ULTRABURN®
COMBUSTION CATALYST SYSTEM

Emissions Evaluation Report

Emissions Trial Performed on
M/V Guemes
Skagit County Public Works Department

June 10, 2013

Under VSA signed March 4, 2013

EMISSIONS TECHNOLOGY

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Executive Summary

This report summarizes the results of the Emissions Trial of the UltraBurn® Combustion Catalyst System (CCS) performed on the two propulsion engines on the Motor/Vessel (M/V) Guemes for the Skagit County Public Works Department (Skagit County).

The main objective of the Emissions Trial was to demonstrate that the UltraBurn CCS could reduce the level of harmful emissions, specifically black smoke from the propulsion engines and genset of the M/V Guemes during normal operation. These emissions are comprised primarily of particulate matter (PM) also known as black smoke or soot and exhaust gases comprised of nitrogen oxides (NOx), carbon monoxide (CO) and carbon dioxide (CO_2).

UltraBurn CCS works by increasing the combustion efficiency inside the diesel engine. This improved efficiency results in a more complete burn, which in turn, results in more power, improved fuel economy, reduced black smoke and other harmful exhaust gas emissions. These assertions are supported in the results of this Emissions Trial.

The Emissions Trial results showed a reduction in black smoke of over 42%, when measured against the baseline and an average reduction in exhaust gases between 7% to 28%. The dramatic reduction in black smoke was observed and confirmed by the operators of the vessel and noted by customers who now enjoy a cleaner transit to and from beautiful Guemes Island.

Emissions Technology estimates that Skagit County will be able to reduce total soot and harmful gas emissions by over 50,000 lbs/year based upon the measured black smoke and exhaust gas emissions results.

Furthermore, an opportunity now exists to save fuel if vessel operators are able to compensate for the extra power inherent in improved combustion efficiency by shortening the periods at maximum RPM during acceleration.

Introduction

The UltraBurn® Combustion Catalyst System (CCS) utilizes both patented injection systems and patented catalyst formulations, developed by Emissions Technology, Inc. (ETI), for use in diesel engines. It works by injecting a nano-particle sized platinum-based aerosol catalyst into the air intake of an internal combustion engine, thereby greatly improving the efficiency of the combustion process. The end user will see a dramatic reduction in both fuel consumption and harmful exhaust emissions.

The Science behind UltraBurn® Combustion Catalyst System

Platinum is a well-known catalyst in the petroleum refining and chemical processing industries. Platinum catalyzes (accelerates) the combustion of hydrocarbons (HC) and carbon monoxide (CO). In the gas phase, for a hydrocarbon to be oxidized, it must encounter either oxygen (O) radicals (reactive atoms) or hydroxyl (OH) radicals. The platinum in UltraBurn catalyst increases the concentration of the O and OH radicals thus facilitating more complete combustion in the power stroke, thereby effectively converting more of the energy contained in the fuel to useful work and lower particulate matter (black smoke) and exhaust gas emissions (HC,NOx,CO, CO_2). *This is the same chemistry that occurs in a catalytic converter, except in that case, the energy released is exhausted as waste heat with no additional benefit to engine performance.*

The simplified non-stoichiometric formula for catalytic combustion process occurring inside the combustion chamber is:

$$O_2 + Pt\ (\text{UltraBurn Catalyst}) \rightarrow O^* + O^*\ (\text{Oxygen Radicals})$$

$$\sim C_{12}H_{26}\ (\text{Diesel Fuel}) + O^* + O^* \rightarrow CO_2 + H_2O + \text{Energy}$$

Nitrogen oxides (NO_x) are generated as a direct result of the combustion of nitrogen (N_2) with oxygen (O_2) at the very high temperatures present in the combustion chamber. The UltraBurn catalyst reduces NO_x through two concurrent phenomena. First, the catalytic effect of platinum causes the combustion reaction to occur at a lower temperature thereby producing less NO_x. Secondly, other components present in the UltraBurn catalyst's formula act in concert with platinum as co-catalysts to further reduce NO_x formation.

The UltraBurn CCS increases engine efficiency by converting the energy contained in the fuel to more usable work that can be used either for more power, or significant fuel reduction at the same load rate. Field results on commercially operating equipment have shown fuel improvements of greater than 10%.

Smoother, more complete combustion in the power stroke has been shown to generate less engine vibration ("rattle") resulting in quieter and smoother operation which will lead to reduced life cycle costs. The significantly reduced soot generation also reduces the amount of carbon in the crankcase oil, providing enhanced lubricating oil properties and the possibility of reduced maintenance intervals over the life cycle of the engine.

Improved fuel economy and lower emissions are a result of improved in-cylinder combustion from using UltraBurn platinum-based catalyst injected as a nano-particle aerosol into the air intake of the engine. Contact between platinum and oxygen is greatly enhanced when injected into the engine as an aerosol through the air intake, as opposed to fuel based additives, which are not in contact with oxygen for as long of a period during the combustion cycle.

Trial Objectives

In March, 2013, the Skagit County Public Works Department (Skagit County) purchased Emissions Technology, Inc. (ETI) UltraBurn® Combustion Catalyst Systems for its two propulsion engines and genset on the M/V Guemes for the primary purpose of reducing black smoke in the vessel's propulsion and genset exhaust stacks during normal operations.

Skagit County requested that ETI perform black smoke, measured as opacity, and exhaust gas emissions testing on the main engines while the vessel was in normal operation in order to numerically verify that the UltraBurn CCS had reduced black smoke and harmful gas emissions. Opacity is a measure of the level of black smoke emitted from the stack. This document is intended to fulfill ETI's contractual requirements as the final report that provides the results of the Emissions Trial.

Emissions Trial Plan

UltraBurn CCS Installation

On March 25, 2013, ETI personnel installed UltraBurn PTI-203DM Combustion Catalyst Systems on each of the Main Engines #1 and #2 and an UltraBurn PTI-103DM on the genset of the M/V Guemes. The installation photographs and closure documentation is shown in Appendices A and B.

