Evaluation of NH_3-SCR Catalyst Technology on a 250 kW Stationary Diesel Genset

Rajashekharam V. Malyala[1], Stephen J. Golden[1], Jim Lefeld[2], and Brian Fillingim[3]

1. Catalytic Solutions Inc, Oxnard, CA, 93033, USA
2. Cinergy Ventures, Cincinnati, OH, USA
3. Naval Surface Warfare Center (NSWC), Crane Division, IN, USA

DEER 2005
Chicago 8/24/05

NH_3-SCR for Diesel Gensets

Goals

Demonstrate “Proof-of-Concept” on a 250 kW Diesel Genset
Confirm results by third Party testing & verification

Catalyst Technology: Ammonia-SCR + Oxidation Catalyst

Partners

Cinergy Ventures, USA	:	Project Sponsor
Catalytic Solutions Inc, USA	:	Catalyst Technology
Arvin-Meritor Inc, USA	:	System Integrator
NSWC, US Navy, Crane, IN, USA	:	Test Site

(NSWC: Naval Surface Warfare Center – Crane Division, IN)

Project Details

250 kW CAT Genset with NH_3-SCR and DOC Catalyst Technology
Exhaust Muffler replaced with catalytic converter system
Catalytic converter system had 40 L of SCR and 10 L DOC
Data on NOx and CO collected for 500 hours at 90% load
Third party emissions verification by GE Energy Management Services

Genset & Catalyst System

Generator Set Specifications

Caterpillar 3306 diesel engine
- rated at 1800 rpm, 250 kW
-10.5 L Engine Displacement
-4-Stroke-Cycle Watercooled Diesel
-15:1 Compression ratio

Installation Base

Location: NSWC, Crane, Indiana
Test site size: 60 ft x 60 ft concrete slab
Load bank located approximately 150 ft away
Anhydrous NH_3 tanks located150 ft away
Pipes, electric supplies are underground with appropriate safety clearances by NSWC
Test data generated by NSWC, planned by CSI/Cinergy

Emissions monitored by third party
- GE Energy Management Services

Engine Data from CAT

Wet Exhaust Mass:	3497 lb/hr
Wet Exhaust flow (994°F):	2175 CFM
Wet Exhaust flow rate (32°F and 29.98 in Hg):	735 CFM
Dry Exhaust flow rate (32°F and 29.98 in Hg):	655 CFM
Fuel consumption:	19 GAL/hr

