

**20% ETHANOL FUEL BLEND EFFECTS
ON FOUR-STROKE
MOTORCYCLE ENGINES**

By

AARON PILGER

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Under the Alternate Plan for the Manufacturing Engineering Technology, Master of Science degree, this report is offered in lieu of a thesis.

Dr. Bruce Jones

Dr. Harry Petersen

Dr. Andrzej Markowski

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CHAPTER I

ABSTRACT

Growing concerns for the environment and natural resource consumption has brought alternative fuels to the forefront of science and technology. Due to these environmental concerns and rising gasoline prices there is a need to study the effects of higher concentration ethanol fuel blends on vehicle emissions and components. The objective of this research was to compare the emissions and air to fuel ratio characteristics of a stock four-stroke motorcycle running on EPA Tier II Certification Fuel, Tier II blended with 10% ethanol, and Tier II blended with 20% ethanol. The use of the three fuels provided a starting point for the evaluation of trends as the amount of ethanol blends was increased.

Data were collected by running a stock 1995 Kawasaki Ninja 250 on a, SuperFlow CycleDyn (Seen in Figure1), eddy current motorcycle dynamometer.

Figure 1: SuperFlow CycleDyn



The motorcycle used in this study was a 1995 Kawasaki Ninja 250 (VIN number JKAEXMF16TA050192). The engine is a liquid cooled, dual over head cam, carbureted, inline twin, with 248cc of displacement. This bike was chosen due to its relatively low cost and high production volume which makes replacement parts readily available. A carbureted motorcycle was chosen because it is more susceptible to lean air fuel ratios caused by ethanol fuel blends. Modern motorcycles with closed loop fuel injection would most likely be capable of adjusting to low percentage ethanol fuel blends without any modifications.

Emissions data will be collected using a California Analytical Instruments emissions console. The unit used is a Constant Volume Sampler (CVS) which uses a 350 cfm Critical Flow Venturi (CFV). Hydrocarbons, carbon monoxide, carbon dioxide, and nitrogen oxides were measured using a FID (flame ionization detector), NDIR (non-dispersive infrared analyzer), and CLD (chemiluminescent detector) respectively. Tier II Certification Fuel was chosen in place of unleaded gasoline because of the discrepancies in gasoline composition. Using Tier II Certification Fuel as a standard emissions test fuel allows better repeatability and comparison with other research by eliminating the variables seen in gasoline. Un-denatured ethanol was used to remove possible variables seen in additives used during the denaturing process.

Air/fuel ratio was monitored using an Innovate Technology LM1, digital air/fuel ratio meter. Looking at the air/fuel ratio provided data used to determine if the higher concentration of ethanol produced a lean mixture that could damage critical engine components.

The research hypothesis was that the 20% ethanol Tier II Certification Fuel fuel blend would reduce the motorcycles HC and CO emissions more than the 10% fuel blend without causing a significant lean condition during normal operation conditions.

CHAPTER II

INTRODUCTION

Tim Pawlenty, the Governor of Minnesota, signed legislature to require all gasoline sold in the state to contain 20% ethanol by August 30, 2013. Before such a mandate could be implemented research was needed to understand the effects this will have on emissions, material compatibility, and drive ability for all vehicles. There are many vehicles produced that are designed to run on higher percentage ethanol fuel blends, but it was not known how vehicles that were not designed for higher blends would be affected by the use of 20% ethanol.

ETHANOL AS AN ALTERNATIVE FUEL AND GASOLINE ADDITIVE

Ethanol is a renewable resource, raises the octane number when added to gasoline, and burns cleaner than gasoline. However, it contains less energy per gallon, is more corrosive, and at the time of this study costs more than gasoline.

Ethanol is produced by converting biomass into sugar and then fermenting into ethyl alcohol (ethanol). Ninety five percent of ethanol produced in the United States is made from corn (Lave, 2001, p.74). You can see why Minnesota's Governor Tim Pawlenty wants to raise the amount of ethanol required in gasoline from 10% to 20%. A large amount of the ethanol produced in the U.S. is right here in Minnesota. The increased use of ethanol would boost the local economy and lessen our dependence on imported gasoline.

Ethanol is an oxygenate, which means that its chemical composition includes oxygen. When ethanol is added to gasoline, the additional oxygen improves fuel

combustion, thereby reducing tailpipe emissions of CO and unburned hydrocarbons that form smog (Wyman, 1996).

Ethanol also has a higher octane rating than gasoline. The octane rating of a fuel is an indication of the fuel's ability to resist detonation. The higher the fuel's octane rating, the more resistant it is to detonation. By adding ethanol to gasoline, it raises the octane number. Ethanol can be used to replace toxic additives such as benzene and MTBE, which have traditionally been used to raise gasoline octane numbers. Higher octane ratings also allow for higher compression ratios due to the fuel's greater resistance to detonation. Larger compression ratios have a beneficial effect on engine efficiency.

Fuel economy of vehicles running on ethanol or ethanol-blended fuel will be lower than vehicles running on gasoline. This is due to the fact that ethanol contains about one-third less energy per gallon than gasoline. This is a disadvantage that cannot be changed, however, it can be outweighed by ethanol's other advantages.

Ethanol is known to be more corrosive than gasoline. When vehicles are designed for higher percentage ethanol fuel blends, this does not cause a problem. However, there is concern about what twenty percent ethanol will do to automotive components not designed for higher ethanol fuel blends. The actual effects are still to be determined by material compatibility testing that goes beyond the scope of this research project.

Gasoline is cheaper than ethanol. If ethanol was cheaper to produce than gasoline, millions of barrels of oil each day would not need to be imported. U.S. ethanol production from corn is cost-effective now because of a \$0.55 per gallon tax subsidy and the high value of byproducts from the process (Lave, 2001, p.75). The use of ethanol as our main energy source will not occur until the price of gasoline rises above the cost of

producing ethanol or advances in producing ethanol make the process more cost effective.

The advantages of ethanol over gasoline and other additives make it a very attractive fuel. Ethanol is better for the environment than gasoline and would help reduce the United States dependency on foreign oil. Requiring 20% ethanol in gasoline sold at Minnesota pumps would provide a boost in the Midwest's economy. Before such mandates can be implemented more research is needed to determine the effects of 20% ethanol on vehicle emissions, components, and drive ability.

MOTORCYCLE EMISSIONS

The EPA currently defines a motorcycle as "Any motor vehicle with a headlight, taillight, and stoplight and having: two or three wheels and a curb weight less than or equal to 1749 pounds" (EPA1, 2003, p.2). The EPA also states that there are close to six million motorcycles on the road in the United States today (EPA2, 2003, p.7). This number is dwarfed by the estimated 95 to 100 million motorcycles in use in China (Li-Wei, 2005, p.29), and 10.5 million motorcycles in Taiwan alone (Juin-Horng, 2000, p.4748). With such a large number of motorcycles being used around the world their emissions are becoming more and more of a concern.

Motorcycles currently account for 0.6 percent of mobile-source hydrocarbon (HC) emissions, 0.1 percent of mobile-source oxides of nitrogen (NOx) emissions, and less than 0.1 percent of mobile-source particulate matter (PM) emissions, in the U.S. (EPA1, 2003, p.3). However until 2006 the federal motorcycle standard for hydrocarbon emissions was about 19 times higher than hydrocarbon standards for today's passenger cars (EPA1, 2003, p.3). Emission standards for motorcycles were recently tightened in

2006 and will tighten again in 2010. Previous motorcycle emissions standards for vehicles produced between 1978 and 2005 are as follows: no more than 5.0 g/km hydrocarbons emissions and no more than 12.0 g/km carbon monoxide emissions, for the useful life of the vehicle (EPA3). The useful life of a motorcycle is defined according to engine size and given by number of years or mileage depending on whichever comes first.

Table 1: Useful Life of a Motorcycle (EPA3)

Class	Engine Size (cc)	# of Years		# of Miles
I	Less than 170	5	or	7,456
II	170-279	5	or	11,185
III	280 and above	5	or	18,641

The new EPA motorcycle emissions standards can be seen in Table 2 and apply to the same useful life definitions as seen in Table 1. The new standards also apply to smaller displacement, 50cc or less, motorcycles such as mopeds.

Table 2: New EPA Motorcycle Emissions Standards (EPA1, 2003, p.2)

Class	Engine Size (cc)	Implementation Date	HC (g/km)	HC+NOx (g/km)	CO (g/km)
I	Less than 170	2006	1.0	-	12.0
II	170-279	2006	1.0	-	12.0
III	280 and above	2006	-	1.4	12.0
III	280 and above	2010	-	0.8	12.0

Open sections of the chart represent no changes to that specific standard. The new motorcycle emissions standards have been categorized by engine displacement. 280cc

and above displacement motorcycles will also have to meet more stringent requirements again in the year 2010. The EPA does not specify how motorcycle manufacturers must meet these requirements. It is expected that most manufacturers will meet them by the use of secondary air injection, electronic fuel injection, and catalytic converters. With the addition of equipment to meet these new standards consumers have asked about the added cost. The EPA projects an average cost of \$30 per highway motorcycle to meet the 2006 standards and \$45 to meet the 2010 standards (EPA1, 2003 p.4).

