EF_PActual)	**5.00**	**kgN2O / tHNO3**						
Abatement Ratio	**51.7%**							
Moving Average Emission Factor Correction	**Actual Factors**	**Moving Average Rule**						
1	4.94	4.94						
2	4.39	4.67						
3	5.00	5.00						
Project Emission Factor (EF_P)	**5.00**	**kgN2O / tHNO3**						
Abatement Ratio	**51.7%**							

ANNEX TO THE MONITORING REPORT

PROJECT: **ACHEMA UKL nitric acid plant N_2O abatement project**

Prepared by:

VERTIS

VERTIS FINANCE

As required by PROCEDURES REGARDING CHANGES DURING PROJECT IMPLEMENTATION (Version 01) issued by the Joint Implementation Supervisory Committee we are stating that there have occurred following changes to the project design comparing to as described in the PDD document from the time when determination was deemed to be final (November 27, 2009):

Change Nr. 1

At the time of the project determination there was not selected yet any Investor Party. The Investor Party LoA has been issued on June 1, 2010 to the company ECOCOM BG Ltd. (the project participant) by The Netherlands (not the project participant).

Besides this change there have occured no other changes relating to project fundaments such as

(a) physical location;
(b) emission sources;
(c) baseline scenario;

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

Achema UKL-7 IPPC permit defines the regulatory level as total mass of N_2O allowed to be emitted from the UKL-7 plant in the years 2008 through 2012. N_2O mass emissions of the Achema UKL-7 plant were in all 3 years from 2008 through 2010, which are subject to the second periodic verification, below the IPPC mass limit value.

For purpose of comparison of the regulatory level and actual baseline emission factors we have applied the baseline emission factors on the nitric acid production which occurred in relevant years on the nitric acid lines subject to the verification (1-8).

As presented in the table below the Achema KL-7 plant would be below the regulatory cap also in case of absence of the JI project. It means, that project can use the baseline emission factors as measured.

Due to the structure of the UKL-7 plant where 8 nitric acid lines falling under the scope of the JI project are operated with different campaign schedules, there will come yet more campaigns to be verified in next verifications (does not apply to the year 2008, where all campaigns have been already finished and verified). It means that in next verifications the calculation will be conducted again and if there would occur any violation of the IPPC mass limit, then such violation would be balanced against the quantity of ERUs claimed in that particular verification making sure that no ERUs would be claimed above the regulatory level.

Results of calculation of hypothetical N_2O emissions from the UKL-7 plant (8 lines) in years 2008, 2009 and 2010 are presented in the table below.

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

Calculated plant emissions in absence of JI project		2008	2009	2010
Total Nitric Acid Produced	*tHNO3*	587,784	521,216	141,502
Calculated N2O Emission in absence of JI project	*kgN2O*	4,472,161	4,367,638	1,360,220
N2O emission above regulatory level	*kgN2O*	**0**	**0**	**0**

Nitric acid produced during project campaigns			2008	2009	2010
Line	Campaign	BEF	NAP		
1	0	9.63	60,691		
2	0	7.92	28,951		
3	0	4.42	42,999		
4	0	7.20	57,815		
5	0	6.61	47,192		
6	0	10.34	60,850		
7	0	7.85	26,856		
8	0	6.61	34,716		
1	1	9.63	1,913	55,103	37,831
2	1	7.92	12,151	241	
3	1	4.42	13,520		
4	1	7.20	11,753	27,403	
5	1	6.61	39,871	20,358	
6	1	10.34	41,416	26,902	
7	1	7.85	31,445		
8	1	6.61	45,181		
1	2				
2	2	9.51		61,628	
3	2	5.45	24,950	31,372	
4	2	7.73		42,744	22,505
5	2	6.61		66,630	4,642
6	2	10.34		66,297	
7	2	9.09		58,897	
8	2	6.96	5,513	53,779	
1	3				
2	3				
3	3				
4	3				
5	3				
6	3	10.34		9,863	76,524
7	3				
8	3				