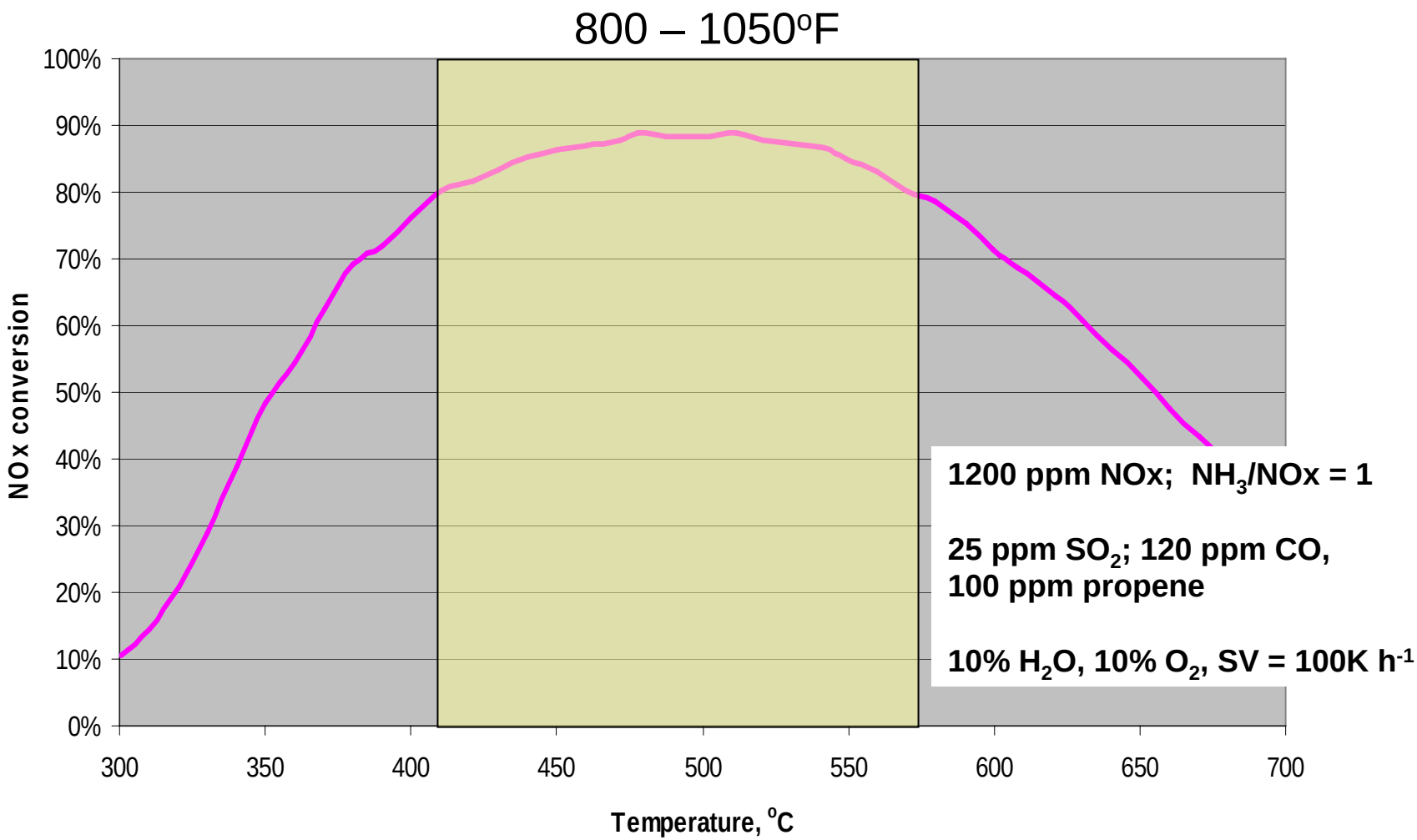
Genset Power	Load	Engine	NOx (as NO2)	CO	HC	O2
kW	%	BHP	lb/hr	lb/hr	lb/hr	%
250	100	382.2	4.29	0.95	0.12	10.1
187.5	75	289	3.64	0.41	0.15	10.9
125	50	198.3	2.83	0.46	0.17	12.2
62.5	25	110.1	1.56	0.49	0.11	14.1
25	10	55.1	0.78	0.74	0.17	15.8

Catalyst System

Four bank system
Each bank has two 5L SCR's and one 2.5L DOC brick
SCR and DOC are 300 cpsi substrates from Corning Inc
Total system
40L of SCR+ 10 L DOC

CSI's NH_3-SCR Catalyst
Lab-scale data

At least 80% NOx conversion at T 400-550°C (750 – 1000°F); 100 K h^{-1} SV
Sample Details: 1" dia x 1" long, cored from 5L, 300 cpsi coated monoliths.