The EPA has also considered the impact of new regulations on small-volume manufactures. A small-volume manufacturer is defined as “manufacturers with fewer than 500 employees’ worldwide and producing fewer than 3,000 motorcycles per year in the United States” (EPA3). Manufactures that fall into this category are not required to meet the 2006 standards until 2008 and will not be required to meet the 2010 standards. The burden to meet the new standards will most likely be placed on the engine manufactures that supply these smaller companies. With these new requirements research is needed to understand the effects that 20% ethanol will have on motorcycle emissions.

A recent article was published in the Journal of Hazardous Materials titled “Influence of Ethanol-gasoline Blended Fuel on Emissions Characteristics from a Four-stroke Motorcycle Engine.” The goal of the study was to determine the effect of 10% ethanol-gasoline blends on motorcycle emissions. Tests were done on a motorcycle chassis dynamometer with a single cylinder, 124 cc, air cooled, four-stroke, with a 9:1 compression ratio. HC, CO, and NO_x were measured by a FID (flame ionization detector), NDIR (non-dispersive infrared analyzer), and CLD (chemiluminescent detector) respectively. Results showed a 30.8% reduction in CO emissions with the E10

fuel blend. HC also showed a significant reduction of 31.7% with the E10 fuel blend. However NO_x showed a smaller reduction of 5.9% (Li-Wei, 2005, p.32). The test results showed that adding small amounts of ethanol to unleaded gasoline can produce a significant reduction in both CO and HC emissions, with a smaller reduction in NO_x emissions. These results again raise the question of the effects 20% ethanol will have on motorcycle emissions.

AIR FUEL RATIO AND DRIVE ABILITY

Due to the lower energy content of ethanol there is concern that higher concentration ethanol fuel blends will cause a lean air/fuel mixture, especially in carbureted vehicles. This concern is multiplied by the high engine speeds seen in today's motorcycle engines.

Air/fuel ratio was logged using an, Innovate Technology LM1, digital air/fuel ratio meter. Looking at the air/fuel ratio allowed the researcher to determine if the higher concentration of ethanol produced a lean mixture that could potentially contribute to the damage critical engine components.

The lower energy content of ethanol may also cause drive ability issues such as hard starting, stalling, surging, hesitation, stumble, and backfires. Engine running and motorcycle drive ability characteristics will be monitored on the dyno. However a large research study that goes beyond the scope of this project is needed to test the effects of 20% ethanol fuel blends on motorcycle drive ability. Said study would need to cover a large variety of motorcycle engine configurations in all weather conditions suitable for motorcycle riding.

CHAPTER III

TESTING PROCEDURES

This chapter includes testing procedures used during the data collection of this study. Procedures included are emissions console calibration procedures, propane verification tests, dynamometer calibration procedure, and data collection procedures.

Each fuel blend was used to run five Hot 505 LA4 drivers traces. The Hot 505 is a 505 second driver trace that is part of the testing procedure used for EPA vehicle emissions certification. This section of the testing procedure is performed with a warm vehicle and consists of a variety of acceleration, deceleration, and idling conditions.

EMISSIONS BENCH CALIBRATION PROCEDURES

The following procedures were used during calibration and use of the California Analytical Instruments emissions console. Test procedures 2-6 were performed before any testing was conducted. The MnCAR Emissions System Propane Verification Test was performed shortly before data collection was started. The MnCAR Emissions System Test Set-up Procedure was performed before each data collection run. The details of these test procedures can be found in the Appendices.

Table 3: Emissions Bench Procedures

1. MnCAR Emissions System Start Up Procedure
2. MnCAR Dilution Bench Baro Calibration Procedure
3. MnCAR Dilution Bench Inlet Pressure Sensor Calibration Procedure
4. MnCAR Dilution Bench Inlet Temperature Sensor Calibration Procedure
5. MnCAR Emissions System Potentiometers Zero / Span
6. MnCAR Emissions System Analog Calibration

7. MnCAR Emissions System Propane Verification Test

8. MnCAR Emissions System Test Set-up Procedure

Specifications used in the MnCAR Emissions System Set-up Procedure used for testing included a 559 lb inertia weight and 3 road horsepower at 50 mph. The drivers trace performed was the Hot 505 sections of the LA4 Trace. The Hot 505 is a 505 second driver trace performed with a warm vehicle consisting of variety of acceleration, deceleration, and idling conditions.

SUPERFLOW CHANNEL SPECIFICATIONS AND CALIBRATION PROCEDURE

The Superflow CycleDyn absorber load cell calibration procedure was performed prior to data collection and can be found on page i of the Appendix. Channel specifications include user entered data specific to the motorcycle that is used to calculate roll resistance applied during acceleration and record test data. Deceleration is controlled by the momentum of the drum roll and user controlled dyno brake. The user entered channel specifications are as follows:

Table 4: Superflow User Entered Channel Specifications

Channel #	Description	Value	Units
77	Engine Bore	62	mm
78	Engine Stroke	41.2	mm
79	# of Cylinders	2	
80	Engine Cycles	4	
81	Induction Type (Normally Aspirated)	0	
82	ECM communications (None)	0	
83	Spark Pulses Per Revolution	1	

84	Stoichiometric Air Fuel Ratio	Test Dependant	
85	Fuel Specific Gravity	Test Dependant	
86	Estimated Effective Frontal Area	4.2	ft ²
87	Counts Per Revolution of Drive Wheel	1	
88	Tire Diameter	24.5	inches
89	Estimated Tire Loss Coefficient	0.11	
90	Estimated Efficiency of the Final Drive System	0.9	
91	Rear Axle Weight	341	pounds
92	Total vehicle Weight With Driver	559	pounds
93	Engine Drive Ratio	3.086	
94	Motorcycle Rotating Inertia	16	pounds
95	Start Speed (N/A)	0	mph
96	Stop Speed (N/A)	100	mph
97	Step Time (N/A)	5	Sec
98	Step Size (N/A)	10	mph
99	Final Drive Ratio	3.21	

LM-1 AIR FUEL RATIO METER CALIBRATION PROCEDURE

An Innovate Motorsports LM-1 wide band oxygen sensor and air to fuel ratio meter were used in conjunction with an LMA-3 data logger, RPM inductive clamp, LC-1 wide band oxygen sensor, and lab top to monitor and record RPM and both cylinders air to fuel ratios. The LM-1 Quick Start Up Guide and LC-1 Quick Start Up Guide which include the free air calibration procedures can be found in the Appendices.

DATA COLLECTION PROCEDURES

The data collection procedures include specifications and guidelines followed during testing. These procedures were set to keep variables between tests to a minimum.

Before testing began a propane verification test was performed to ensure that the emissions console was calibrated properly. A torque calibration was also performed on the Super Flow Cycledyn. A free air calibration was performed on both the LM-1 and LC-1 wide band oxygen sensors.

The motorcycle rear tire pressure was set to the motorcycle manufactures recommendation of 32 psi. Engine oil and coolant levels were set to recommended levels. Oil temperature was recorded using a thermocouple located in the oil pan through the drain plug. Engine coolant temperature was measured in the passageway between the engine and the thermostat. Thermocouples were also placed in each side of the exhaust header to monitor exhaust gas temperatures. Before test fuels were added fuel was drained from both the gas tank and carburetor float bowls. The motorcycle was then allowed to idle for five minutes to ensure that all previous fuel had been consumed. Just prior to data collection two test runs were performed to ensure proper functioning of the emissions console, dyno, wide band oxygen sensors, and motorcycle.

Once the emissions console, dyno, and air fuel ratio meters were prepared the motorcycle was run at idle until the engine oil temperature reached 180 degrees farenheight. At this point the Hot 505 drives trace and data collection was started. RPM was recorded by both the WinDyn and Logworks software so that the temperature and air fuel ratio data traces could be overlapped. The drivers trace was performed five times for each fuel blend. All efforts were made to repeat shift points and throttle application

between each test for consistent data. The motorcycle was allowed to cool for approximately ten minutes between runs while data was saved and equipment was reset.

CHAPTER IV

RESULTS AND CONCLUSIONS

By comparing temperatures, air to fuel ratios, and emissions data collected for all three fuel blends, information about the combustion characteristics of each fuel can be gathered. If the combustion characteristics are similar for each fuel we can conclude that engine components will not be adversely affected by the use of 20% ethanol.

