	Advanced Methanol Amsterdam B.V. New 260 MTPD Methanol Plant Amsterdam, The Netherlands	**Proj. No.:** A09480 **Doc. No.:** A09480M-E-PRH-3602 **Rev.:** 00 **Sheet No.:** 1 of 13
ADVANCED METHANOL AMSTERDAM		**Client Proj. No.:** 1 **Client Doc. No.:**

FIRED HEATER EMISSION REPORT

CONFIDENTIAL

Form TDT01-rev02

REV.	**DATE**	**DESCRIPTION**	**PREPARED**	**CHECKED**	**APPROVED**

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1 INTRODUCTION

G.I. Dynamics B.V. (GID) is developing a Gasification to Bio-Methanol Plant for and on behalf of Advanced Methanol Amsterdam B.V. (AMA).

The facility will be located in Amsterdam, and is based on HTW Gasification technology from GIDARA Energy B.V.

This plant will produce Advanced Methanol from Refuse Derived Fuel (RDF) and Waste Wood (WW).

Since the plant will be located close to a protected area, the local authorities require more stringent limits both in term of NO_x emissions and NH_3 slip.

In particular, zero dispersion of ammonia is allowed at ground level.

G.I. Dynamics B.V. (GID) has requested to CASALE SA to provide a report in order to describe the NO_x Control Technologies selected for the AMA Project.

2 SCOPE

The purpose of this report is to give evidence about the maximum achievable emission reduction level with the technologies selected for the AMA Project.

3 NO_X CONTROL STRATEGIES EXECUTIVE SUMMARY

Based on the current best available technologies, different strategies have been adopted in order to achieve the required emission level imposed by local regulations.

The system has been properly designed with the following features:

- Burners design has been selected as Low-NO_x type achieving the minimum achievable emission level without excessively affecting the combustion efficiency.
- The fired heater has been designed adopting a configuration able to burn all the available plant waste gas (the lower emission producer), minimizing the make-up fuel gas consumption (higher emission producer).
- SCR System has been foreseen in combination with the Low-NO_x Burners in order to achieve the required both the NO_x and NH_3 target values. Selective Catalytic Reduction (SCR) is recognized worldwide as the most effective NO_x control technology when substantial NO_x reduction of 50% up to 99% is required.
- The ammonia slip has been reduced as much as possible both with a proper design for injection/mixing distribution system and a proper fine control system for the ammonia dosing unit. The design been optimized as much as possible to achieve the target value.

