COMBINED HEAT & POWER PRODUCTION AT TIOXIDE Cy, in Calais (F)

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In 2000, TRACTEBEL Energy Engineering realized for the TIOXIDE Cy, Calais (F) a plant including :
- A cogeneration unit of 47 MWe including postcombustion
- Two auxiliary boilers of 38 and 61 MW maintained in "stand by" mode
The plant is managed by ELYO Cy.

1 - COGENERATION UNIT

The HRSG supplied by STANDARD FASEL LENTJES (NL) is equipped with a "TEG" by-pass including a vent and diverter and with a PILLARD postcombustion burner REBURNFLAM® type operating in either TEG or ambient air mode.

Main characteristics :

Gas turbine	: LM 6000 GE, 47 MWe	
HRSG	: 75 t/hr steam at 71 bar/480°C	
	+ 10 t/hr low pressure steam at 20 bar/250°C	
TEG	: Max flow	: 128,8 kg/sec at 455°C
	O_2 content	: 14,2 %
	H_2O content	: 6,2 %
PILLARD burner type REBURNFLAM®	: In TEG mode	: P = 1,7 to 50 MW (turndown ratio 1 to 30)
	In ambient air mode	: P = 1,7 to 90 MW (turndown ratio 1 to 50)
	Fuel	: Natural gas
	Number of rows	: 6 (operation possible with 2, 4 or 6 rows)

In ambient air mode, the combustion air is supplied by 2 fans located symmetrically each side of the duct, upstream to the burner.

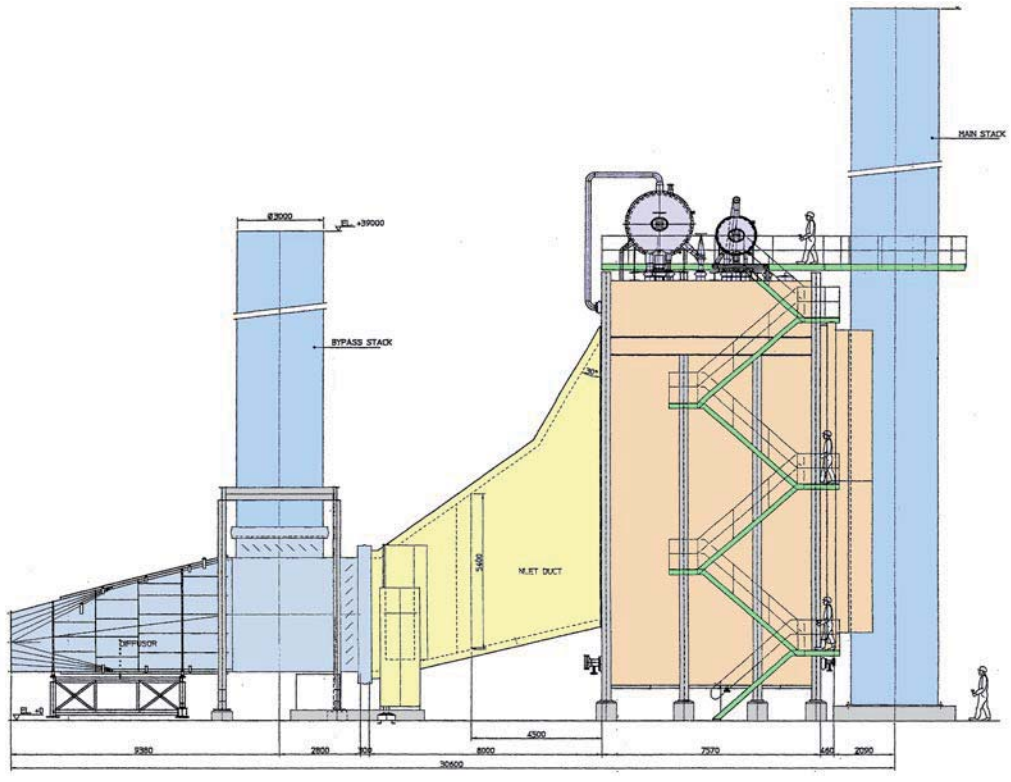


Fig.1 - General outlook of the Cogeneration unit

EMISSIONS LIMITS AS SPECIFIED

In TEG mode :
The emissions limits for NOx and CO are identical to those at the turbine outlet. Therefore the burner must refrain from increasing them.