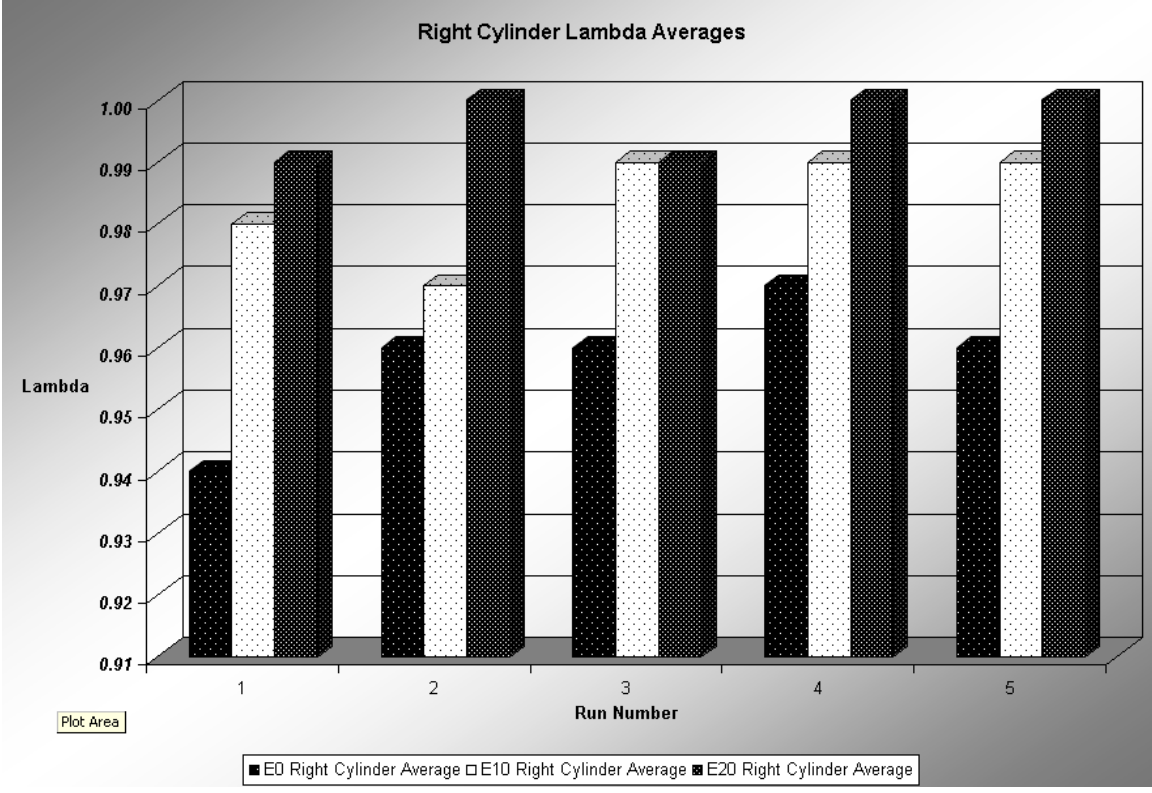
AIR FUEL RATIO RESULTS

Graphical data below represents lambda averages recorded during each 505 second test. Lambda is calculated by dividing the measured air to fuel ratio by the stoichiometric air to fuel ratio for each fuel. A stoichiometric air to fuel ratio has the correct parts of air to fuel for a complete ideal burn without left over hydrocarbons. The stoichiometric air to fuel ratios used for testing during this research were 14.7:1 for the Tier II Certification Fuel, 14.1:1 for 10% ethanol, and 13.6:1 for 20% ethanol. A lambda reading of 1 corresponds to a stoichiometric air to fuel ratio. Lambda readings larger than 1 represent a lean air to fuel ratio and a lambda reading less than 1 represents a rich air to fuel ratio.

Serious mechanical engine damage can occur due to lean air to fuel ratios. A lean mixture will burn hotter and raise combustion chamber and exhaust gas temperatures. Extended exposure to these extreme temperatures can cause premature engine failure most likely related to exhaust valve seat and guide wear. Lean air fuel ratios can also cause detonation. Detonation causes large pressure spikes inside the combustion chamber that can engine damage such as blown head gaskets and even holes in pistons.

Figure 2 shows the right cylinder lambda average for each test. The lambda averages for the 0% ethanol fuel blend are the lowest and the 20% ethanol fuel blend lambda averages are the highest. However the 20% ethanol fuel blend lambda averages do not exceed stoichiometric. The second by second data did not show any extremely lean conditions. Maximum and minimum lambda readings recorded during each test run can be seen in Table 5.

Figure 2: Right Cylinder Lambda Averages



The left cylinder lambda averages seen in Figure 3 correlate very closely to the lambda averages of the right cylinder. Once again we see a rise in the lambda averages between 0% and 10% ethanol fuel blends and a rise between the 10% and 20% fuel blends. All lambda averages for the left cylinder are slightly lower than the lambda

averages of the right cylinder. Uneven air fuel ratios are common in multi-cylinder multi-carbureted motorcycles. Adjustments can be made to each carburetor to reduce the difference between each cylinder, but perfect synchronization is not always achieved. The difference between the left and right cylinder air to fuel ratios correlates to the exhaust gas temperature measurements reported in the next section.

Figure 3: Left Cylinder Lambda Averages

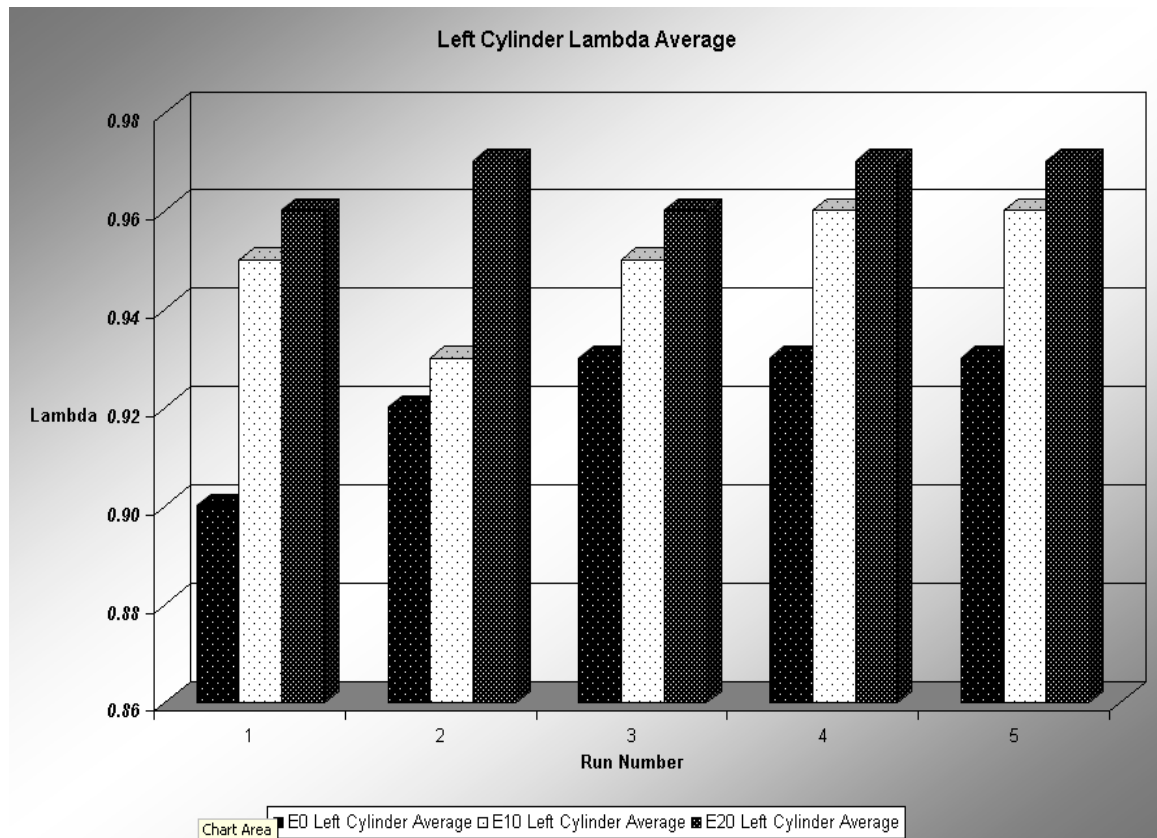
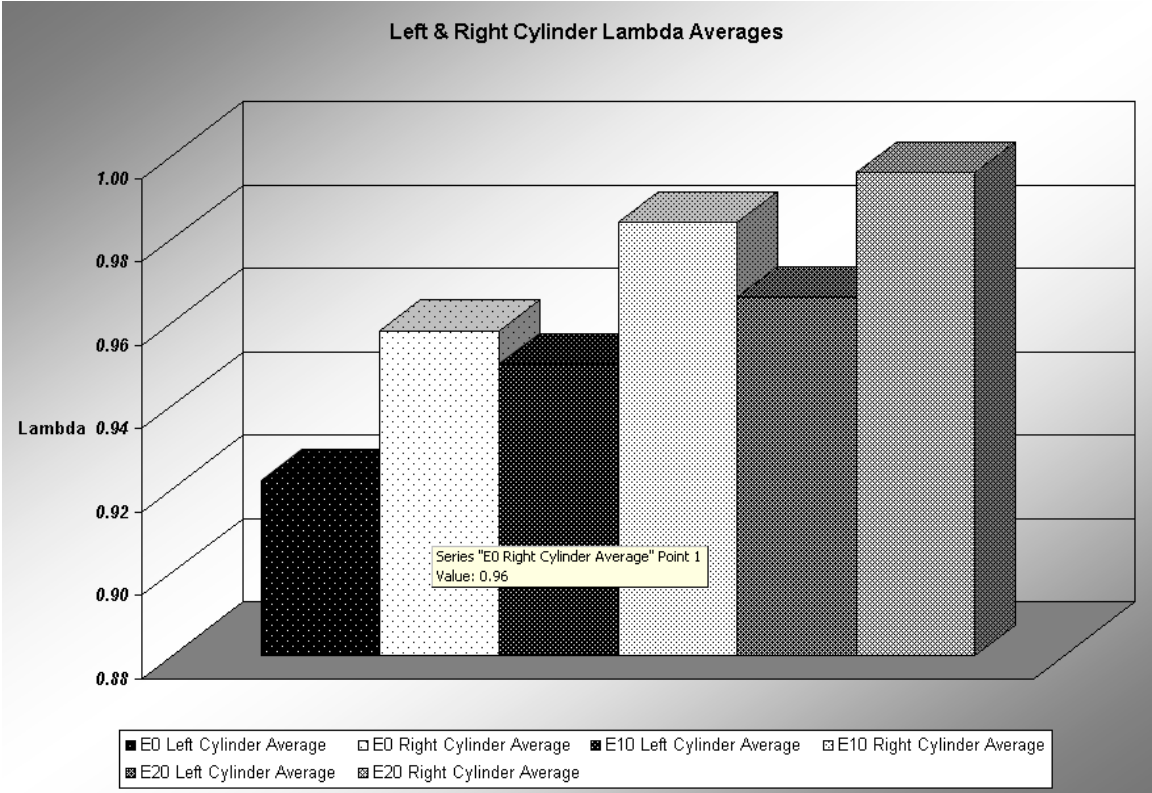


Figure 4 represents the left and right cylinder lambda total averages for all five tests of each fuel. It very clearly shows a rise in air to fuel ratio corresponding to a rise in ethanol percentage.