The patented UltraBurn PTI series injection systems are specifically designed for engines up to 700 hp. The PTI-103DM system draws catalyst from one 700 milliliter reservoir (bottle) and is typically selected for engines up to 15 gallons per hour per turbo depending upon operating conditions. The PTI-203DM system utilizes two 700 milliliter reservoirs (bottles) for engines and is typically selected for engines that consume up to 30 gallons per hour per turbo depending upon operating conditions.

Emissions Technology selected one of its patented catalyst formulations which has been used extensively in dozens of high speed diesel engine applications for several years.

This sealed catalyst reservoir system is a replacement/consumable item and is designed for easy replacement without physical contact with the catalyst. Spent catalyst reservoir disposal requirements are similar to that of engine coolant containers, presenting no additional hazmat procedures by the vessel operators. The catalyst Material Safety Data Sheet is provided in Appendix H.

The M/V Guemes has two Cummins model KTA19-M3 main propulsion engines rated 600 hp @ 1800 rpm arranged in a double ended push-pull configuration and one Caterpillar C4.4 Acert genset rated at 82.6 hp @ 1400 rpm.

Consistent with the catalyst injection requirements for the M/V Guemes and its typical operating profile, the vessel will consume approximately 5 to 6 catalyst bottles per month.

Test Methodology

There are three phases of operation during an UltraBurn evaluation period defined as follows:

- **"Baseline Phase"** - the period of time prior to the UltraBurn CCS commencing operation, during which a pattern or average of standard operation is established. It is assumed in this phase that the engines have been properly tuned and are running normally.
- **"Conditioning Phase"** - the period of time, typically lasting 100 to 200 hours, when the UltraBurn CCS is initially turned on, which is required before the full catalytic enhancement effect is seen. Most engines are laden with carbon on the piston crowns and cylinder heads that must be burned off catalytically before the steel surfaces inside the cylinders can be coated with the catalytic elements.
- **"UltraBurn Phase"** - the period of time when the UltraBurn CCS has completed the Conditioning Phase and is fully operating, during which time data can be drawn to conclude on the functionality of the system.

Opacity and exhaust gas emissions testing were performed on the two main engines over a period of one day of normal operations during both the Baseline and the UltraBurn Phases. The Baseline Phase measurements were taken on April 17, 2013 and the UltraBurn Phase measurements were taken on May 22, 2013 after about a 400 hour Conditioning Phase for the two main engines. The genset was started immediately upon installation on March 25th and was not part of the testing program. The M/V Guemes followed a consistent operating schedule as shown in Appendix C during both phases. Other conditions, such as ambient temperature, current conditions and round trip load levels were comparable between the Baseline and UltraBurn Phases although the vessel operators were different.

Measurement Intervals

Baseline Phase – April 17, 2013

Exhaust gas emissions measurements for the Baseline Phase were taken continuously at six second intervals on Main Engine #1 over a period of three round trips during the day. Exhaust gas emission measurements were also taken continuously at six second intervals for Main Engine #2 over a period of three different round trips during the day. Approximately 2,100 exhaust gas measurements were taken during the Baseline Phase.

Opacity measurements were taken manually on Main Engine #1 at several minute intervals over a period of three round trips during the course of the day. Opacity measurements were also taken manually on Main Engine #2 at several minute intervals over a period of three different round trips during the day. A total of 42 average readings were taken. Each average reading consists of three individual measurements automatically logged by the instrument. Therefore a total of 126 individual measurements were obtained during the Baseline Phase.

UltraBurn Phase – May 22, 2013

Exhaust gas emissions measurements for the UltraBurn Phase were taken continuously at six second intervals on Main Engine #1 over a period of three round trips during the day. Exhaust gas emission measurements were also taken continuously at six second intervals for Main Engine #2 over a period of three different round trips during the day. Approximately 2,100 exhaust gas measurements were taken during the UltraBurn Phase.

Opacity measurements were taken manually on Main Engine #1 at several minute intervals over a period of one partial round trip during the day. Similarly opacity measurements were taken manually on Main Engine #2 at several minute intervals over another partial round trip during the day. The opacity test had to be terminated early because a connecting cable between the measurement head and the device became damaged. A total of 21 individual opacity measurements were taken during the UltraBurn Phase.

Instrumentation

Opacity (Black Smoke) Measurement Equipment

Opacity measurements were taken manually by ETI personnel using a Wager 6500 digital smoke opacity meter. This device is widely accepted within the industry and is designed to meet or exceed all of the specifications required in the SAE J1667 test procedure for opacity measurements in internal combustion engines. Measurements were taken at the top of the main propulsion exhaust stacks using a hand-held 20 ft extension pole upon which the sensor head was mounted.

Exhaust Gas Emissions Measurement Equipment

Exhaust gas emissions measurements were taken by ETI's emissions testing contractor using a Testo 350 Maritime Emissions Analyzer. Oxygen (O_2), carbon monoxide (CO), carbon dioxide (CO_2) and nitrogen oxides (NO_x) were measured. Exhaust gas measurements were taken at the exhaust temperature sensor port. (ETI is not an accredited emissions testing facility and did not perform the rigorous testing protocols defined by the Environmental Protection Agency (EPA)).

Emissions Trial Results

Opacity Analysis

The opacity results are summarized in Table 1. The table shows the average opacities for both main engines in the Baseline Phase (before the Ultraburn system was switched on) and the

UltraBurn Phase (approximately one month after the UltraBurn System was switched on). On average, the black smoke was reduced by over 43% using UltraBurn CCS. This is consistent with results obtained from evaluations performed with other customers. It is likely that the black smoke reduction will further improve over time with continued use of UltraBurn. The full dataset is shown is Appendices D and E.

In order to better analyze the results, three sigma limits were generated on the baseline data to determine the stability of the measurements. Measurements that reached or exceeded the 3-sigma upper control limit (UCL=14.6%) were removed from the calculation of the average for both the phases. This resulted in the elimination of only thirteen data points, but it helped to numerically clarify the overall reduction in black smoke through all modes of operation.