Turbine emissions :
NOx < 50 mg/Nm³ (@ 15 % O_2 dry)
CO < 80 mg/Nm³ (@ 15% O_2 dry)

Emissions downstream from the burner :
NOx < 50 mg/Nm³ (@ 15% O_2 dry)
CO < 80 mg/Nm³ (@ 15% O_2 dry)

In ambient air mode :
NOx < 200 mg/Nm³ (@ 3 % O_2 dry)
CO < 240 mg/Nm³ (@ 3% O_2 dry)

COMBUSTION TECHNIQUE APPLIED

Induct burner type REBURNFLAM® LOW NOx, section 3700 x 5400 mm

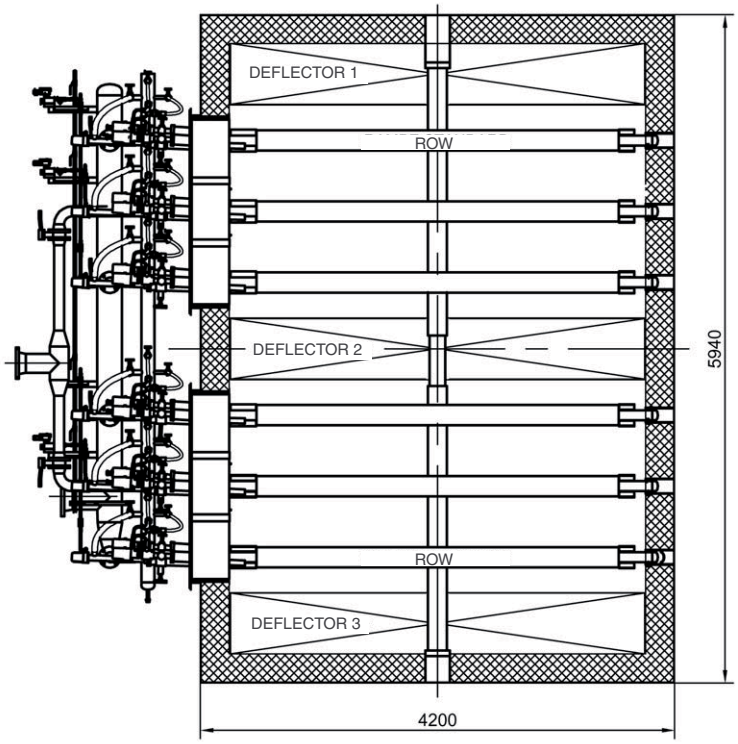


Fig.2 - PILLARD burner type REBURNFLAM® LOW NOx

In order to obtain a sufficient combustive velocity through the burner, 3 deflectors have been installed.

The target being to reach a turndown ratio of 1 to 30 in TEG mode, 1 to 50 in ambient air mode, the burner is equipped with 2 natural gas feeds allowing to operate with 2, 4 or 6 rows.

Operational choices :

TEG mode	1,7 to 10 MW	: 2 rows
	3,4 to 20 MW	: 4 rows
	5,1 to 30 MW	: 6 rows
Ambient air mode	1,7 to 30 MW	: 2 rows
	3,4 to 60 MW	: 4 rows
	5,1 to 90 MW	: 6 rows

The necessity to obtain less than 200 mg/Nm³ NOx @ 3% O_2 in ambient air mode without CO, meant fitting 4 rows out of 6 with “LOW NOx” elements (PILLARD patent n° 00/01455), operated as follows :
Operating with 2 rows : 2 LOW NOx rows
Operating with 4 rows : 2 LOW NOx rows (+) 2 standard rows
Operating with 6 rows : 4 LOW NOx rows (+) 2 standard rows

MEASURED EMISSIONS

The emissions have been verified by CETE APAVE Cy on the 19th and 20th of February 2002 at nominal loads for the 2 modes (TEG and ambient air).

CETE apave nord ouest

SOCIETE : TRACTEBEL site TIOXIDE - CALAIS — DOSSIER : 02.1001.5014

Installation : TAG en cycle post combustion allure maxi — DATE D'INTERVENTION : 20 février 2002

RESULTATS DE MESURES — TABLEAU C

Identification de l'installation et mesures effectuées	Unité	Résultats aux conditions de dilution existantes (basic results)		Résultats aux conditions de référence (Results)				(corrected value)	Horaires
		sur gaz dry	sur gaz humid	formule corrective	base de correction % H2O	CO2	O2	Valeur corrigée	de prélèvements
						5,29	11,53		14h50 à 16h20
NOX en NO2	mg/Nm³	52,15	Non eff.	15% O2 sur sec	"	"	"	33,0	14h50 à 16h20
NO en NO2	mg/Nm³	32,44	Non eff.	15% O2 sur sec	"	"	"	20,6	14h50 à 16h20
NO2 en NO2	mg/Nm³	19,71	Non eff.	15% O2 sur sec	"	"	"	12,5	14h50 à 16h20
CO	mg/Nm³	63,13	Non eff.	15% O2 sur sec	"	"	"	39,99	14h50 à 16h20