Figure 4: Left and Right Cylinder Lambda Averages



The exact averages along with the maximum and minimum lambda readings recording during each test can be seen in Table 5.

The left cylinder average lambda from all five test runs rises from 0.92 for 0% ethanol to 0.95 for 10% and again to 0.97 for 20% ethanol. Which equals a rise of 0.03 from 0% to 10%, 0.02 from 10% to 20%, and a total of 0.05 from 0% to 20%. The 20% ethanol fuel blend lambda average is still less than 1. Which means the air to fuel ratio is richer than stoichiometric.

Right cylinder average lambda from all five tests rises from 0.96 for 0% ethanol to 0.98 for 10% ethanol and again to 1.00 for 20% ethanol. Which equals a rise of 0.02 from 0% to 10%, 0.02 from 10% to 20%, and a total of 0.04 from 0% to 20%.

These small increments in average lambda between fuel blends along with very little difference seen between the maximum and minimum lambda readings recording during each test run boasts positively for the use of 20% ethanol fuel blends.

Table 5: Lambda Measurements

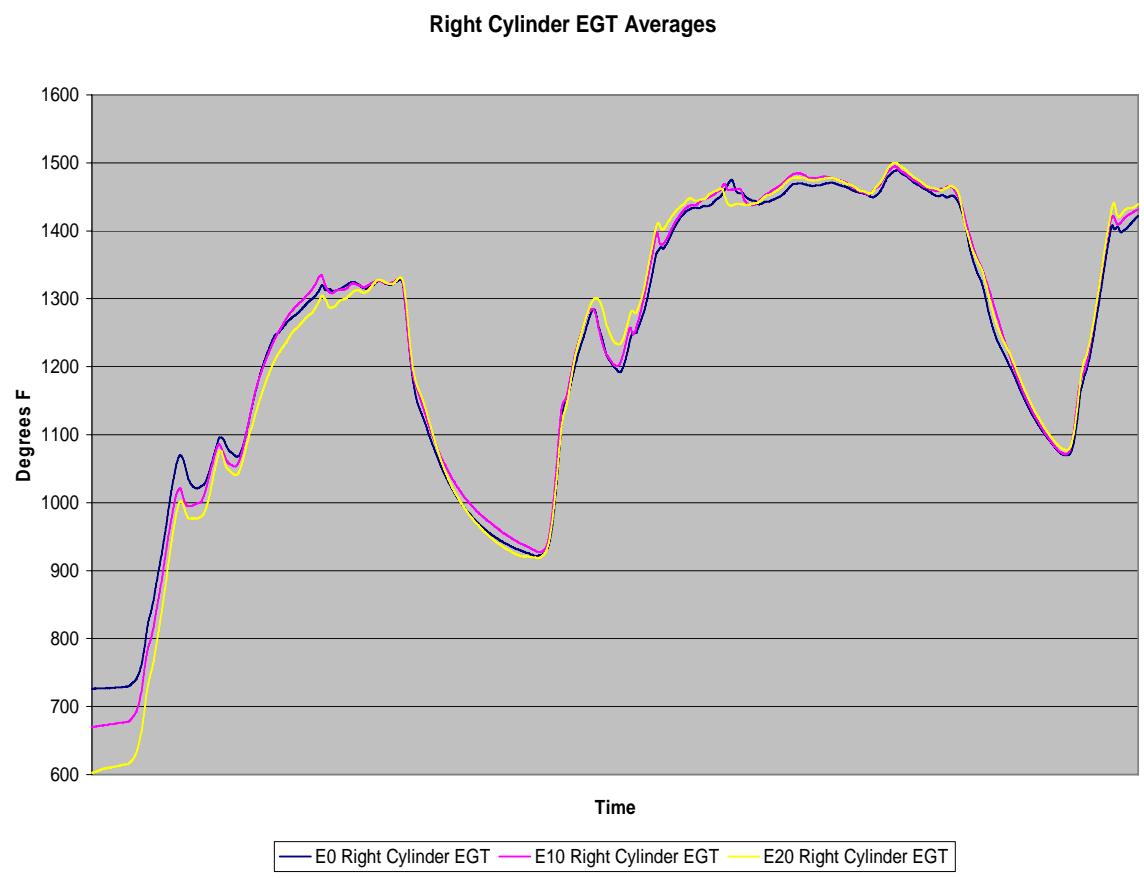
Left Cylinder				Right Cylinder			
0% Ethanol	Average	Maximum	Minimum	0% Ethanol	Average	Maximum	Minimum
Run1	0.90	1.13	0.72	Run1	0.94	1.15	0.73
Run2	0.92	1.16	0.72	Run2	0.96	1.20	0.75
Run3	0.93	1.15	0.69	Run3	0.96	1.17	0.75
Run4	0.93	1.15	0.72	Run4	0.97	1.18	0.74
Run5	0.93	1.15	0.73	Run5	0.96	1.17	0.74
Average	0.92	1.15	0.72	Average	0.96	1.17	0.74
Left Cylinder				Right Cylinder			
10% Ethanol	Average	Maximum	Minimum	10% Ethanol	Average	Maximum	Minimum
Run1	0.95	1.16	0.72	Run1	0.98	1.16	0.73
Run2	0.93	1.15	0.72	Run2	0.97	1.16	0.74
Run3	0.95	1.18	0.72	Run3	0.99	1.17	0.75
Run4	0.96	1.15	0.73	Run4	0.99	1.18	0.75
Run5	0.96	1.15	0.72	Run5	0.99	1.18	0.74
Average	0.95	1.16	0.72	Average	0.98	1.17	0.74
Left Cylinder				Right Cylinder			
20% Ethanol	Average	Maximum	Minimum	20% Ethanol	Average	Maximum	Minimum
Run1	0.96	1.15	0.73	Run1	0.99	1.17	0.74
Run2	0.97	1.15	0.73	Run2	1.00	1.20	0.75
Run3	0.96	1.16	0.72	Run3	0.99	1.16	0.74
Run4	0.97	1.15	0.72	Run4	1.00	1.17	0.74
Run5	0.97	1.18	0.72	Run5	1.00	1.21	0.73
Average	0.97	1.16	0.72	Average	1.00	1.18	0.74

TEMPERATURE MEASUREMENT RESULTS

Thermocouples were used to measure oil, coolant, intake air, and exhaust gas temperatures during each test. All test were started at an oil temp of 180 + or - 1 degree Farenheight. Although dyno cell temperature was not able to be controlled during testing intake air temp only varied from 67.9 to 78.1 degrees Farenheight. This temperature range was seen throughout testing with almost no differences between each test.

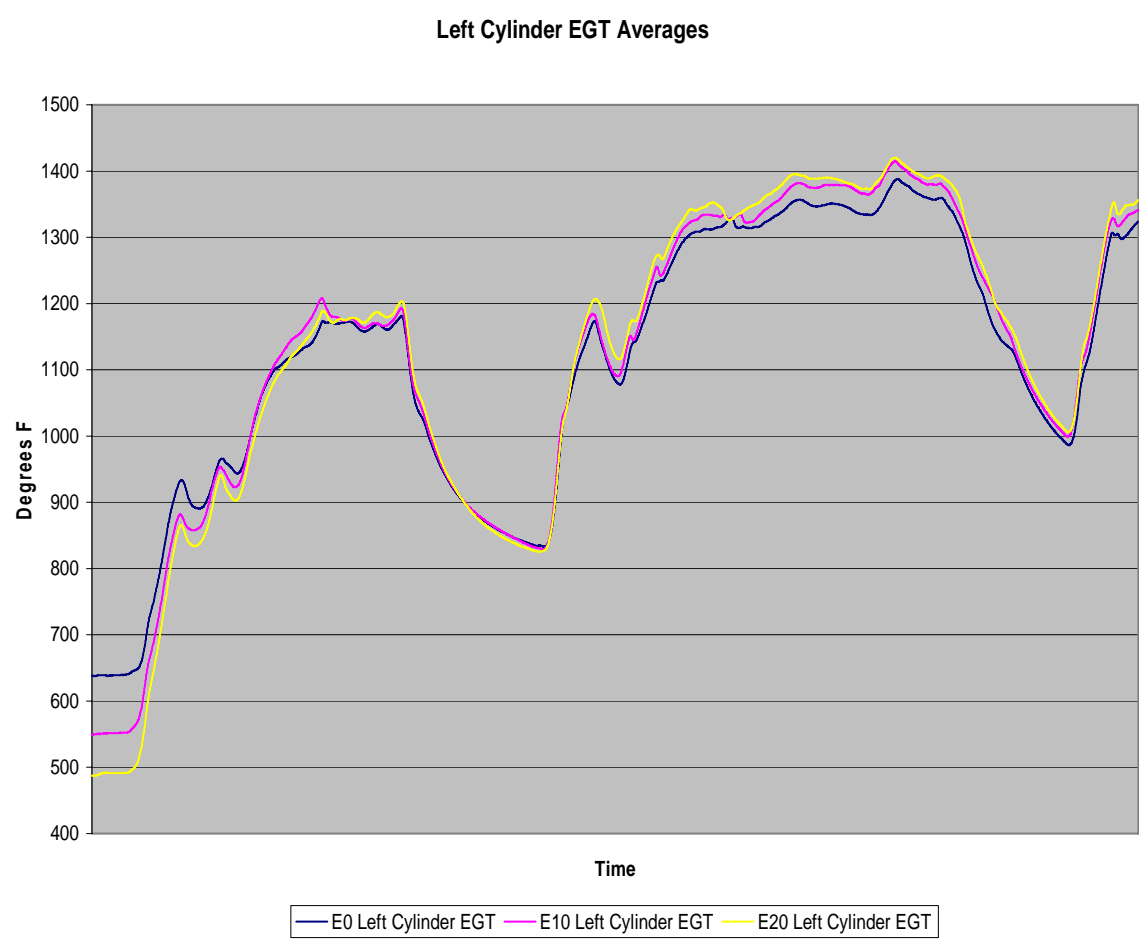
Figure 5 shows the right cylinder exhaust gas temperature averages for each fuel blend. The exhaust gas temperatures are almost identical for all three fuel blends. This infers that there is almost no difference in combustion temperatures dependant on the ethanol percentage of the fuel blend under these operating conditions.