Table 1 – Opacity Comparison - Baseline vs UltraBurn Phases

Opacity Analysis **M/V Guemes**	
	Opacity Run Avg (%)
Baseline (without UltraBurn)[1,2,3]	
Main Engine # 1	**4.5**
Main Engine # 2	**5.2**
Baseline Average	**4.9**
UltraBurn Run (with UltraBurn)[4,5,6,7]	
Main Engine #1	**2.6**
Main Engine #2	**2.9**
UltraBurn Average	**2.8**
Calculated Opacity Reduction (% Change)	
Main Engine #1	**42.2%**
Main Engine #2	**44.2%**
Average Total Reduction	**43.3%**

(1) Baseline Run data collected on April 17, 2013 - Wager 6500
(2) Main Engine # 1: Based upon 69 individual measurements.
(3) Main Engine # 2: Based upon 46 individual measurements.
(4) UltraBurn Run data collected on May 22, 2013 - Wager 6500
(5) Main Engine # 1: Based upon 12 individual measurements.
(6) Main Engine # 2: Based upon 7 individual measurements.
(7) Wager Test Head was damaged during run and testing was terminated.
(8) All data subjected to 3-sigma stability test (13 of 147 measurements rejected)

Exhaust Gas Emissions Analysis

The exhaust gas emissions results are summarized in Table 2. All three primary pollutants were reduced on-average, however the exhaust emission data on Main Engine #1 was inconsistent with the expected results and those results obtained on Main Engine #2.

Table 2 – Exhaust Gas Emissions Comparison – Baseline vs UltraBurn Phase

Exhaust Gas Emissions Analysis M/V Guemes			
	CO Run Avg (ppm)	NOx Run Avg (ppm)	CO_2 Run Avg (%)
Baseline (without UltraBurn)[(1)]			
Main Engine # 1 Engine Run Average	460	951	4.19
Main Engine # 2 Engine Run Average	280	929	4.04
Baseline Average	**370**	**940**	**4.12**
UltraBurn Run (with UltraBurn)[(2)]			
Main Engine #1 Engine Run Average	290	963	4.19
Main Engine #2 Engine Run Average	243	804	3.59
UltraBurn Average	**267**	**884**	**3.89**
Calculated Reduction (% Change)			
Main Engine #1	37.0%	-1.3%	0.0%
Main Engine #2	13.2%	13.5%	11.1%
Average Total Reduction	**28.0%**	**6.0%**	**5.5%**

(1) Baseline run data collected on April 17, 2013 - Measurements: Testo 350 Maritime
(2) UltraBurn run data collected on May 22, 2013 - Measurements: Testo 350 Maritime

Engine specific emissions analysis is shown in four data tables in Appendices F and G. Emissions measurements were made during all seven operational modes characteristic of a single round trip; 1) Idle, 2) Accelerated Run – Push or Pull, 3) Deceleration, 4) Idle, 5) Accelerated Run – Pull or Push, 6) Deceleration, 7) Idle.

Estimated Annualized Exhaust Gas Emissions Reduction

The total annual reduction in CO, CO_2 and NO_x can be as a result of the decrease in exhaust gas emissions concentrations measured during the UltraBurn Phase. This is shown in Table 3. This calculation was performed using data from the engine manufacturer at rated power conditions based upon 1,800 RPM. Since it has been shown that the ferry operates well below this rated level, the exhaust gas emission reduction is probably on the higher end. Therefore, estimate the total reduction between 50,000 lb/yr to 150,000 lb/yr.

While the black smoke opacity results are not easily converted to mass flow rate, the 40+% reduction in overall black smoke represents a significant reduction in physical particulate matter over a twelve month operating period.

Table 3 – Annualized Estimated Exhaust Gas Emissions Reduction

Estimated Emissions Reduction[1] M/V Guemes Main Engines #1 and #2			
	CO (lb/hr)	**NOx** (lb/hr)	**CO2** (lb/hr)
Baseline Run **AVG**	**3.2**	**13.2**	**554.1**
UltraBurn Run **AVG**	**2.3**	**12.4**	**523.2**
Calculated Emissions Reduction %	**27.8**	**6.0**	**5.6**
M/V Guemes Emissions Reduction[2,3] (lbs/yr)	**4,231**	**3,779**	**148,475**

(1) Calculations performed at Cummins rated power conditions: 1800 RPM, exhaust gas flow 2,850 CFM
(2) Est Exhaust Gas Mass Flow: 8864 lb/hr (both propulsion engines) @ rated power conditions
(3) Mass Flow (lb/hr) = Gas concentration x MW of Gas x (Exhaust Gas Mass Flow (lb/hr)/MW Air)
(4) Assumes UltraBurn is installed on both propulsion engines
(5) Assumes the vessel operates 400 hours per month 12 months per year

Summary

The UltraBurn® Combustion Catalyst System has dramatically and effectively lowered the level of black smoke emitted from the M/V Guemes during normal ferry operations and has also reduced the amount of exhaust gas pollutants. These reductions will have a significant impact on the vessel's environmental impact in the local area.

Furthermore, if vessel operators are able to compensate for the extra power inherent in improved combustion efficiency by shortening the periods at maximum RPM during acceleration, then the additional fuel saved will translate to an economic benefit that can provide a positive return on investment.

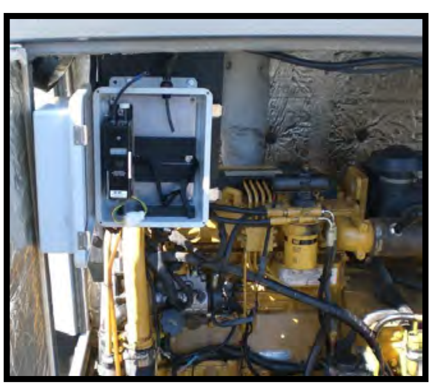
Appendix A – UltraBurn CCS Installation on M/V Guemes

Main Engine # 1 – Unit Mounting

Main Engine #1 – ASF (Injector) Installation

Main Engine #2 – Unit Mounting

Main Engine #2 – ASF (Injector) Installation



Genset – Unit Mounting

Genset – ASF (Injector) Installation

Appendix B – UltraBurn CCS Installation Closure Report

EMISSIONS TECHNOLOGY

Install Closure

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Company:	**Skagit County**	**Install Date**	**3/25/13**	**SO/WO:**	1326

Unit #	M/V Guemes	Engine Make/Model	Cummins KTA19-M3 (s/n 37219054) Main 1	Engine Year	
PTI/DI S/N	**60408130007 (PTI-203DM)**				
Electrical Hook up	On alternator				
Mounting	Inside the engine house; front left side				
Problems/Notes	Not active (will activate after emissions testing)				
Field Changes	Used washers with ASF to make compression and seal of the rubber boot.				

