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30844 Century Drive
Wixom, MI 48393
Tel: 248 926 8200

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Emission Testing Report

Project Name: Carbon Mon Oxide and Nitrogen Oxides Destruction Efficiency
Testing to satisfy the requirements of DEQ Permit to Install 327-98D
Report No. DEQ-0915C

Department: Test Cells

Prepared By:

Document Owner(s)	Project/Organization Role
Ashley Barrett	General Manager

Report Version Control

Version	Date	Author	Change Description
1.0	9/15/15	Ashley Barrett	Document created DEQ-0915A
2.0	10/08/15	Ashley Barrett	Gas Calibration Certificates readability improved. And analyzer calibration records added. DEQ-0915B
3.0	10/13/15	Ashley Barrett	Note on calibration added in section 2.1 & contact information added. DEQ-0915C

1 Overview

This report summarizes the testing and presents the results of emissions tests carried out for verification testing for catalyst destruction efficiencies for carbon monoxide (CO) and nitrogen oxides (NOx) to satisfy the requirements of DEQ Permit to Install 327-98D. Tests were carried out on representative engines, catalyst configurations and operating cycles. For CO this was conducted on a gasoline engine and for NOx the test was conducted on a diesel engine.

Destruction efficiency over 24hrs for CO was 98.0% and for NOx was 89.2%.

2 Testing Description

2.1 Background

Each test consisted of running a gasoline and diesel engine over a twenty four (24) hour period, utilizing typical test cycles and catalysts and establishing the destruction efficiencies of CO and NOx respectively. This was achieved by sampling emissions upstream and downstream of each catalyst system each hour. From these results an emission destruction efficiency was calculated. The analysers used were Horiba Mexa 7500D's calibrated with NIST traceable gasses. (See appendix 4.3). All analysers are zeroed and spanned with their relevant calibration gasses. (See appendix 4.3) prior to use.

2.2 Test Cycles

2.2.1 Diesel Nitrogen Oxides (NOx) Reduction Test

The test was to demonstrate that the NOx produced during the catalyst aging test cycle is reduced, the catalyst destruction efficiency is equal to or greater than 75% and report the total mass of NOx over a 24hr period.

The test used a Sensors EFM3 in the exhaust stream to calculate exhaust volume directly.

The test was run over a twenty four hour period with emissions and relevant engine data sampled on an hourly basis. NOx emissions were measured using a Horiba Mexa CLA-720A NOx analyzer (See appendix 4.1) as well as the on board NOx sensors fitted to the catalyst system. The analyzers were calibrated prior to testing with NIST traceable gases. (See appendix 4.3). Results were then calculated to establish the mass emissions produced and overall catalyst destruction efficiency.

Testing was started on 24th August 2015 and completed 24 hours later utilizing standard low Sulphur diesel.

See appendix 4.21 for set up sheet and location of sampling points.

2.2.2 Gasoline Carbon Monoxide (CO) Reduction Test

The test was to demonstrate that the CO produced during the catalyst aging test cycle is reduced, the catalyst destruction efficiency is equal to or greater than 95% and report the total mass of CO over a 24hr period.

The test measured exhaust flow rate by calculation from measured air fuel ratio and fuel flow on an hourly basis.

The test was run over a twenty four hour period with emissions and relevant engine data sampled on a second by second basis. CO emissions were measured using Horiba Mexa NDIR CO analyzers AIA-722 (high). (See appendix 4.1). The analyzers were calibrated prior to testing with NIST traceable gases. (See appendix 4.3). Results were then calculated to establish the mass emissions produced and overall catalyst destruction efficiency.

Testing was started on 3rd September 2015 and completed 24 hours later utilizing standard ULG 95 gasoline.

See appendix 4.22 for set up sheet and location of sampling points.

2.3 Test Equipment

All testing was conducted within test cell number 19 for the diesel NO_x efficiency tests and test cell number 17 for the gasoline CO efficiency tests. The test equipment and setup were typical of any of the other test cells within the facility.