Figure 5: Right Cylinder Exhaust Gas Temperature Averages



Left cylinder exhaust gas temperatures seen in Figure 6 also show very little variation in temperature between each fuel blend. The cooler left cylinder exhaust gas temperatures correlate with the richer left cylinder lambda readings recorded during testing.

Figure 6: Left Cylinder Exhaust Gas Temperature Averages



Engine oil temperature averages displayed in Figure 7 show that the average oil temperature for 20% ethanol is actually lower than the average oil temperatures for both the 0% and 10% ethanol fuel blends. There is almost no difference in the engine oil temperatures recorded for the 0% and 10% ethanol fuel blends.

Figure 7: Engine Oil Temperature Averages

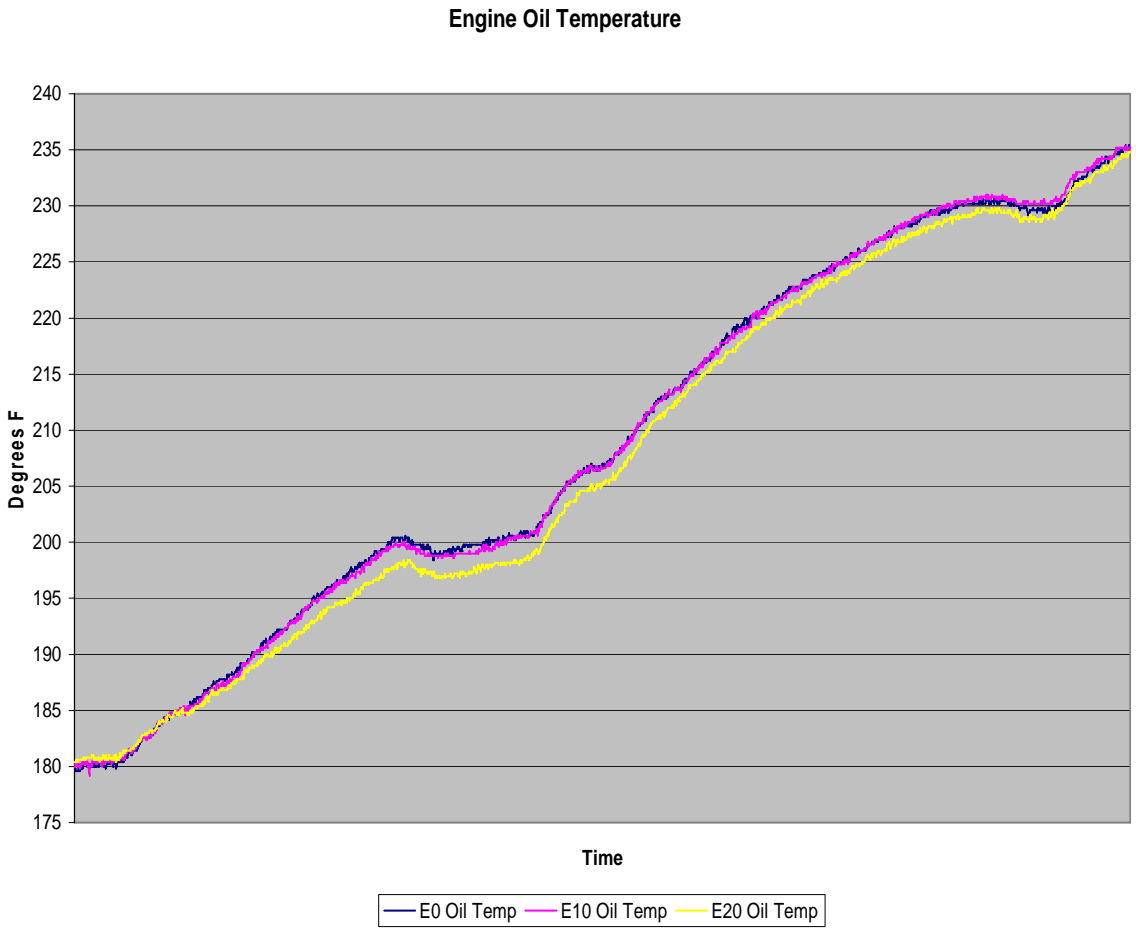
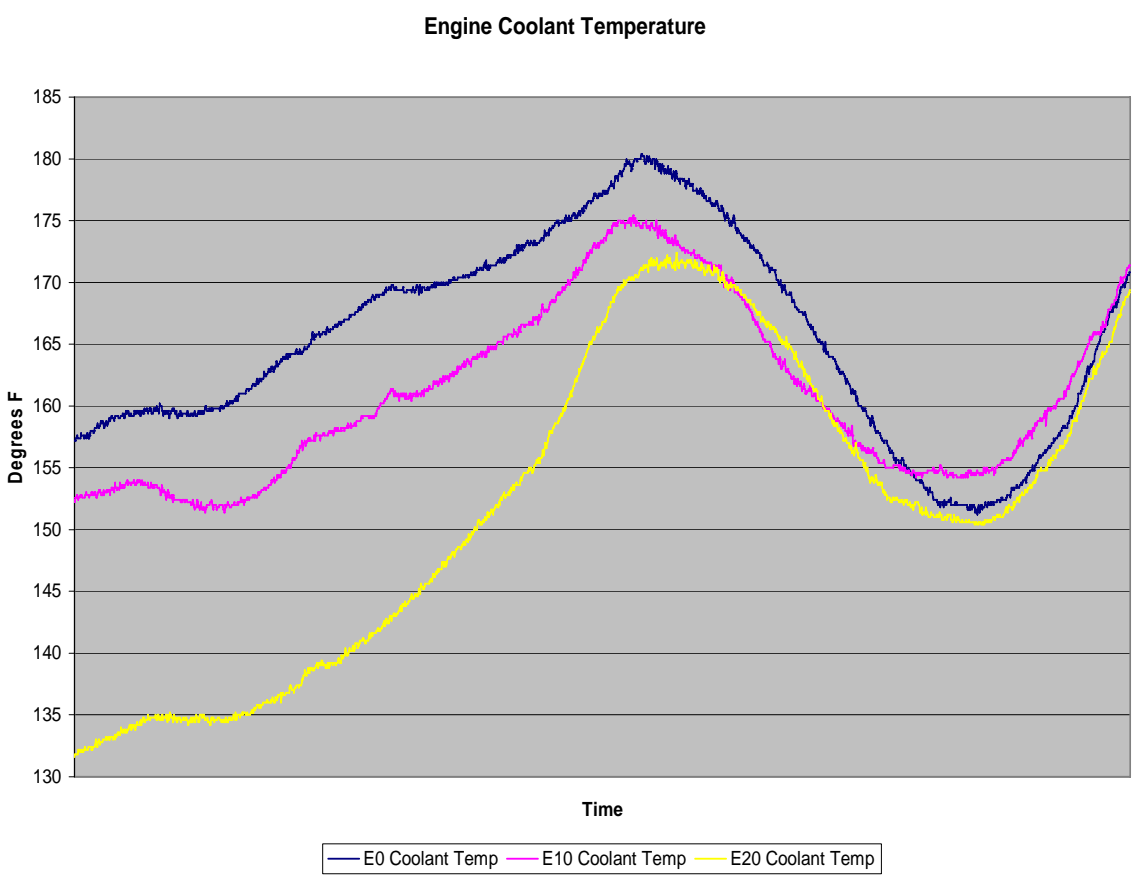


Figure 8 represents the average engine coolant temperatures for each fuel blend. Once again the 20% ethanol temperatures are lower than the 0% and 10% fuel blends.