Unit #	M/V Guemes	Engine Make/Model	Cummins KTA19-M3 (s/n 37217216) Main 2	Engine Year	
PTI/DI S/N	**60408130008 (PTI-203DM)**				
Electrical Hook up	On alternator				
Mounting	Back wall of engine house – center inside				
Problems/Notes	Not active (will activate after emissions testing)				
Field Changes	Used washers with ASF to make compression and seal of the rubber boot.				

Unit #	M/V Guemes	Engine Make/Model	CAT C4.4 Acert – non turbo (s/n D1K00396)	Engine Year	
PTI/DI S/N	**60308130003 (PTI-103DM)**				
Electrical Hook up	On alternator				
Mounting	Front left wall inside engine house				
Problems/Notes	System active. They plan to replace generator with new.				
Field Changes	Used washers with ASF to make compression and seal of the rubber boot.				

Installer Signature	RD	Date	05-APR-13

More Power. Reduced Emissions.

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COMBUSTION CATALYST SYSTEM

Appendix C – Operating Schedule - M/V Guemes

GUEMES ISLAND FERRY

NON-PEAK Sailing Schedule Effective October 1st through May 19th

Anacortes Departure Times

Ferry departs Guemes approximately 8 minutes after the listed times.

Crossing time approximately 5 minutes. Round-trip time approximately 20-25 minutes.

MON - THURS	FRIDAY	SATURDAY	SUNDAY
6:30 AM	6:30 AM	6:30 AM	
7:00 AM	7:00 AM	7:00 AM	
7:30 AM	7:30 AM		
8:00 AM	8:00 AM	8:00 AM	8:00 AM
8:30 AM	8:30 AM		8:30 AM
			9:00 AM
9:15 AM*	9:15 AM	9:15 AM	
9:45 AM	9:45 AM	9:45 AM	10:00 AM
10:15 AM	10:15 AM	10:15 AM	
10:45 AM	10:45 AM	10:45 AM	10:45 AM
11:15 AM	11:15 AM	11:15 AM	11:15 AM
1:00 PM	1:00 PM	1:00 PM	1:00 PM
1:30 PM	1:30 PM	1:30 PM	1:30 PM
2:00 PM*	2:00 PM	2:00 PM	2:00 PM
2:30 PM	2:30 PM		
		2:45 PM	2:45 PM
3:15 PM	3:15 PM		
		3:30 PM	3:30 PM
4:00 PM	4:00 PM	4:00 PM	4:00 PM
4:30 PM	4:30 PM		4:30 PM
5:00 PM	5:00 PM	5:00 PM	
5:30 PM	5:30 PM	5:30 PM	5:15 PM
			5:45 PM
6:15 PM	6:15 PM	6:15 PM	
6:45 PM	6:45 PM	6:45 PM	7:00 PM
			7:30 PM
8:00 PM	8:00 PM	8:00 PM	8:00 PM
8:30 PM	8:30 PM	8:30 PM	
	9:15 PM	9:15 PM	
	10:00 PM	10:00 PM	
	11:00 PM	11:00 PM	

***Wednesday 9:15 AM to Guemes and 2:00 PM from Guemes are hazardous materials runs only.**

No other vehicles or passengers may travel on these runs.

Ferry may make one extra trip when overloaded at 11:15 AM, or when there is an hour between runs. No extra trips at 5:45 PM or 6:45 PM. For one extra trip on the 8:00 PM, 8:30 PM, or 11:00 PM, the fare will be $100.00, plus fare, regardless of how many vehicles are in line. This fare may be split by all those who wish to travel.

When New Year's Day, Fourth of July, Labor Day, Thanksgiving, or Christmas falls on a Sunday through Thursday, service will be provided on a Saturday schedule, ending at 10:00 PM

SCHEDULE SUBJECT TO CHANGE WITHOUT NOTICE

Source: Skagit County Washington (2013).

Appendix D – Baseline Phase – Opacity Data

OPACITY BASELINE PHASE TEST DATA (4/17/2013) - M/V Guemes

Count	Operating Mode	Main Engine #	Record Number	Time	Date	Test	Measurement Average	Range
RUN A								
1	A to B	1	1252	8:23 AM	04/17/13	7.2		
						5.5		
						5.2	6.0	1.9
2	A to B	1	1253	8:25 AM	04/17/13	7.1		
						7.2		
						6.4	6.9	0.8
3	Stop B	1	1254	8:26 AM	04/17/13	7.8		
						17.7		
						6.6	10.7	11.0
4	B to A	1	1255	8:29 AM	04/17/13	9.6		
						19.6		
						4.4	11.2	15.2
5	Stop A	1	1256	8:30 AM	04/17/13	71.2		
						3.4		
						0.0	24.9	71.2
6	Idle	1	1257	8:33 AM	04/17/13	5.6		
						8.9		
						4.8	6.4	4.8
				Average - Run A		**6.0**	**11.0**	**17.5**
RUN B								
7	Idle	1	1274	10:38 AM	04/17/13	1.4		
						2.4		
						2.3	2.0	1.1
8	A to B	1	1275	10:39 AM	04/17/13	4.6		
						4.0		
						3.4	4.0	1.2
9	Stop B	1	1276	10:40 AM	04/17/13	5.6		
						8.1		
						2.3	7.0	2.4
10	B to A	1	1277	10:42 AM	04/17/13	13.4		
						13.5		
						3.9	10.3	9.6
11	B to A	1	1278	10:45 AM	04/17/13	0.0		
						1.4		
						0.5	0.6	1.4
12	Stop A	1	1279	10:49 AM	04/17/13	2.8		
						2.9		
						9.5	5.1	6.7
13	Idle	1	1280	10:59 AM	04/17/13	3.7		
						3.5		
						3.2	3.5	0.5
				Average - Run B		**4.4**	**4.6**	**3.3**
RUN C								
14	Idle	1	1294	2:05 PM	04/17/13	3.7		
						1.8		
						0.0	1.8	3.7
15	A to B	1	1295	2:07 PM	04/17/13	16.0		
						15.0		
						10.8	14.0	5.2
16	Stop A	1	1296	2:18 PM	04/17/13	13.9		
						10.5		
						3.3	9.2	10.6
17	Idle	1	1297	2:22 PM	04/17/13	2.5		
						2.3		
						2.6	2.4	0.3
18	Idle	1	1298	2:24 PM	04/17/13	2.3		
						1.8		
						2.2	2.1	0.4
19	B to A	1	1299	2:24 PM	04/17/13	10.6		
						4.8		
						2.8	6.1	7.7
20	Run	1	1300	2:26 PM	04/17/13	1.2		