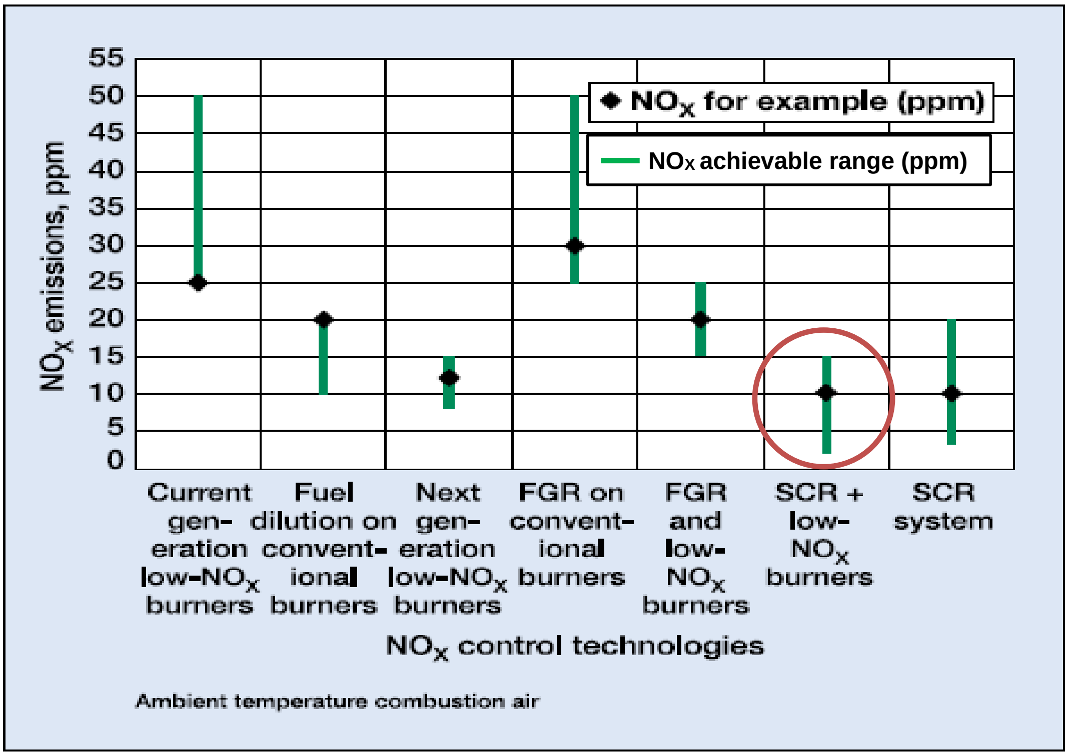

Fig. 3.1 NO_x control technology - Achievable NO_x emission range

The achievable NO_x emission range using the combination of the Low-NO_x Burners and the SCR System is 2 ÷ 15 ppmv @3%O_2 dry basis depending on the installed catalyst volume. (**Fig**.3.1).

4 NO_X CONTROL SELECTED TECHNOLOGIES FOR AMA PROJECT

4.1 LOW-NO_X BURNERS

Combustion control techniques reduce the amount of NO_x emission by limiting the amount of NO_x formation during the combustion process.

In particular, LNB burners can use air staging, fuel staging or internal furnace gas recirculation to lower peak flame temperatures and directly reduce NO_x emissions from combustion.

4.1.1 LNB REQUIRED PERFORMANCES

For this specific project, LNB Burners have been foreseen in order to achieve a maximum NO_x content of 35 ppmv @3%O_2 dry (70 mg/Nm^3), as a guaranteed figure, in the flue gas from the combustion zone.

This value is in compliance with the maximum NO_x emission levels allowed by the EU regulation and it can be guaranteed by all Top Class Burner Vendors (i.e. ZEECO, John Zink, Callidus, etc).

4.2 SCR SYSTEM

SCR process is based on the chemical reduction of the NO_x molecule through the ammonia injected upstream in presence of a metal-based catalyst with activated sites to increase the rate of the reduction reaction.

The reagent reacts selectively with the flue gas NO_x within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NO_x into molecular nitrogen (N_2) and water vapor (H_2O).

Selective catalytic reduction can be utilized where exhaust gases are between 250°C and 650°C, depending on the catalyst used.

Theoretically, SCR systems can be designed for NOx removal efficiencies up close to 100 percent. In practice, commercial fuel gas fired SCR systems are often designed to meet control targets of over 95 percent. Properly designed SCR systems, which operate close to the theoretical stoichiometry and supply adequate catalyst volume, maintain low ammonia slip levels, approximately less than 2 ppm [1].

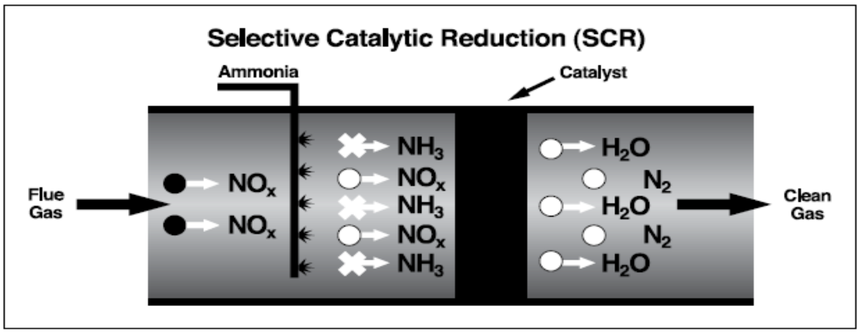

Fig. 4.2.1 SCR System Operation Scheme

4.2.1 SCR REQUIRED PERFOMANCES

Due to the AMA complex location constrains, an extremely low emission levels are allowed in order to be in compliance with the local law requirements.

In particular, the results of the dispersion study require that the SCR System performances shall be the following:

- max 1 ppmv @ 3%O_2 dry of NO_X
- max 0.2 ppmv @ 3%O_2 dry of NH_3

4.3 SCR VENDOR DATA

In the next paragraph are shown the expected and guaranteed performances of three different SCR Catalyst Vendors.