NOx : 33 mg/Nm³ @ 15 % O_2 (dry)
CO : 39,99 mg/Nm³ @ 15 % O_2 (dry)

CETE apave nord ouest

SOCIETE : TRACTEBEL site TIOXIDE - CALAIS — DOSSIER : 02.1001.5014

Installation : Chaud. récupération mode air frais (80 T/H HP) — DATE D'INTERVENTION : 19 février 2002

RESULTATS DE MESURES — TABLEAU A

Identification de l'installation et mesures effectuées	Unité	Résultats aux conditions de dilution existantes (basic results)		Résultats aux conditions de référence (Results)				(corrected value)	Horaires
		sur gaz dry	sur gaz humid	formule corrective	base de correction % H2O	CO2	O2	Valeur corrigée	de prélèvements
						3,22	15,21		15h00 à 16h30
NOX en NO2	mg/Nm³	61,53	Non eff.	3% O2 sur sec	"	"	"	191,3	15h00 à 16h30
NO en NO2	mg/Nm³	44,43	Non eff.	3% O2 sur sec	"	"	"	138,1	15h00 à 16h30
NO2 en NO2	mg/Nm³	17,10	Non eff.	3% O2 sur sec	"	"	"	53,2	15h00 à 16h30
CO	mg/Nm³	43,38	Non eff.	3% O2 sur sec	"	"	"	134,8	15h00 à 16h30

NOx : 191,3 mg/Nm³ @ 3 % O_2 (dry) (guaranteed 200)
CO : 134,8 mg/Nm³ @ 3 % O_2 (dry) (guaranteed 240)

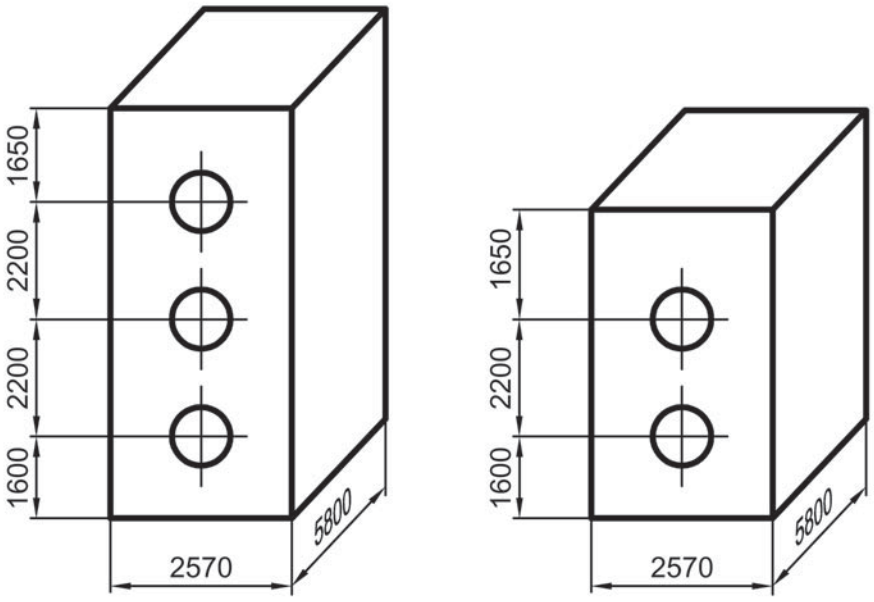
In conclusion, all emissions comply with the guaranteed ones.

2 - AUXILIARY BOILERS IN "STAND-BY" MODE

Their purpose is to ensure steam production even if the Cogen unit stops. The 2 auxiliary boilers have been supplied by STANDARD FASEL LENTJES (NL), and are equipped with PILLARD burners, GRC LONOxFLAM gas type.

Main characteristics :

Boilers	:	Production :	50 t/hr	and	80 t/hr steam
		Steam :	40 bar /250°C		
PILLARD burner type :		Heat release	4,8 to 38 MW	7,6 to 61 MW (turndown ratio 1 to 8)	
GRC LONOxFLAM gas		Number	2	3	
		Fuel	natural gas	natural gas	



80 t/hr boiler 50 t/hr boiler

Fig.3 - Position of burners

TARGETS SET FOR THE AUXILIARY BOILERS

- First, if the cogen unit stops, the boilers much reach their nominal power very quickly (about 30 seconds) so that there is no interruption in steam production.
- Second, to meet the following emissions limits :

NOx < 100 mg/Nm³ (@ 3% O_2 dry)
CO < 100 mg/Nm³ (@ 3% O_2 dry)

COMBUSTION TECHNIQUE APPLIED

The target of 100 mg/Nm³ NOx @ 3% O_2 dry, led to the use of the PILLARD burner, GRC LONOxFLAM gas type which includes an internal FGR principle thanks to a venturi effect, sucking flue gas from the furnace and causing a decrease in the O_2 content of the flame.