Appendix D – Baseline Phase – Opacity Data – Cont'd

21	Stop B	1	1301	2:28 PM	04/17/13	11.9		
						14.6		
						3.5	10.0	11.1
22	Idle	1	1302	2:33 PM	04/17/13	2.5		
						2.5		
						2.3	2.4	0.2
23	Idle	1	1303	2:35 PM	04/17/13	1.0		
						1.7		
						1.8	1.5	0.8
24	A to B	1	1304	2:35 PM	04/17/13	8.7		
						2.9		
						7.8	6.5	5.8
25	Run	1	1305	2:37 PM	04/17/13	1.1		
						0.8		
						1.0	1.0	0.3
				Average - Run C		**3.9**	**4.8**	**3.9**

Count	Operating Mode	Main Engine #	Record Number	Time	Date	Test	Measurement Average	Range
RUN A								
1	A to B	2	1239	7:46 AM	04/17/13	4.0		
						5.1		
						4.4	4.5	1.1
2	A to B	2	1240	7:48 AM	04/17/13	4.7		
						5.6		
						6.4	5.6	1.7
3	Stop B	2	1241	7:51 AM	04/17/13	6.9		
						3.7		
						6.7	5.8	3.2
4	B to A	2	1242	7:52 AM	04/17/13	3.9		
						2.7		
						3.4	3.4	1.2
5	Stop A	2	1243	7:55 AM	04/17/13	8.1		
						7.3		
						4.7	6.7	3.4
6	Idle	2	1244	7:57 AM	04/17/13	2.8		
						5.4		
						4.2	4.2	2.6
				Average - Run A		**5.0**	**5.0**	**2.2**
RUN B								
7	A to B	2	1282	11:04 AM	04/17/13	4.6		
						4.4		
						5.0	4.7	0.5
8	A to B	2	1283	11:05 AM	04/17/13	4.0		
						6.5		
						8.8	6.4	4.8
9	A to B	2	1284	11:08 AM	04/17/13	4.0		
						4.5		
						5.2	4.6	1.2
10	B to A	2	1286	11:17 AM	04/17/13	12.7		
						12.0		
						3.5	9.4	9.2
11	B to A	2	1287	11:18 AM	04/17/13	15.7		
						16.0		
						21.0	17.6	5.3
12	B to A	2	1288	11:19 AM	04/17/13	6.5		
						0.0		
						0.0	2.2	6.5
				Average - Run B		**5.4**	**7.5**	**4.6**
RUN C								
13	B to A	2	1289	1:45 PM	04/17/13	6.3		
						10.5		
						11.7	9.5	5.4
14	B to A	2	1290	1:48 PM	04/17/13	2.8		
						3.5		
						0.6	2.3	2.8
15	Idle	2	1291	1:52 PM	04/17/13	2.6		
						3.0		

Appendix D – Baseline Phase – Opacity Data – Cont'd

16	B to A	2	1292	1:54 PM	04/17/13	3.3		
						3.3		
						3.3	3.3	0.0
17	Stop A	2	1293	1:57 PM	04/17/13	22.7		
						22.3		
						12.6	19.2	10.1
				Average - Run C		**5.1**	**7.4**	**3.7**

Total Count	126
Used	115

Control Limits based upon 100% of baseline data:

UCL	14.6
Mean	6.4
LCL	-1.9

Data greater than or equal to UCL was eliminated from analysis

Appendix E – UltraBurn Phase – Opacity Data

OPACITY ULTRABURN PHASE TEST DATA (5/22/2013) - M/V Guemes

Count	Operating Mode	Main Engine #	Record Number	Time	Date	Test	Measurement Average	Range
RUN A								
1	B to A	1	1327	9.57 AM	05/22/13	3.9		
						3.6		
						3.3	3.6	0.6
2	B to A	1	1328	9:50 AM	05/22/13	12.7		
						1.2		
						0.5	4.8	12.1
3	B to A	1	1329	10:02 AM	05/22/13	1.6		
						1.6		
						1.3	1.5	0.3
4	B to A	1	1330	10.04 AM	05/22/13	1.1		
						0.0		
						0.4	0.5	1.1
				Average - Run A		**2.6**	**2.6**	**3.5**

Count	Operating Mode	Main Engine #	Record Number	Time	Date	Test	Measurement Average	Range
RUN A								
1	A to B	2	1333	10:13AM	05/22/13	3.4		
						2.5		
						3.4	3.1	0.9
2	A to B	2	1334	10:14 AM	05/22/13	14.6		
						26.0		
						9.5	16.7	16.5
3	A to B	2	1241	10:21 AM	05/22/13	0.9		
						0.5		
						0.0	0.5	0.9
				Average - Run A		**2.9**	**6.8**	**6.1**

Total	21
Used	19

Control Limits based upon 100% of baseline data:

UCL	14.6
Mean	6.4
LCL	-1.9

Data greater than or equal to UCL was eliminated from analysis

Appendix F – Baseline Phase - Exhaust Gas Emissions Data Summary

Main Engine #1

Baseline Data - Main Engine #1

Operational Mode	Time (min)	O_2 (%)	CO (ppm)	NOx (ppm)	CO_2 (%)	RPM	% Time @750	% Time @ 1800
Main One - Run #1								
Idle	12.0	14.47	90	733	4.04	750		
Accelerated Run - Push	3.4	11.41	236	1478	5.92	1800		
Deceleration	0.4	10.77	1396	1282	6.7	900		
Idle	5.1	14.00	141	847	4.33	750		
Accelerated Run - Pull	3.3	11.16	216	1535	6.03	1800		
Deceleration	0.7	8.35	2287	1472	8.21	900		
Idle	0.9	14.76	353	779	3.5	750		
Total Transit Time (Avg)	25.8	12.13	674	1161	5.53	1029	69.8%	26.0%
Main One - Run #2								
Idle	6.5	18.86	29	237	1.06	750		
Accelerated Run - Pull	3.3	11.43	189	1445	5.66	1800		
Deceleration	1.0	13.20	523	1036	4.57	900		
Idle	15.2	19.02	29	232	0.97	750		
Accelerated Run - Push	2.5	11.57	227	1360	5.56	1850		
Deceleration	1.7	12.89	343	1300	4.82	900		
Idle	1.7	18.71	69	291	1.08	747		
Total Transit Time (Avg)	31.9	15.10	201	843	3.39	958	73.4%	18.2%
Main One - Run #3								
Idle	0.8	20.95	0	1	0.00	750		
Accelerated Run - Push	3.7	10.95	195	1288	6.00	1809		
Deceleration	0.8	16.66	460	655	2.52	900		
Idle	13.3	19.15	30	212	0.88	747		
Accelerated Run - Pull	3.3	11.39	176	1418	5.67	1807		
Deceleration	0.6	12.45	1849	1079	4.36	900		
Idle	0.8	17.40	310	434	2.49	750		
Total Transit Time (Avg)	22.5	14.67	503	848	3.65	1094	62.7%	31.1%
Main Engine #1 Total Transit Time (Avg)	26.7	13.97	460	951	4.19	1027	68.6%	25.1%

Average RPM during deceleration estimated at 900

Appendix F – Baseline Phase - Exhaust Gas Emissions Data Summary – Cont'd

Main Engine #2

Baseline Data - Main Engine #2								
Main Two - Run #1								
Operational Mode	Time (min)	O_2 (%)	CO (ppm)	NOx (ppm)	CO_2 (%)	RPM	% Time @750	% Time @ 1800
Idle	6.2	15.21	91	612	3.52	749		
Accelerated Run - Push	3.4	11.93	176	1452	5.54	1809		
Deceleration	0.7	11.53	559	1302	5.46	900		
Idle	17.9	16.02	138	548	2.95	748		
Accelerated Run - Pull	3.5	11.61	152	1478	5.69	1806		
Deceleration	0.5	9.07	1279	1535	6.78	900		
Idle	2.4	14.75	188	719	3.7	750		
Total Transit Time (Avg)	34.6	12.87	369	1092	4.81	965	76.6%	19.9%
Main Two - Run #2								
Idle	0.6	15.85	61	479	2.66	750		
Accelerated Run - Pull	3.5	11.46	176	1441	5.69	1809		
Deceleration	0.8	10.06	1127	1500	6.8	900		
Idle	7.5	14.35	124	701	3.89	750		
Accelerated Run - Push	3.5	12.05	171	1408	5.36	1810		
Deceleration	1.0	13.72	794	936	4.31	900		
Idle	2.5	14.89	144	637	3.56	750		
Total Transit Time	19.4	13.20	371	1015	4.61	1146	54.6%	36.1%
Main Two - Run #3								
Idle	4.1	19.27	26	171	0.81	751		
Accelerated Run - Pull	3.8	11.77	107	1459	5.45	1810		
Deceleration	0.9	17.34	239	573	2.51	900		
Idle	5.9	19.83	24	130	0.46	747		
Accelerated Run - Push	3.9	12.70	117	1311	4.9	1803		
Deceleration	0.6	14.87	153	934	4.1	900		
Idle	2.1	19.40	43	189	0.71	749		
Total Transit Time	21.3	16.45	101	681	2.71	1142	56.8%	36.2%
Main Engine #2 Total Transit Time (Avg)	25.1	14.18	280	929	4.04	1085	62.7%	30.7%

Average RPM during deceleration estimated at 900

Appendix G – UltraBurn Phase – Exhaust Gas Emissions Data Summary

Main Engine #1

UltraBurn Data - Main #1

Operational Mode	Time (min)	O_2 (%)	CO (ppm)	NOx (ppm)	CO_2 (%)	RPM	% Time @750	% Time @ 1800
Main One - Run #1								
Idle	11.9	20.06	44	106	0.37	750		
Accelerated Run - Push	4.5	11.14	201	1337	5.85	1806		
Deceleration	1.3	14.29	556	800	3.88	900		
Idle	6.0	16.88	92	497	2.29	1000		
Accelerated Run - Pull	3.4	11.02	197	1418	5.97	1805		
Deceleration	1.0	14.98	311	821	2.95	900		
Idle	1.4	20.13	70	147	0.24	750		
Total Transit Time (Avg)	29.5	15.50	210	732	3.08	1044	65.4%	26.8%
Main One - Run #2								
Idle	3.8	13.12	134	914	4.73	910		
Accelerated Run - Pull	3.4	10.73	250	1448	6.19	1805		
Deceleration	0.9	11.81	505	1188	4.91	900		
Idle	16.6	17.25	124	428	2.14	749		
Accelerated Run - Push	3.4	10.64	313	1487	6.13	1808		
Deceleration	0.8	8.72	1047	1557	7.16	900		
Idle	1.8	13.08	359	974	4.79	747		
Total Transit Time (Avg)	30.7	12.19	390	1142	5.15	992	72.3%	22.1%
Main One - Run #3								
Idle	11.7	17.68	117	360	1.76	750		
Accelerated Run - Push	3.1	10.85	349	1336	5.92	1807		
Deceleration	1.7	10.00	653	1511	6.51	900		
Idle	4.3	14.34	112	742	3.83	852		
Accelerated Run - Pull	3.7	10.76	233	1507	6.04	1809		
Deceleration	0.9	12.11	246	1229	4.69	900		
Idle	1.2	18.05	178	413	1.61	750		
Total Transit Time (Avg)	26.6	13.40	270	1014	4.34	1035	64.7%	25.6%
Main Engine #1 Total Transit Time (Avg)	28.9	13.70	290	963	4.19	1024	67.5%	24.8%