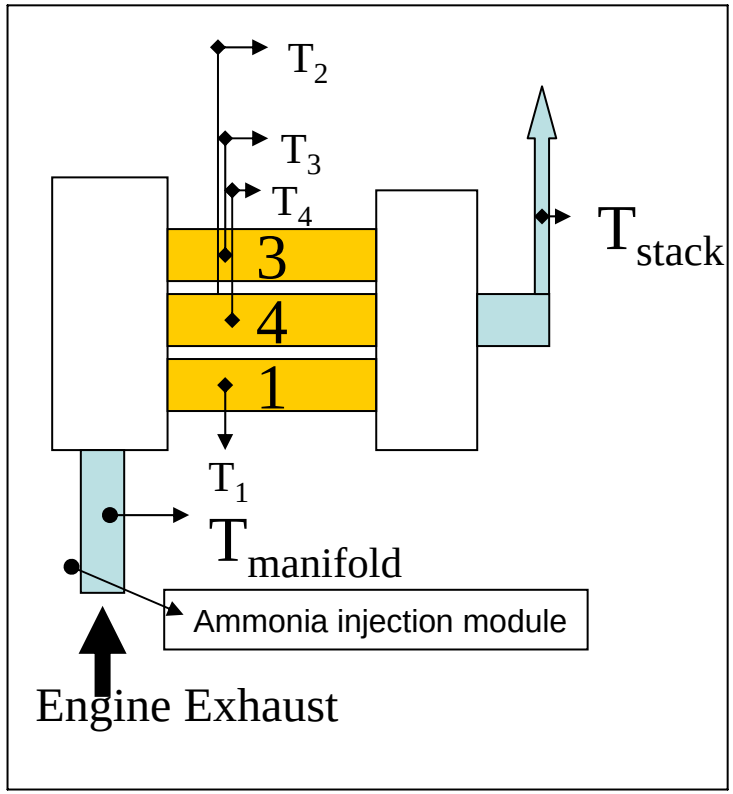
Field Tests on 250 kW Genset

Engine maintained at 90% load (225-230 kW). Used US#2 Diesel fuel.