Specification of the emission analyzers can be found in appendix 4.1

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3 Results Summary

3.1 Results of 24 Hour NOx Efficiency Test

Log Date	Log Time	Time into Test	EXHAUST FLOW	Speed	Torque	Throttle Position	Power	Urea Pressure	Fuel Flow	Nox In (Hoiba)	Nox Out (Hoiba)	Catalyst	4 Hour	Eng Out (mass)	Catalyst Out(mass)
	HH:MM:SS	HH:MM:SS	lbs/hr	rpm	lbft	%	HP	Psig	lbs/hr	ppm	ppm	Efficiency	Average	lbs/hr	lbs/hr
													%	%	
24/08/2015	15:09:39	0:00:00	1062.0	2000	217.1	99.2	83	49.4	28.3	441	60	86.4%		0.468	0.064
24/08/2015	16:09:43	1:00:00	1057.3	2000	219.8	99.4	83	47.8	29.0	439	46	89.5%		0.464	0.049
24/08/2015	17:09:43	2:00:00	1044.8	2000	220.1	99.4	83	48.6	29.1	461	64	86.1%		0.482	0.067
24/08/2015	18:09:43	3:00:00	1062.4	1999	215.9	99.4	82	48.0	28.3	456	59	87.1%		0.484	0.063
24/08/2015	19:09:48	4:00:00	1057.1	1999	215.8	99.3	83	48.9	28.0	452	56	87.6%	87.3%	0.478	0.059
24/08/2015	20:09:48	5:00:00	1045.9	1999	218.0	99.4	82	48.8	28.0	445	55	87.6%		0.465	0.058
24/08/2015	21:09:53	6:00:00	1052.7	2000	211.1	99.4	82	48.5	28.1	440	61	86.1%		0.463	0.064
24/08/2015	22:09:53	7:00:00	1065.9	2000	213.9	99.3	83	49.2	28.3	427	60	85.9%		0.455	0.064
24/08/2015	23:09:53	8:00:00	1057.3	2000	213.6	99.3	82	49.4	28.3	446	58	87.0%	86.8%	0.472	0.061
25/08/2015	0:09:53	9:00:00	1076.1	2000	216.6	99.3	83	49.4	28.4	493	54	89.0%		0.531	0.058
25/08/2015	1:09:53	10:00:00	1069.2	2001	225.6	99.3	84	49.6	28.2	437	50	88.6%		0.467	0.053
25/08/2015	2:09:53	11:00:00	1076.5	1999	212.1	99.3	82	49.5	28.2	435	50	88.5%		0.468	0.054
25/08/2015	3:09:53	12:00:00	1048.7	2001	213.9	99.3	81	49.5	28.3	434	44	89.9%	88.3%	0.455	0.046
25/08/2015	4:09:53	13:00:00	1063.3	1998	212.3	99.3	80	49.5	27.9	443	44	90.1%		0.471	0.047
25/08/2015	5:09:53	14:00:00	1061.7	2000	214.4	99.3	83	49.5	28.0	432	28	93.5%		0.459	0.030
25/08/2015	6:09:53	15:00:00	1048.1	2000	210.7	99.3	82	49.4	27.9	448	46	89.7%		0.470	0.048
25/08/2015	7:09:53	16:00:00	1040.6	1999	211.2	99.3	81	49.5	27.9	432	30	93.1%	90.8%	0.450	0.031
25/08/2015	8:09:53	17:00:00	1042.8	2000	213.9	99.3	82	49.5	28.2	433	47	89.1%		0.452	0.049
25/08/2015	9:09:53	18:00:00	1039.3	2001	211.6	99.3	82	49.6	27.9	431	32	92.6%		0.448	0.033
25/08/2015	10:10:50	19:00:00	1044.5	1998	211.3	99.3	82	49.5	28.9	438	45	89.7%		0.458	0.047
25/08/2015	11:10:50	20:00:00	1036.8	2000	215.5	99.3	82	49.4	28.0	435	32	92.6%	91.1%	0.451	0.033
25/08/2015	12:10:56	21:00:00	1033.5	2000	209.2	99.4	82	49.3	28.1	454	63	86.1%		0.469	0.065
25/08/2015	13:47:08	22:00:00	1042.3	1999	212.4	99.3	81	49.3	28.2	437	45	89.7%		0.456	0.047
25/08/2015	14:47:08	23:00:00	1035.5	2001	213.8	99.3	82	49.0	28.0	435	48	89.0%		0.450	0.050
25/08/2015	15:47:17	24:00:00	1023.2	2000	216.7	99.3	82	49.2	27.9	421	20	95.2%	89.4%	0.431	0.020