Average RPM during deceleration estimated at 900

Appendix G – UltraBurn Phase - Exhaust Gas Emissions Data Summary – Cont'd

Main Engine #2

UltraBurn Data - Main Engine #2								
Main Two - Run #1								
Operational Mode	Time (min)	O_2 (%)	CO (ppm)	NOx (ppm)	CO_2 (%)	RPM	% Time @750	% Time @ 1800
Idle	9.9	20.38	38	67	0.16	750		
Accelerated Run - Push	3.7	11.34	169	1359	5.77	1808		
Deceleration	0.9	12.07	751	1111	5.08	900		
Idle	8.9	19.61	56	153	0.62	750		
Accelerated Run - Pull	4.6	11.44	124	1393	5.74	1810		
Deceleration	0.8	14.64	265	883	3.6	900		
Idle	2.0	20.53	32	80	0.03	748		
Total Transit Time (Avg)	30.8	15.72	205	721	3.00	1043	67.5%	26.9%
Main Two - Run #2								
Idle	3.1	19.28	121	192	0.91	750		
Accelerated Run - Pull	3.2	11.38	222	1368	5.73	1809		
Deceleration	1.2	11.43	173	1361	5.66	900		
Idle	5.7	18.67	171	271	1.36	749		
Accelerated Run - Push	2.9	11.36	230	1404	5.77	1812		
Deceleration	1.6	11.41	776	1184	5.96	900		
Idle	1.6	15.06	110	640	3.46	749		
Total Transit Time (Avg)	19.3	14.08	258	917	4.12	1106	53.9%	31.6%
Main Two - Run #3								
Idle	11.5	19.05	117	202	0.94	749		
Accelerated Run - Push	3.5	11.15	238	1406	5.77	1801		
Deceleration	1.3	10.10	804	1285	6.44	900		
Idle	15.2	18.10	124	302	1.5	750		
Accelerated Run - Pull	4.1	11.18	295	1291	5.91	1808		
Deceleration	0.4	14.67	164	701	4.05	900		
Idle	1.4	19.05	128	230	0.9	750		
Total Transit Time (Avg)	37.4	14.76	267	774	3.64	971	75.1%	20.3%
Main Engine #2 Total Transit Time (Avg)	29.2	14.85	243	804	3.59	1040	65.5%	26.3%

Average RPM during deceleration estimated at 900

Appendix H – Material Safety Data Sheet (MSDS) for CAT-1 UltraBurn Catalyst

Material Safety Data Sheet

Emissions Technology, Inc.
360 Garden Oaks Blvd.
Houston, Texas 77018

Telephone No.: 713-691-1211

Revision: **March 25, 2011**

SECTION I - PRODUCT IDENTIFICATION

Trade Name: Catalyst Solution, 4-Part
Chemical Family: Mixture of inorganic salts and propylene glycol in water
Physical Description: Orange solution with no appreciable odor.
Item Description: CAT-1

SECTION II – EXPOSURE INFORMATION

Hazardous Components:	ACGIH TLV	OSHA PEL
Propylene Glycol (1, 2- propanediol)	None	None
Lithium Chloride	None	None
Catalyst Group	0.001 mg/m³	0.001 mg/m³

These proprietary chemicals as used are in dilution <.009% and NIOSH exposure limits are for the chemicals in their most concentrated form.

SECTION III – PHYSICAL PROPERTY INFORMATION

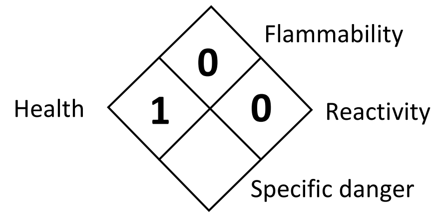
Melting/Freezing Point: -32 C /-26 F
Vapor Pressure (mm of Mercury): .1 mmHg at 20C (68 F)
Boiling Point: 197.8 C /388 F
Vapor Density: 2.1
Specific Gravity (Water = 1): 1.12
Percent Volatile (by Volume): NA
Solubility in Water: Soluble
Evaporation Rate (Butyl Acetate = 1): NA
pH: **3-**4

SECTION IV – HAZARD IDENTIFICATION

Hazardous Material Information System (United States)	National Fire Protection Association NFPA (United States)

Appendix H – Cont.

Health	
Fire	0
Reactivity	0
Personal protection	



SECTION V – FIRE AND EXPLOSION INFORMATION

Flammable Limits: Not flammable
Flashpoint: 117.8 C (244 F) (PMCC)
Auto-Ignition Temperature: N/A
Oxidizer: No
Means of Extinction: Dry Chemical on container and water on the surroundings.
Special Firefighting Procedures: Use of self-contained breathing apparatus is required in fighting fires when chemicals are involved.

SECTION VI – HEALTH INFORMATION

Emergency Overview:

- HARMFUL IF SWALLOWED
- MAY CAUSE DIZZINESS AND DROWSINESS
- MAY CAUSE EYE AND SKIN IRRITATION
- ASPIRATION HAZARD IF SWALLOWED – CAN ENTER LUNGS AND CAUSE DAMAGE
- FOR INDUSTRIAL USE ONLY
- CAN CAUSE LIVER AND KIDNEY DAMAGE IF SWALLOWED
- CONTAINS LITHIUM CHLORIDE WHICH MAY CAUSE BIRTH DEFECTS BASED ON ANIMAL DATA

Routes of Entry: Absorbed through: Skin, Eye contact, Inhalation, Ingestion

Potential Acute Effects:

Eyes: May cause irritation, experienced as mild to severe discomfort or burning

Skin: Brief contact may cause slight irritation. Prolonged contact, as with clothing wetted with material, may cause more severe irritation and discomfort, seen as local redness and swelling. Other than the potential skin irritation effects noted above, acute (short term) adverse effects are not expected from brief skin contact.

Inhalation: Vapors or mist, in excess of permissible concentrations or in unusually high concentrations generated from spraying, heating the material or as from exposure in poorly ventilated areas or confined spaces, may cause irritation of the nose and throat, headache or nausea. Prolonged or repeated overexposure may result in the absorption of potentially harmful amounts of material.

Ingestion: Contains proprietary chemicals <1%, which are harmful when swallowed. Symptoms include headache, weakness, confusion, dizziness, staggering, slurred speech, loss of coordination, faintness, nausea and vomiting, increased heart rate, unconsciousness, convulsions, collapse, and coma.