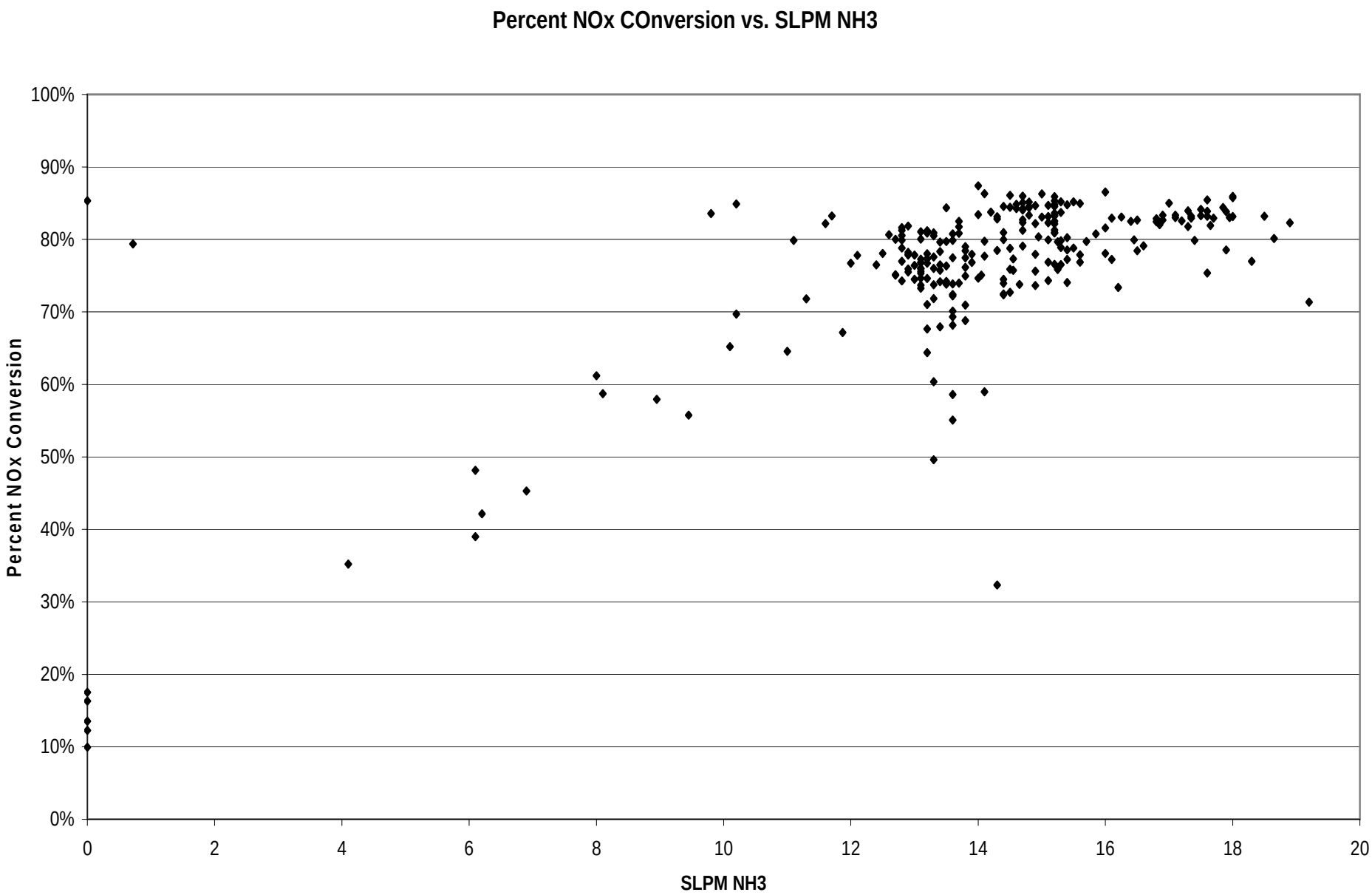
Data collected at different weather conditions by running the engine for 500 hours at 90% load.