Figure 8: Engine Coolant Average Temperatures



The temperature data collected during testing shows no concerns related to the ethanol percentage of each fuel blend. Exhaust gas temperatures show very little variation between each fuel blend. Both the engine oil and coolant temperature averages for 20% ethanol are lower than the respective 0% and 10% fuel blend temperature averages. The temperature ranges recorded with all three fuel blends in these operating conditions do not appear to pose any threat to premature engine component damage or wear.

ENGINE EMISSIONS DATA AND RESULTS

Total hydrocarbons, carbon monoxide, carbon dioxide, and nitrogen oxides emissions were measured during each test run. Other internal combustion engine emissions that were not measured include water, sulfur, phosphorus, and particulate matter.

Total hydrocarbon emissions are a good indication of air to fuel ratios. Leftover or unburned hydrocarbons from rich air to fuel ratios correlate to higher total hydrocarbon emissions. Hydrocarbon emissions are a contributor to smog creation. Engine oil that reaches the combustion chamber past piston rings and valve stem guides also contribute to hydrocarbon emissions.

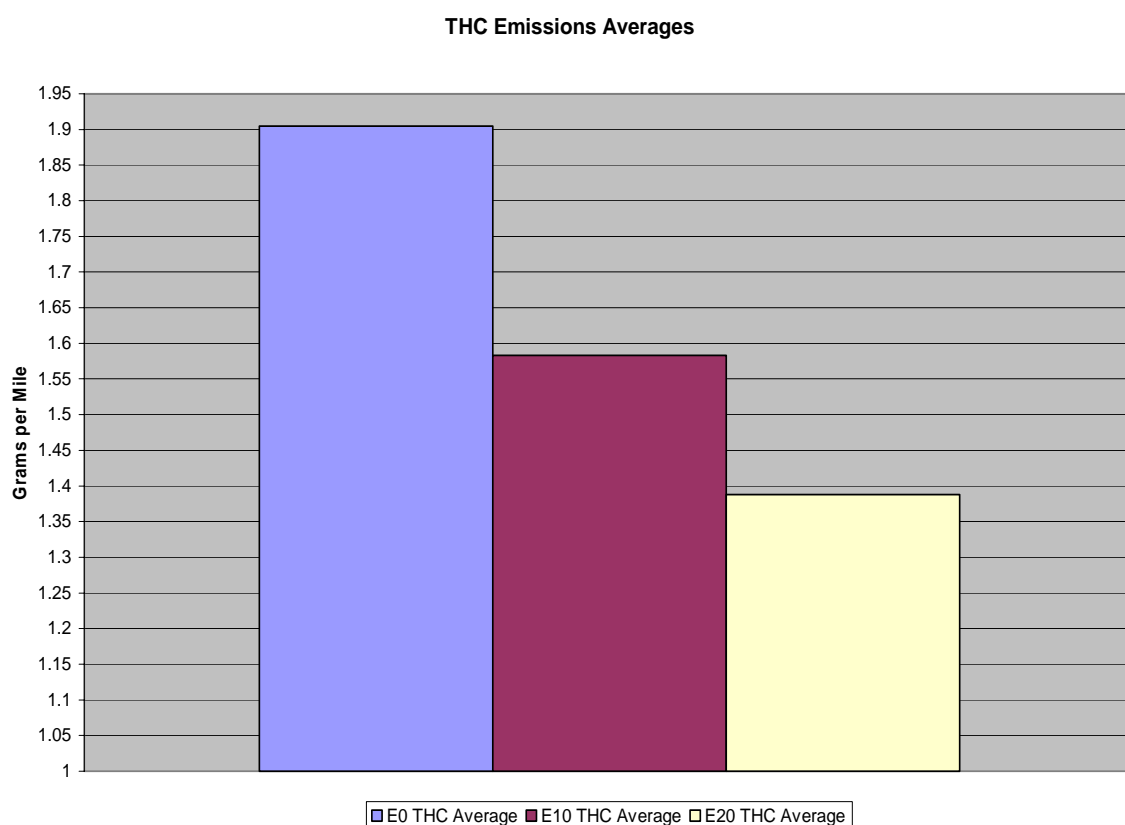
Carbon monoxide emissions also provide a good indication of air to fuel ratio and combustion characteristics. Higher carbon monoxide emissions are related to rich air to fuel ratios where there is not enough oxygen present during combustion to convert all carbon into carbon dioxide.

Therefore higher carbon dioxide emissions correlate to leaner air to fuel ratios where enough oxygen is present during combustion to form more carbon dioxide instead of carbon monoxide. Carbon monoxide is undesirable not only because it is toxic to humans, but represents an incomplete burn that wastes chemical energy.

Higher nitrogen oxides emissions are seen due to hotter combustion temperatures caused by lean air to fuel ratios. Nitrogen oxides are also a contributor to smog. Looking at the emissions data we would like to see reduction in harmful hydrocarbon and carbon monoxide emissions without seeing a rise in the nitrogen oxides emissions.

Figure 9 shows the total hydrocarbon emissions averages in grams per mile for each fuel blend. The 0% ethanol fuel blend has the highest amount of hydrocarbon emissions at 1.905 grams per mile. The 20% ethanol fuel blend recorded the lowest amount of hydrocarbon emissions at 1.388 grams per mile. The 10% ethanol fuel blend falls in the middle at 1.583 grams per mile. This motorcycle would not be able to meet the new 2006 motorcycle hydrocarbon emissions standard of 1.609 grams per mile running on 0% ethanol. However it would be able to meet these standards running on the 10% and 20% ethanol fuel blends.

Figure 9: Total Hydrocarbon Emissions Averages



Carbon monoxide emissions averages seen in Figure 10 follow the same trend seen in the total hydrocarbon emissions data. The 20% ethanol fuel blend recorded the lowest carbon monoxide emissions at 9.247 grams per mile. The 10% ethanol fuel blend recorded an average of 11.222 grams per mile, and the 0% ethanol fuel blend recorded an average of 16.885 grams per mile. In this case all three fuel blends would meet the new 2006 carbon monoxide emissions standard of 19.312 grams per mile.

Figure 10: Carbon Monoxide Emissions Averages

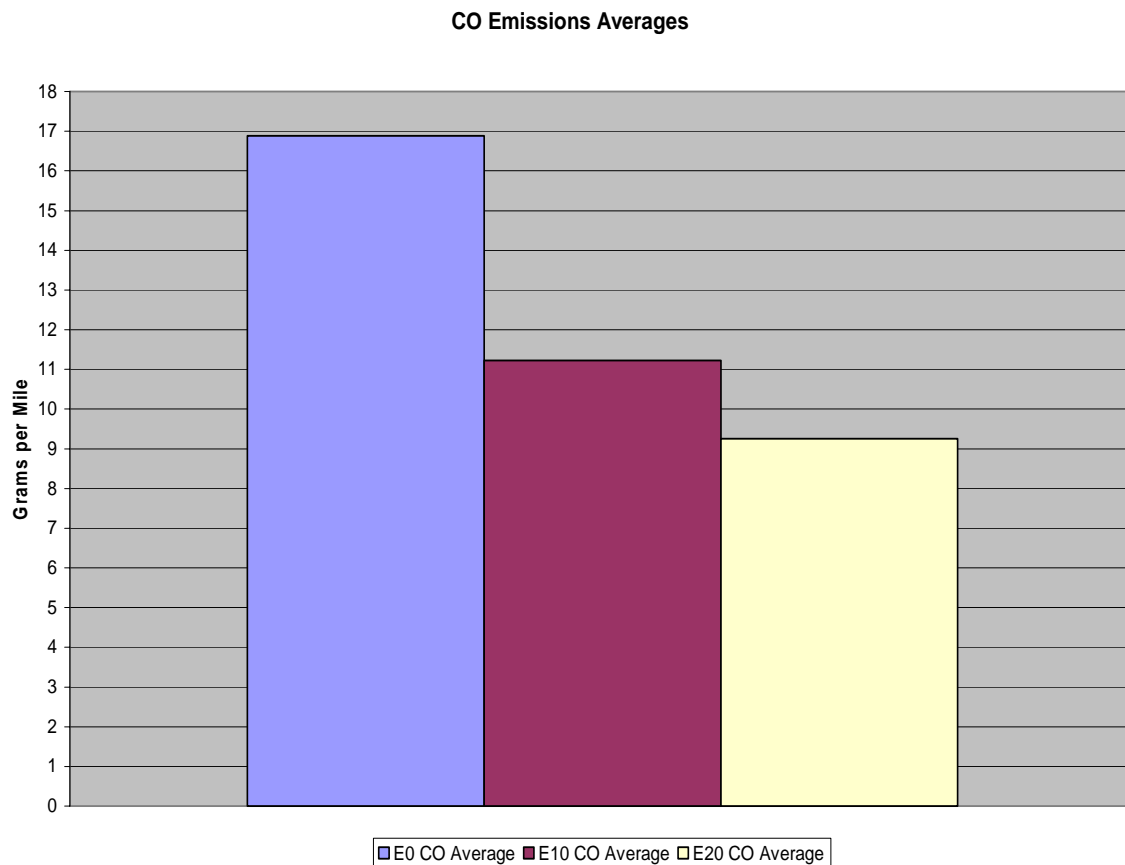
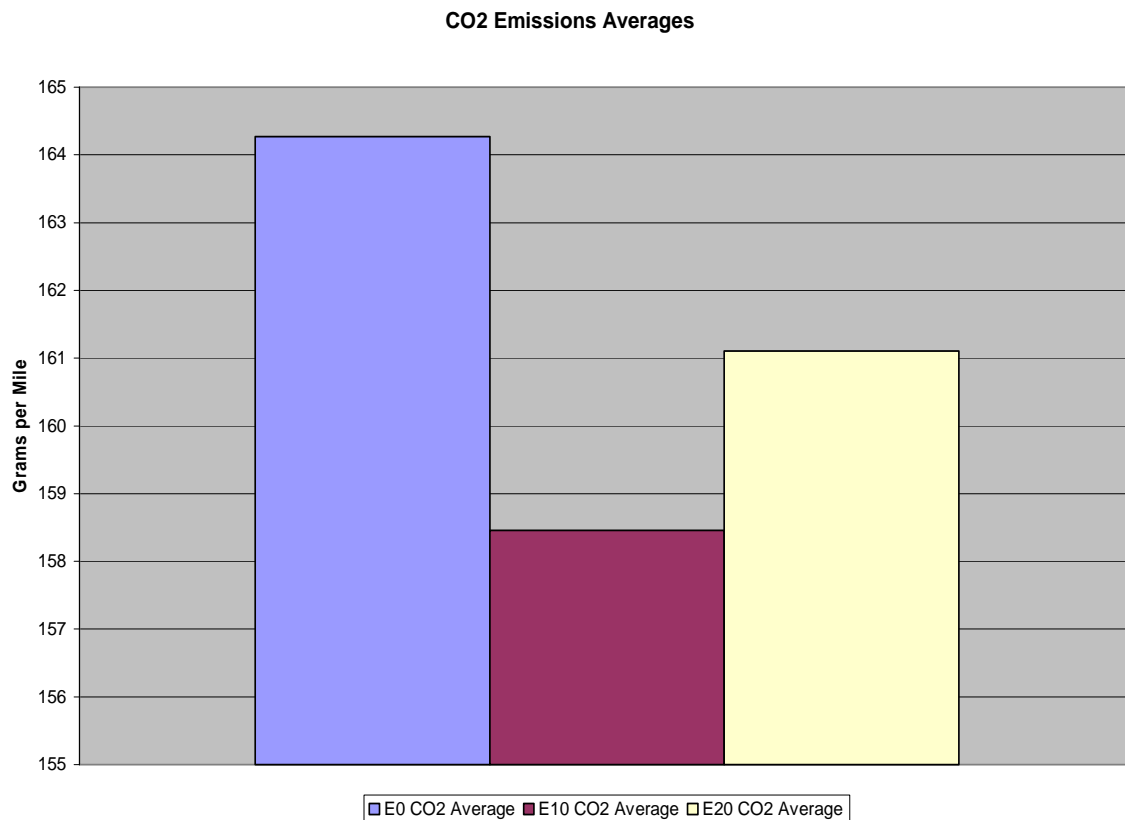