4.3.1 DESIGN BASIS

FLUE GAS OPERATING CONDITION					
OPERATING CASE:		**EOR DESIGN CASE**	**SOR CASE**	**MOR MINIMUM REACTIVITY CASE**	**MOR MAXIMUM REACTIVITY CASE**
Flowrate	kg/h	6609	6560	6678	4253
Temperature	°C	333	333	333	333
Inlet Pressure	mmWCg	-145	-145	-147	-122
MW		28.1	28.1	27.8	28.3
Composition:	%v				-
O_2		2.3	2.3	2.3	2.3
N_2		66.3	66.3	69.2	65.8
Ar		0.9	0.9	1	0.9
CO_2		11.4	11.4	9	12.2
H_2O		19.1	19.1	18.5	18.8
SO_2	ppmv	N/A	N/A	N/A	N/A
NO_X	ppmv	35 max	35 max	35 max	35 max
Maximum Allowable NO_X @ SCR SYSTEM OUTLET				ppmv @3% O_2 dry	**≤ 1**
Maximum Allowable NH_3 Slip @ SCR SYSTEM OUTLET				ppmv @3% O_2 dry	**≤ 0.2**

Tab. 4.3.1.1. SCR System Performances Design Basis

4.3.1.1 ZEECO SCR PERFORMANCES

ZEECO provided a technical offer both Burner and SCR so that can be considered responsible for the overall NO_x and NH_3 stack emissions.

in the table below are shown the guaranteed performances both for the Radiant Chamber Burners and the SCR System:

Burner	Unit	Guaranteed
NOx	mg/Nm3	70(*)
CO	ppmvd	50
UHC	ppmvd	4
Particulates	ppmvd	100
Stack Emission	**Unit**	**Guaranteed**
NOx	ppm	< 1,0
Ammonia slip	ppm	< 0,2
Pressure drop	mmWC	< 90 (**)

(*) Zeeco will be responsible to guarantee the NOx stack emissions since we are offering both Burners and SCR system.
(**) The above pressure drop doesn't take in account the pressure drop of the static mixer that might be necessary after CFD analysis to be installed downstream the ammonia atomizing gun to ensure that the necessary distribution NH3/NOx is reached. In case static mixer will be necessary, the pressure drop of the system will be 200mmWC.

These values are understood to apply only when the system is operated in accordance with the operating conditions stipulated in the design summary and for the waste(s) stipulated in the design basis sections of this proposal. VOC is defined as non-methane and non-ethane hydrocarbons.

Tab. 4.3.1.1.1 ZEECO SCR System Performances

For details refer to the Attachment 1.

4.3.1.1.1 ZEECO REFERENCES

Refer to Attachment 2.

4.3.1.2 FUEL TECH SCR PERFORMANCES

5.0 SCR NO_x DESIGN BASIS

Parameter	Units	EOR	SOR	MOR minimum reactivity	MOR maximum reactivity
Flue gas flow	kg/h wet	6609	6560	6678	4253
Flue gas flow	Nm^3/h wet	5266	5227	5381	3370
Temperature	°C	338	334	337	330
Duct Inlet pressure	mmwg	-45	-45	-47	-22
Inlet NO_x	**ppm @3% O_2 dry**	**35**	**35**	**35**	**35**
NOx present as NO_2	%	20	20	20	20
Inlet CO	mg/Nm^3 @ 3% O_2 dry	n.a.	n.a.	n.a.	n.a.
O_2, volume	% wet	2.3	2.3	2.3	2.3
H_2O, volume	% wet	19.1	19.1	18.5	18.8
CO_2, volume	% wet	11.4	11.4	9	12.2
SO_2	ppm @ op. O_2 wet	<1	<1	<1	<1
SO_3	ppm @ op. O_2 wet	n.a.	n.a.	n.a.	n.a.
Particulate <10µ	mg/Nm^3 wet	< 130	<130	<130	<130

5.1 SCR Performance

Parameter	Units	EOR	SOR	MOR minimum reactivity	MOR maximum reactivity
NOx outlet **guaranteed**	**ppm @3% O_2 dry**	**1.0**	**1.0**	**1.0**	**1.0**
NH_3 slip **guaranteed**	**ppm @3% O_2 dry**	**0.2**	**0.2**	**0.2**	**0.2**
Estimated Reagent	kg/h @ 24.5% NH_4OH	0.45	0.45	0.49	0.29
Pressure drop guaranteed *(within battery limits)*	mmH_2O @ 4°C	100	100	100	100

Expected NH_3 slip w/ new catalyst vs. EoL catalyst	-	None
Ammonia inj. rate w/ new catalyst vs. EoL catalyst	-	None*

** There might be other dust with the ability to oxidize NH3 in the flue gas which can deposit on catalyst: this might cause NH3 consumption to increase.*

Tab. 4.3.1.2.1 Fuel Tech SCR System Performances

For details refer to the Attachment 3.