Exhaust gas analysis (NO, NO_2, CO, CO_2, and O_2) upstream and downstream of catalytic converter. Catalyst bed temperatures, manifold and stack temperatures also recorded.

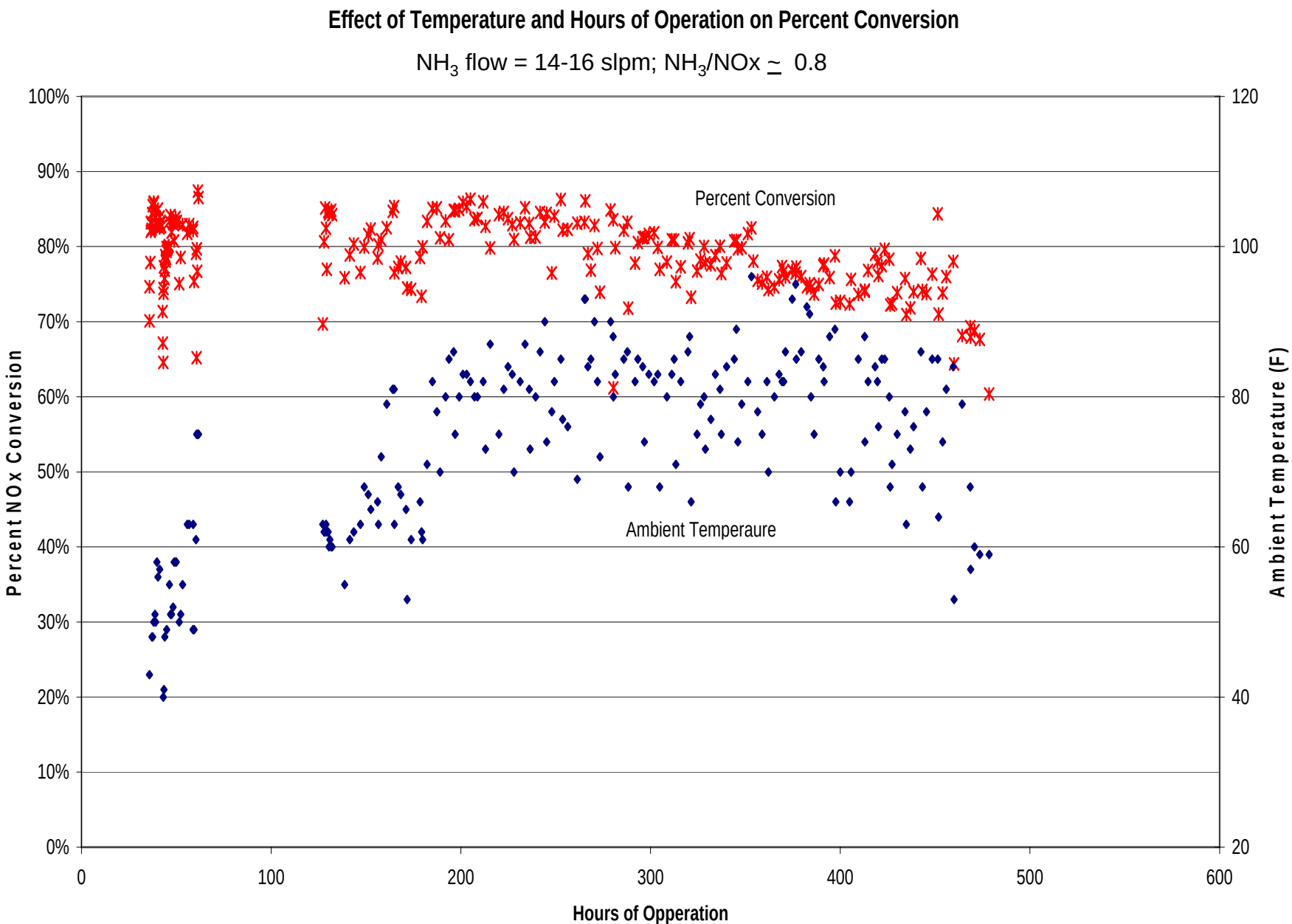
Secondary Emissions (NH_3, CO, VOCs and particulates) verified by third party - GE Management Services.