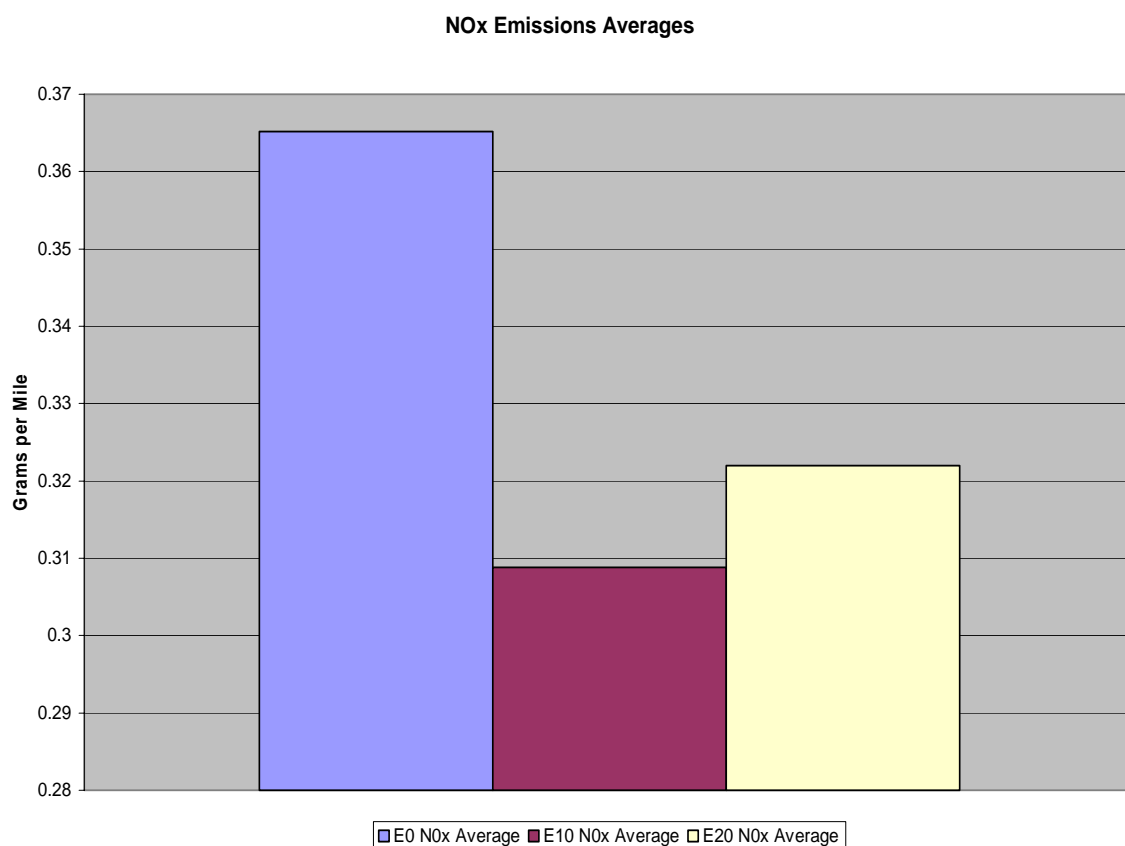
Figure 11 represents the carbon dioxide emissions averages for all three fuel blends. Unexpectedly the 0% ethanol fuel blend recorded the highest carbon dioxide emissions average at 164.27 grams per mile. The 10% ethanol fuel blend recorded the lowest average at 158.46 grams per mile. The 20% ethanol fuel blend carbon dioxide emissions average falls in between at 161.11 grams per mile. Although these results were unexpected the carbon dioxide emissions for the 20% ethanol fuel blend in question falls between the carbon dioxide emissions of both previously accepted fuels.

Figure 11: Carbon Dioxide Emissions Averages



Although the quantity of nitrogen oxides emissions are small compared to the other emissions recorded during testing they may be the most significant. Figure 12 shows the nitrogen oxides emissions averages for all three test fuels. These results follow the same trend seen in the carbon dioxide emissions averages. The 0% ethanol fuel blend recorded the highest nitrogen oxides emissions average at 0.365 grams per mile. The 10% ethanol fuel blend recorded the lowest average of 0.309 grams per mile, and the 20% ethanol fuel blend recorded an average nitrogen oxides emission of 0.322 grams per mile. This infers that the combustion temperatures for the 20% ethanol fuel blend falls between the combustion temperatures for 0% and 10% fuel blends.

Figure 12: Nitrogen Oxides Emissions Averages



The 20% ethanol fuel blend total hydrocarbon and carbon dioxide emissions were lower than 0% and 10% ethanol fuel blends. This is because of the extra oxygen introduced to the combustion process when ethanol is added to gasoline. It allows for a more complete burn that reduces the amount of harmful hydrocarbon and carbon monoxide emissions. Carbon dioxide and nitrogen oxides emissions for the 20% ethanol fuel blend were lower than the 0% ethanol fuel blend emissions and higher than the 10% ethanol fuel blend emissions. Most importantly the amount of nitrogen oxides emissions for the 20% ethanol fuel blend are in between the nitrogen oxides emissions of two widely accepted fuels.

CONCLUSION

The small increments in average lambda between fuel blends along with very little difference seen in the maximum and minimum lambda readings recording during each test run boasts positively for the use of 20% ethanol fuel blends.

The temperature data collected during testing shows no concerns related to the ethanol percentage of each fuel blend. Exhaust gas temperatures show very little variation between each fuel blend. Both the engine oil and coolant temperature averages for 20% ethanol are lower than the respective 0% and 10% fuel blend temperature averages. The temperature ranges recorded with all three fuel blends in these operating conditions do not pose any threat to premature engine component damage or wear.

The 20% ethanol fuel blend total hydrocarbon and carbon dioxide emissions were lower than 0% and 10% ethanol fuel blends. Carbon dioxide and nitrogen oxides emissions for the 20% ethanol fuel blend were lower than the 0% ethanol fuel blend emissions and higher than the 10% ethanol fuel blend emissions. With the use of 20%

ethanol harmful hydrocarbon and carbon monoxide emissions were reduced while the amount of nitrogen oxides emissions fell between the nitrogen oxides emissions of two widely accepted fuels.

There was no noticeable difference in engine performance throughout the testing process. Under the normal operating conditions seen during testing the 20% ethanol fuel blend performed well enough that it could be used interchangeably in this motorcycle with the other test fuels without concern.