4.3.1.2.1 FUEL TECH REFERENCES

Refer to Attachment 4.

4.3.1.3 CECO PEERLEES SCR PERFORMANCES

A. **DESIGN CONDITIONS:** The proposed SCR System design is based on the following design conditions; the data is for one (1) unit. Should the actual gas conditions be different from the design data, the performance shall be re-evaluated, based on the corrected design data.

PROCESS DATA								
Design Case					Case 1	Case 2	Case 3	Case 4
Customer Design Case					EOR Design	SOR Design	MOR Min Reactivity	MOR Max Reactivity
Percent Load				Percent	100%	100%	100%	100%
Fuel Case					Gas	Gas	Gas	Gas
Exhaust Gas Mass Flowrate, Wet				kg/h	7269,0	6560,0	6678,0	4253,0
Exhaust Gas Volumetric Flowrate, Wet				Nm3/h	5786	5221	5374	3366
Exhaust Gas Temperature				degrees C	338,0	334,0	337,0	330,0
Exhaust Gas Composition								
Component	*MW*							
O2	31,999			vol% (wet)	2,30	2,30	2,30	2,30
H2O	18,015			vol% (wet)	19,10	19,10	18,50	18,80
N2	28,013			vol% (wet)	66,30	66,30	69,20	65,80
CO2	44,010			vol% (wet)	11,40	11,40	9,00	12,20
Ar	39,948			vol% (wet)	0,90	0,90	1,00	0,90
					100,00	100,00	100,00	100,00
Emissions from the Source		@	%O2	3				
Nox as NO2				ppmvd	35.00	35.00	35.00	35.00
Nox as NO2				kg/h	0,34	0,31	0,32	0,20
SO2				ppmvw	1,00	1,00	1,00	1,00
SO2				kg/h	0,02	0,01	0,02	0,01
Particulates				mg/Nm3 (dry)	130,00	130,00	130,00	130,00
Amount of Nox as NO2				Percent	20,00	20,00	20,00	20,00
Nox Reduction				Percent	97,14	97,14	97,14	97,14
Aqueous Ammonia Requirement				kg/h	0,619	0,614	0,638	0,398
Aqueous Ammonia Requirement				m3/month	1,000	0,492	0,511	0,319
Performance Warranties		@	%O2	3				
Nox as NO2				ppmvd	1,0	1,0	1,0	1,0
Nox as NO2				kg/h	0,010	0,009	0,009	0,006
NH3 Slip				ppmvd	1,00	1,00	1,00	1,00
NH3 Slip				kg/h	0,004	0,003	0,003	0,002

Tab. 4.3.1.3.1 CECO Peerless SCR System Performances

For details refer to the Attachment 4.

4.3.1.3.1 CECO PEERLEES REFERENCES

Refer to the Attachment 6.

4.4 CASALE REFERENCES

Casale confirms that in some Acid Nitric Plant licensed by Casale and provided with an SCR Unit, the following parameters have been achieved:

Performance guarantee for 100% load	Guarantee value	Measured figure (without tolerance)	Evaluated figure (with tolerance)	Result
NOx (as NO2) in any vented stream	≤ 30 ppmv	10,68	9,68	OK
NH3 in any vented stream	≤ 2 ppmv	0,000 Note a	0,000 Note a	OK

Note:

a. Not detectable

Tab. 4.4.1. SCR System Performances - Casale Ammonia Nitric Plant

Casale can not disclose Client name due to confidentiality issue.

In any case the above data (**Tab**. 4.4.1) is an evident proof that the “zero” ammonia slip is industrially achievable with an SCR Unit.

5 REFERENCES

[1]. Institute of Clean Air Companies (ICAC). White Paper. Selective Catalytic Reduction (SCR) Control of NO_x Emissions From Fossil Fuel-Fired Electric Power Plants. May 2009.

6 ATTACHMENTS

- ATTACHMENT 1: ZEECO SCR PERFORMANCES
- ATTACHMENT 2: ZEECO REFERENCE LIST – will follow
- ATTACHMENT 3: FUEL TECH SCR PERFORMANCES
- ATTACHMENT 4: FUEL TECH REFERENCE LIST
- ATTACHMENT 5: CECO PEERLESS SCR PERFORMANCES
- ATTACHMENT 6: CECO PEERLESS REFERENCE LIST