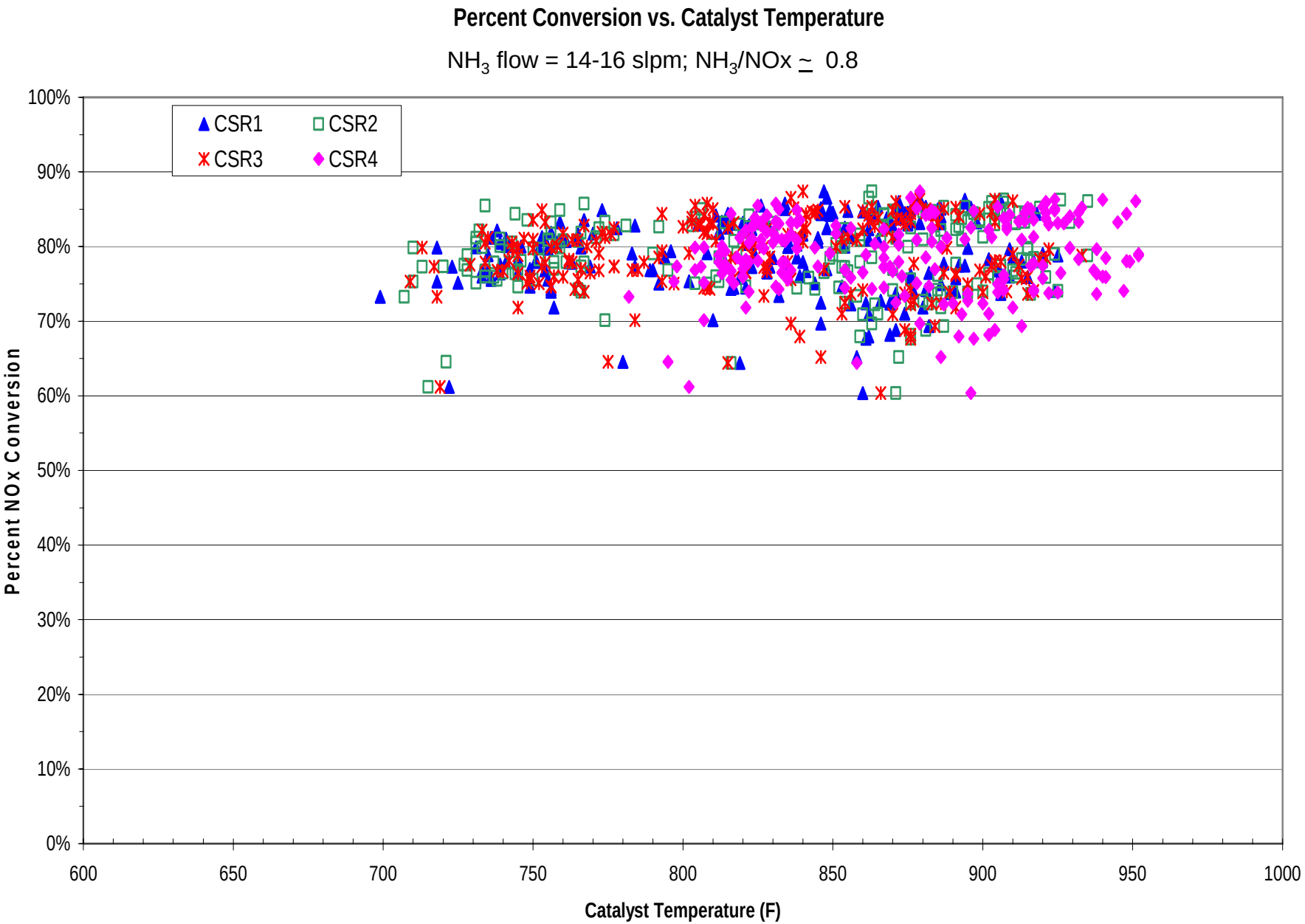
Field Tests on
250 kW CAT Diesel Genset



Field Tests on
250 kW CAT Diesel Genset

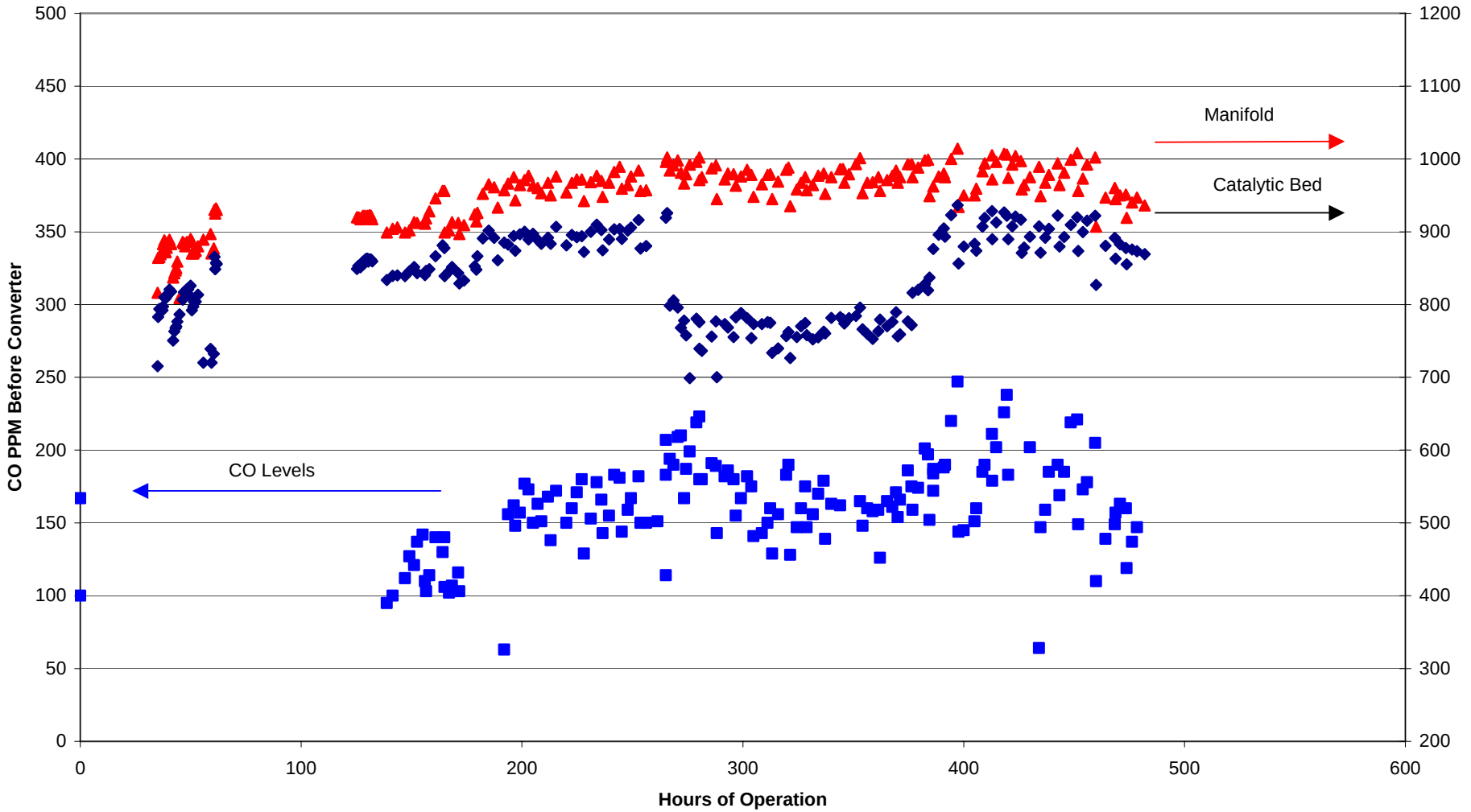


Field Tests on
250 kW CAT Diesel Genset



Field Tests on
250 kW CAT Diesel Genset

Pre-converter CO = 150-200 ppm. Post-converter CO < 2 ppm

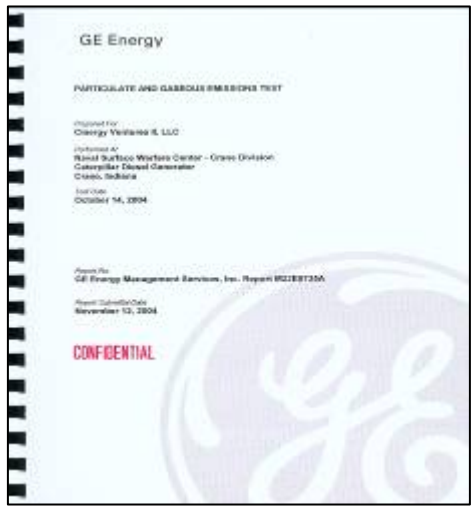


Third Party Testing & Verification

Gaseous Emissions and Particulates testing and verification by GE Energy Management Services Inc

Testing and verification by GE performed after 500 hours of engine run time with the catalytic converter