Average over 24hrs 89.2%

24 Hour Nox Efficiency Test

Log Date	Log Time	Time into Test	SPEED	TORQUE	FUEL FLOW	POWER	CAT 1A IN LAMBDA	Air Fuel Ratio	Exhaust Flow	Front CO	Rear CO	CO Catalyst	4 Hour	Front CO Mass	Rear CO Mass	Front THC	Rear THC	THC Catalyst	4 Hour	Front THC Mass	Rear THC Mass
	HH:MM:SS	HH:MM:SS	RPM	LB/FT	Lbs/Hr	HP	Lambda		lbs/hr	Vol%	Vol%	Efficiency	Average	lbs/hr	lbs/hr	ppm/10	ppm/10	Efficiency	Average	lbs/hr	lbs/hr
												%	%					%	%		
3/9/2015	15:58:34	0:00:00	2301	58	17.88	26	1.00	14.70	280.7	0.55	0.00	100.0%		1.544	0.000	162.33	6.36	96.1%		0.456	0.018
3/9/2015	16:58:36	1:00:00	2300	57	17.86	27	0.99	14.55	277.8	0.55	0.00	100.0%		1.528	0.000	163.96	5.62	96.5%		0.455	0.016
3/9/2015	17:58:36	2:00:00	2299	57	17.88	27	0.99	14.55	278.1	0.51	0.00	100.0%		1.418	0.000	157.30	5.52	96.5%		0.437	0.015
3/9/2015	18:58:36	3:00:00	2300	56	17.3	25	1.00	14.70	279.5	0.54	0.02	96.3%		1.509	0.056	154.60	6.32	95.9%		0.432	0.018
3/9/2015	19:58:36	4:00:00	2299	56	17.76	24	0.99	14.55	276.2	0.54	0.01	98.1%	98.6%	1.492	0.028	156.17	5.98	96.2%	96.3%	0.431	0.017
3/9/2015	20:58:36	5:00:00	2301	59	17.68	24	0.99	14.55	275.0	0.52	0.00	100.0%		1.430	0.000	157.80	6.76	95.7%		0.434	0.019
3/9/2015	21:58:35	6:00:00	2300	54	17.6	26	1.00	14.70	276.3	0.50	0.02	96.0%		1.382	0.055	157.69	6.19	96.1%		0.436	0.017
3/9/2015	22:58:35	7:00:00	2300	58	17.59	25	0.99	14.55	273.6	0.51	0.01	98.0%		1.395	0.027	164.00	6.07	96.3%		0.449	0.017
3/9/2015	23:58:36	8:00:00	2299	56	17.58	24	1.00	14.70	276.0	0.50	0.02	96.0%	97.5%	1.380	0.055	160.51	5.31	96.7%	96.2%	0.443	0.015
4/9/2015	0:58:36	9:00:00	2300	56	17.56	25	1.00	14.70	275.7	0.50	0.02	96.0%		1.378	0.055	155.49	5.36	96.6%		0.429	0.015
4/9/2015	1:58:36	10:00:00	2301	56	17.56	25	0.99	14.55	273.1	0.54	0.01	98.1%		1.475	0.027	153.66	6.36	95.9%		0.420	0.017
4/9/2015	2:58:36	11:00:00	2299	56	17.55	25	0.99	14.55	273.0	0.50	0.01	98.0%		1.365	0.027	164.87	5.99	96.4%		0.450	0.016
4/9/2015	3:58:36	12:00:00	2300	59	17.54	26	0.99	14.55	272.8	0.56	0.02	96.4%	97.1%	1.528	0.055	158.67	5.47	96.6%	96.3%	0.433	0.015
4/9/2015	4:58:36	13:00:00	2300	54	17.55	25	0.99	14.55	273.0	0.56	0.01	98.2%		1.529	0.027	162.75	6.43	96.0%		0.444	0.018
4/9/2015	5:58:36	14:00:00	2300	57	17.54	25	0.99	14.55	272.8	0.54	0.01	98.1%		1.473	0.027	156.63	6.06	96.1%		0.427	0.017
4/9/2015	6:58:36	15:00:00	2301	57	17.58	25	1.00	14.70	276.0	0.51	0.00	100.0%		1.408	0.000	157.12	5.64	96.4%		0.434	0.016
4/9/2015	7:58:36	16:00:00	2301	58	17.57	25	0.99	14.55	273.3	0.54	0.01	98.1%	98.6%	1.476	0.027	161.84	6.32	96.1%	96.2%	0.442	0.017
4/9/2015	8:58:36	17:00:00	2299	58	17.61	24	1.00	14.70	276.5	0.51	0.02	96.1%		1.410	0.055	160.30	6.60	95.9%		0.443	0.018
4/9/2015	9:58:36	18:00:00	2299	56	17.61	24	1.00	14.70	276.5	0.54	0.01	98.1%		1.493	0.028	162.64	5.39	96.7%		0.450	0.015
4/9/2015	10:58:36	19:00:00	2300	55	17.63	26	1.00	14.70	276.8	0.55	0.02	96.4%		1.522	0.055	155.37	5.93	96.2%		0.430	0.016
4/9/2015	11:58:36	20:00:00	2300	59	17.63	25	0.99	14.55	274.2	0.50	0.02	96.0%	96.6%	1.371	0.055	161.08	6.47	96.0%	96.2%	0.442	0.018
4/9/2015	12:58:36	21:00:00	2299	56	17.55	24	1.00	14.70	275.5	0.54	0.00	100.0%		1.488	0.000	163.54	6.54	96.0%		0.451	0.018
4/9/2015	13:58:36	22:00:00	2301	60	17.58	24	1.00	14.70	276.0	0.51	0.02	96.1%		1.408	0.055	153.70	6.44	95.8%		0.424	0.018
4/9/2015	14:58:36	23:00:00	2299	58	17.61	26	1.00	14.70	276.5	0.54	0.00	100.0%		1.493	0.000	157.79	6.38	96.0%		0.436	0.018
4/9/2015	15:58:36	24:00:00	2299	60	17.56	26	1.00	14.70	275.7	0.54	0.00	100.0%	99.0%	1.489	0.000	158.36	5.31	96.5%	96.1%	0.437	0.015

Average over 24 hrs 98.0%

Average over 24 hrs

96.2%

24 Hour CO Efficiency Test

3.2 Results of 24Hour CO Efficiency Test

Prepared by Ashley Barrett

Approved by



A handwritten signature in black ink, appearing to be 'ASB', is written above a horizontal line.