Symptoms may be delayed. Decreased urine output and kidney failure may also occur.

Chronic Effects: Repeated ingestion may cause liver and kidney damage.

Medical Conditions Aggravated by Exposure:
Because of its irritating properties, repeated skin contact may aggravate an existing dermatitis (skin condition). Repeated overexposure may aggravate existing liver or kidney disease, or other general deterioration of health by an accumulation in one or many human organs.

SECTION VII – FIRST AID MEASURES

Eyes: Immediately flush eyes with plenty of water for at least 15 minutes. Hold eyelids apart while flushing to rinse entire surface of eye and lids with water. Get medical attention.

Skin: Wash skin with plenty of soap and water for several minutes. Get medical attention if skin irritation develops or persists.

Ingestion: If person is conscious and can swallow, immediately give two glasses of water (16 oz.) but do not induce vomiting. If vomiting occurs, give fluids again. Have physician determine if condition of person will permit induction of vomiting or evacuation of stomach. Do not give anything by mouth to an unconscious or convulsing person.

Inhalation: If inhaled, remove to fresh air. If not breathing, clear person's airway and give artificial respiration. If breathing is difficult, qualified medical personnel may administer oxygen. Get medical attention immediately.

SECTION VIII – ACCIDENTAL RELEASE MEASURES

Procedures in Case of Accidental Release, Breakage or Leakage:
Ventilate area. Avoid breathing vapor. Wear appropriate protective equipment, including appropriate respiratory protection. Contain spill if possible. Wipe up or absorb on suitable material and shovel up. Prevent entry into sewers and waterways. Avoid contact with skin, eyes or clothing.

SECTION IX – HANDLING & STORAGE

Handling: Minimum feasible handling temperatures should be maintained

Storage: Periods of exposure to high temperatures should be minimized. Water contamination should be avoided.

SECTION X – EXPOSURE CONTROLS/PERSONAL PROTECTION

Protective Equipment (Type)
Eye/Face Protection: Safety glasses, chemical type goggles, or face shield recommended to prevent eye contact.

Skin Protection:	Workers should wear chemical-resistant protective gloves and wash exposed skin several times daily with soap and water. Soiled work clothing should be laundered or dry-cleaned.
Respiratory Protection:	Airborne concentrations should be kept to lowest levels possible. If vapor, mist or dust is generated and the occupational exposure limit of the product, or any component of the product, is exceeded, use appropriate NIOSH or MSHA approved air purifying or air supplied respirator after determining the airborne concentration of the contaminant. Air supplied respirators should always be worn when airborne concentration of the contaminant or oxygen content is unknown.
Ventilation:	Adequate to meet occupational exposure limits (see below)

SECTION XI – REACTIVITY INFORMATION

Stability Under Normal Conditions: Stable
Hazardous Decomposition Products: Thermal decomposition may release hydrogen chloride gas.
Incompatibility: Strong bases, strong reducers
Other: None known

SECTION XII – SPILL OR LEAK INFORMATION

Steps to be Taken in Event of Spill or Release: Recover and recycle by diking and absorbing with inert materials.

Wear gloves, goggles, boots, and apron or lab coat. After spill is cleaned up, clean shoes. Prevent product from reaching sewers, streams or water sources. Prevent onlookers from touching spilled material.

Waste Disposal: Recover and recycle, unnecessary to dispose. Be sure to follow all current federal, state and local regulations for the hazardous materials listed on this MSDS.

SECTION XIII – EXPOSURE CONTROL INFORMATION

Ventilation Requirements: Provide general and/or local exhaust ventilation to control airborne levels below the exposure guidelines.
Respiratory Protection: Use NIOSH approved respirator. Follow the respirator programs as established by OSHA 29CFR 1910.134.
Protective Gloves: Use chemical-resistant gloves.
Eye Protection: Chemical goggles
Other Protective Equipment: Use additional PPE as needed.

SECTION XIV – HANDLING AND STORING INFORMATION

When handling, all exposed skin should be covered with protective clothing. For storage, place chemical in plastic or glass containers and away from acute fire hazards. Keep containers closed and stored in ventilated areas.

Appendix H – Cont.

Always wash hands and face before eating and never bring contaminated materials or safety equipment into areas approved for eating, drinking or smoking.

SECTION XV – REGULATORY INFORMATION

OSHA HAZARD COMMUNICATION RULE, 29 CFR 1910.1200: This chemical is considered hazardous if present in more than trace amounts.
CERCLA/SUPERFUND, 40 CR 117, 302: This product contains Reportable Quantity (RQ) Substances.
SARA HAZARD CATEGORY: Does not meet any hazard category after review of applicable definitions under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SARA Title III).
SARA 313 INFORMATION: This product does not contain substances subject to the reporting requirements of section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.
TOXIC SUBSTANCES CONTROL ACT (TSCA): The components of this product mixture are all on the 8(b) inventory list.
CALIFORNIA PROPOSITION 65: This product does not contain a chemical known to the State of California to cause cancer and/or reproductive toxicity.
TRANSPORTATION CLASSIFICATION: Not hazardous for transportation

References

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2. CAT C4.4 ACERT Industrial Engine Specifications, 2012.

3. Doane, E.P., Campbell, J.A.L., Lee, F.H and J.W. Haskew. (1995). Minimizing Diesel Emissions by Catalysis. *Proceedings of the 7th Mine Ventilation Symposium*, 95. Lexington, KY.

4. Griffiths, T.R. (2002). Use of a Pt-based Aerosol Catalyst for Improved Combustion and Reduced Emissions. *Interfacial Applications in Environmental Engineering*, 275.

5. SAE International. (October 1, 1986). *Joint TMC/SAE Fuel Consumption Test Procedure – Type II*. Retrieved from http://standards.sae.org/j1321_198610/

6. Valentine, J.M., Peter-Hoblyn, J.D., and G.K Acres. (June 2000). Emissions Reduction and Improved Fuel Economy Performance from a Bimetallic Platinum/Cerium Diesel Fuel Additive at Ultra-Low Dose Rates. *SAE International Spring Fuels and Lubricants Meeting*, SAE Paper No. 2000-01-1934.