GE Report M22E0735A, 100 page confidential report



Test Procedures

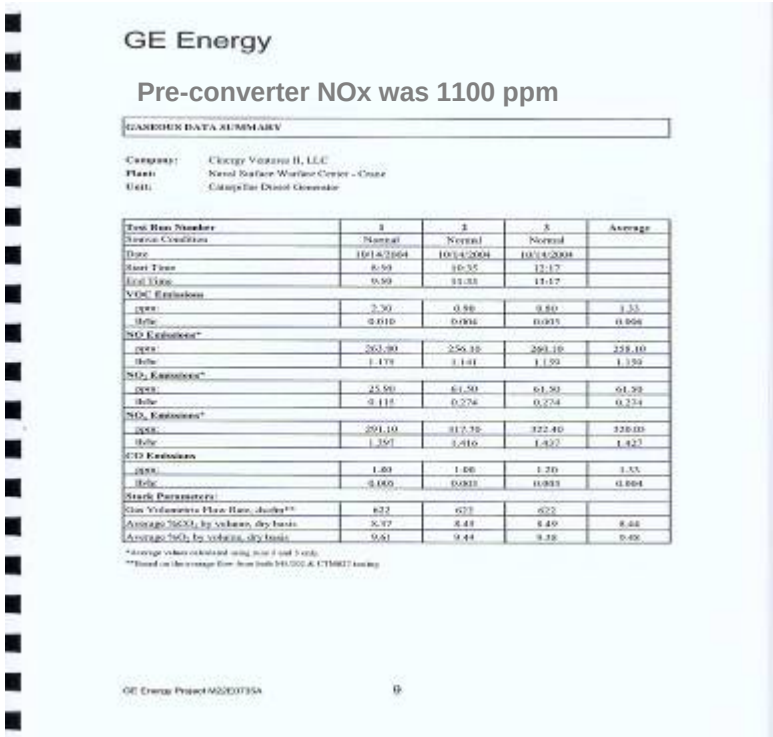
Volumetric Flowrate Determination	Method 2, 40CFR60
Oxygen (O2) Determination	Method 3A, 40CFR60
Carbon Dioxide (CO2) Determination	Method 3A, 40CFR60
Particulate Determination	ASTM Standard Method D-2986-71
Condensible Particulate Determination	Methods 5, 40CFR60
Nitrogen Oxides (NOx) Detemination	Method 7E, 40CFR60
Carbon Monoxide Determination	Method 10, CFR60
Total Organic Concentration Determination	USEPA Method 25A, 40CFR60
Ammonia Determination (CTM-027)	USEPA Method 5-type (sampling train and four impingers)

References

40CFR60: Title 40, Code of Federal Regulations, Part 60
Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods, United States Environmental Protection Agency (USEPA) 60/4-77-027b

Summary

Typical results on Gas Analysis



GE Energy

Pre-converter NOx was 1100 ppm

GASEOUS DATA SUMMARY

Company: Energy Ventures II, LLC
Plant: Naval Surface Warfare Center - Crane
Unit: Caterpillar Diesel Generator

Test Run Number	1	2	3	Average
Source Condition	Normal	Normal	Normal	
Date	10/14/2004	10/14/2004	10/14/2004	
Start Time	8:50	10:35	12:17	
End Time	9:50	11:33	13:17	
VOC Emissions				
ppm	2.30	0.80	0.80	1.33
lb/hr	0.010	0.006	0.003	0.006
NO Emissions*				
ppm	263.90	256.10	260.10	258.10
lb/hr	1.179	1.141	1.159	1.159
NO2 Emissions*				
ppm	25.90	61.50	61.50	61.33
lb/hr	0.115	0.274	0.274	0.224
NOx Emissions*				
ppm	291.10	317.70	322.40	328.00
lb/hr	1.297	1.416	1.437	1.427
CO Emissions				
ppm	1.00	1.00	1.20	1.33
lb/hr	0.000	0.003	0.003	0.004
Stack Parameters:				
Gas Volumetric Flow Rate, dscfm**	822	673	622	
Average %CO2 by volume, dry basis	8.37	8.43	8.49	8.44
Average %O2 by volume, dry basis	9.61	9.44	9.38	9.48

*Average values calculated using runs 1 and 3 only.
**Based on the average flow from both M1/2/3 & CTM027 testing

GE Energy Project #020735A 9

Results after 500 hours of operation

Parameter			Post Converter Measurements
Particulate	Filterable	grains/dscf	0.0237
		lbs/hr	0.127
	Condensible	grains/dscf	0.009
		lbs/hr	0.049
	Total	grains/dscf	0.0327
		lbs/hr	0.175
VOC as C_3H_8		ppm	1.33
		lbs/hr	0.006
NO		ppm	258.1
		lbs/hr	1.15
NO2		ppm	61.5
		lbs/hr	0.27
NOx		ppm	320
		lbs/hr	1.43
NOx Conversion		%	70.9%
CO		ppm	1.33
		lbs/hr	0.004
Ammonia		ppm	0.12
		lbs/hr	0.0002
O_2		%	9.48
CO_2		%	8.44

70-80% NOx conversion to N_2 at 90% load and NH_3/NOx~ 0.8

No secondary emissions

Report with complete data & trouble shooting under final review