In order to maintain the boilers in «stand-by» mode, permanent pilot burners for 5 % of the max heat release have been installed. They allow to maintain the boiler ready to immediately increase its load by lighting up the main burners, increasing their heat release up to 100 % in about 30 seconds.

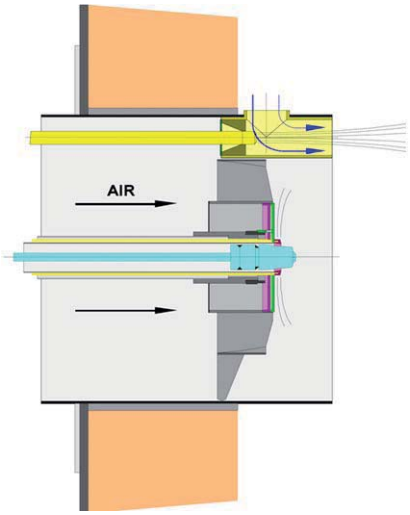


Fig.4 - PILLARD burner
type GRC LONOxFLAM® gas

MEASURED EMISSIONS

The emissions were verified by CETE APAVE Cy on the 14th of June 2001

For the 80 t/hr boiler :

CETE apave nord ouest

RESULTATS DE MESURES	Chaud.aux.80 T/H	14-juin-01

Identification de l'installation et mesures effectuées	Unité	Résultats aux conditions de dilution existantes (basic results)		Résultats aux conditions de référence (Results)				(corrected value) Horaires
		sur gaz dry	sur gaz humid	formule corrective	base de correction % H2O	CO2	O2	Valeur corrigée	de prélèvements
Température du rejet	°C		240		######	11,79	2,09		10:30 à 12:00
NOX en NO2	mg/Nm³	105,32	#DIV/0!	3% O2 sur sec	"	"	"	100,3	10:30 à 12:00
NO en NO2	mg/Nm³	101,21	#DIV/0!	3% O2 sur sec	"	"	"	96,3	10:30 à 12:00
NO2 en NO2	mg/Nm³	4,11	#DIV/0!	3% O2 sur sec	"	"	"	3,9	10:30 à 12:00
CO	mg/Nm³	23,50	#DIV/0!	3% O2 sur sec	"	"	"	22,4	10:30 à 12:00

NOx : 100,3 mg/Nm³ @ 3 % O_2 (dry) (guaranteed 100)
CO : 22,4 mg/Nm³ @ 3 % O_2 (dry) (guaranteed 100)

For the 50 t/hr boiler :

CETE apave nord ouest

RESULTATS DE MESURES	Chaud.aux.50 T/H	14-juin-01

Identification de l'installation et mesures effectuées	Unité	Résultats aux conditions de dilution existantes (basic results)		Résultats aux conditions de référence (Results)				(corrected value) Horaires
		sur gaz dry	sur gaz humid	formule corrective	base de correction % H2O	CO2	O2	Valeur corrigée	de prélèvements
Température du rejet	°C		240		######	11,06	2,62		15:00 à 16:30
NOX en NO2	mg/Nm³	102,03	#DIV/0!	3% O2 sur sec	"	"	"	99,9	15:00 à 16:30
NO en NO2	mg/Nm³	97,52	#DIV/0!	3% O2 sur sec	"	"	"	95,5	15:00 à 16:30
NO2 en NO2	mg/Nm³	4,52	#DIV/0!	3% O2 sur sec	"	"	"	4,4	15:00 à 16:30
CO	mg/Nm³	<2,50	#DIV/0!	3% O2 sur sec	"	"	"	<2,4	15:00 à 16:30

NOx : 99,9 mg/Nm³ @ 3 % (dry) (guaranteed 100)
CO : < 2,4 mg/Nm³ @ 3 % (dry) (guaranteed 100)

In conclusion, all emissions comply with the guaranteed ones.

CONCLUSION

This plant allowed to reconfirm the performance of :
- REBURNFLAM® LOW NOx postcombustion burners in turndown as well as for low emissions.
- GRC LONOxFLAM gas burners for their flexibility as well as for their low emissions.

In particular it shows the possibility of a very high turndown of 1 to 50 in HRSG's postcombustion burners and the reliable operation of boiler burners allowing to reach the maximum in less than 1 minute in total safety.