FURTHER TESTING RECOMMENDATIONS

Continued testing of 20% ethanol fuel blends will need to be performed before it can be accepted for public use in motorcycles. There are concerns about the compatibility of 20% ethanol with some of the materials used in automobile fuel system and engine construction. Material compatibility testing would need to cover all materials used in these applications and show that the 20% ethanol is not significantly more corrosive than 10% ethanol fuel blends that are already accepted.

There are also concerns about drive ability characteristics of motorcycles running on 20% ethanol. The lower energy content of ethanol may cause drive ability issues such as hard starting, stalling, surging, hesitation, stumble, and backfires. Although none of these conditions appeared during testing with this motorcycle on the dyno more testing is needed. Testing would need to cover a large variety of motorcycle engine configurations and sizes in all weather conditions suitable for motorcycle riding. The test fuel would need to be compared to a baseline fuel using object feedback from riders oblivious to the fact they are testing different fuels.

Although this motorcycle performed very well using the 20% ethanol fuel blend under these operating conditions it is only one confined study performed on one motorcycle. Testing of other motorcycle engine sizes and configurations will still need to be performed. Higher performance, larger displacement, higher compression ratio, different cooling configuration, and cylinder configuration motorcycle engines will have different combustion characteristics and may encounter air to fuel and temperature problems with the use of 20% ethanol. In addition, this study did not address the performance of two-stroke engines used in a large number of off road motorcycles when fueled with 20% ethanol blended fuel.

For the best comparison true engine durability testing would need to be performed monitoring engine temperatures, air to fuel ratios, emissions, and in-cylinder combustion pressures under rigorous conditions. Almost all air to fuel ratio problems caused by 20% ethanol could be solved by changing jet size, ignition timing, and engine mapping parameters, but requiring the public to do so by only offering 20% ethanol at the fuel pumps may be unrealistic.

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APPENDIX

SUPERFLOW LOAD CELL CALLIBRATION

1. The test system and dyno cell should be at normal operating temperature.
Leave the test system power on for at least 15 minutes prior to performing a torque calibration.
2. Hang the calibration arm on the load cell, with the balance point in the center of the absorber (there is a notch cut in the top of the absorber box for this).
Make sure there is no weight on the calibration arm at this time.
3. Zero the Eddy Current Torque Channel using Windyn select “**Calibrate Channels**” from the main menu. A calibration dialog box appears. Scroll down the list until channel #2 (EcTrq1) appears and select it. Click on “**Zero**” and “**OK**”.
4. Put the three 20 lb weights that come with the dyno on the end of the 3-foot long calibration arm. The applied torque is then: $3 \text{ ft} \times 60 \text{ lbs} = 180 \text{ lb-ft}$.
Wait a few seconds for the arm to stabilize.
5. Click on “**Calibrate**”, enter the new value of 180 lb-ft. and click “**OK**” followed by “**Done**”.
6. The calibrated value should appear on the handheld and Windyn displays. If this is not so, there may be something binding or broken in the eddy current absorber or the load cell. Contact SuperFlow Customer Services for assistance.

7. Remove the calibration weights one at a time, let the reading stabilize each time, and check for linearity. The display should indicate 180 lb-ft, 120 lb-ft, and 60 lb-ft. Linearity should be better than ± 1 lb-ft of torque.

MNCAR EMISSIONS SYSTEM START UP PROCEDURE

- ___1. Turn on the **TRANSFORMER DISCONNECT** (mounted on north wall - labeled "**CD 1**")
- ___2. Turn on **CHASSIS DYNO PIT FAN** and wait 15 seconds (east wall – labeled "**CD 2**")
- ___3. Turn on **CHASSIS DYNO 120 VAC, D1** (after removing lock) (east wall – labeled "**CD 3**")
- ___4. Turn on **CHASSIS DYNO 480 VAC, D2** (after removing lock) (east wall – labeled "**CD 4**")
- ___5. Turn on the **CHASSIS DYNO PRINTER** (on desk).
- ___6. Turn on **DRIVER'S AID MONITOR** (on the driver's trace trolley).
- ___7. Turn on the **POWER SWITCH** and **OUTLET STRIP** inside the rear door of the **EMISSION CONSOLE**. (located in the upper right corner).
- ___8. Turn on **MAIN COMPUTER** at **EMISSION CONSOLE** – in about 45 seconds the **BOOT-UP MENU** will appear on monitor screens.
- ___9. Turn on main valve on Tank #1 Zero Air and Tank #2 H/He (regulators should be at approximately 40 PSI) (remember to fill out Tank Log Sheet).
- ___10. Check **OZONE** button on **NO_x ANALYZER** (it should be pushed in – red light should come on and – **NO/NO_x** will also be on with button pushed in).
- ___11. Select **FID IGNITE** from **BOOT-UP MENU** and **ENTER** -- wait several seconds – you will hear a click and then a pop sound at the **EMISSION CONSOLE** as the **FID** lights –after it heats up for 10-20 seconds, the red **IGNITE** light on the **HC ANALYZER** will come on indicating the **FID** is lit. If after 60 seconds, the **Ignite** button is not lit, repeat Step 12
NOTE: **FID** should be lit for at least 1 hour before analyzer is used.
- ___12. Turn on the **CHASSIS DYNO CELL** room ventilation system. [switch is on the NE corner of the **ENGINE TEST CELL** wall. Make sue it is set to **SUMMER** mode].

- ___13. Fill out the **EMISSION DYNO USAGE LOG** on the clipboard on the right side of the **EMISSION CONSOLE**.

MNCAR DILUTION BENCH BARO CALIBRATION PROCEDURE

Explanation: This procedure is to be used to calibrate the barometer on the Dilution Bench. You will be measuring the BP using the mercury barometer in the MnCAR lab and verifying that the emission system reads the correct values. Connect a Teflon line to the Baro Sensor port in the Dilution Bench. The Baro Sensor is located inside the left side door in the bottom left corner. Then connect the MeriCal and Vacuum Pump to the Teflon line with a “T”.

1. Read BP from the mercury barometer in the MnCAR lab.

Example:

$$\begin{array}{r}
 29.12 \quad @76 \text{ F} \\
 - .124 \quad (\text{Temperature Correction}) \\
 \hline
 29.996 \\
 - .004 \quad (\text{Latitude Correction}) \\
 \hline
 \mathbf{28.992}
 \end{array}$$

2. Go to **ANALOG CALIBRATION** on the Main Menu on the computer
3. Select **BARO**.
4. You will be asked what the **ENGINEERING UNITS** are.
5. The **ENGINEERING UNITS** for the first point will be $28.992 - 2.000 = 26.992$ “HG. (*FOR THIS EXAMPLE*)
6. On the **MeriCal** press the #4 key to set to Inches HG.
7. Apply 2.00” HG to the setup with the Vacuum Pump.
8. When the **MeriCal** value is 2.000”HG press the **ENTER** key.
9. Press **ACCEPT** on the computer keyboard.
10. Disconnect the pump.
11. You will be asked what the **ENGINEERING UNITS** are.
12. Enter 28.992 “HG. (*FOR THIS EXAMPLE*)

13. When the reading is stable press **ENTER**.

14. Press **E** for end.

15. **DEGREE OF EQUATION = 1**

16. **FORCE CURVE THROUGH 0 = No**

17. Press **ENTER**.

18. **STORE RESULTS** to C

MNCAR DILUTION BENCH INLET PRESSURE SENSOR CALIBRATION

PROCEDURE

Explanation: This procedure is to be used to calibrate the CVS Inlet Pressure Sensor on the Dilution Bench. Connect a Teflon line to the CVS Inlet Pressure Sensor port in the Dilution Bench. CVS Inlet Pressure Sensor is located on the Critical Flow Venturi inside the Dilution Bench cabinet. Then connect the MeriCal and Vacuum Pump to the Teflon line with a “T”.

1. Read BP from the mercury barometer in the MnCAR lab.

Example:

$$\begin{array}{r}
 29.13 \quad @76 \text{ F} \\
 - .124 \quad (\text{Temperature Correction}) \\
 \hline
 29.996 \\
 - .004 \quad (\text{Latitude Correction}) \\
 \hline
 \mathbf{28.992}
 \end{array}$$

2. Go to **ANALOG CALIBRATION** on the Main Menu
3. Select **CVS IP**.
4. You will be asked what the **ENGINEERING UNITS** are.
5. On the **MeriCal** press the #4 key to set to Inches HG.
6. Apply 2.00” HG to the setup with the Vacuum Pump.
7. The **ENGINEERING UNITS** for the first point will be $28.992 - 2.000 = 26.992$ “HG.
8. When the **MeriCal** value is 2.000”HG press the **ENTER** key.
9. Press **ACCEPT**
10. Disconnect the pump.
11. You will be asked what the **ENGINEERING UNITS** are.
12. Enter 28.992 “HG.
13. When the reading is stable press **ENTER**.
14. Press **E** for end.
15. **DEGREE OF EQUATION = 1**
16. **FORCE CURVE THROUGH 0 = No**

17. Press **ENTER**.

18. **STORE RESULTS** to C

MNCAR DILUTION BENCH INLET TEMPERATURE SENSOR CALIBRATION PROCEDURE

Explanation: This procedure is to be used to calibrate the CVS Inlet Temperature Sensor on the Dilution Bench. Connect Altec Model 222A to the CVS Inlet Temperature Sensor in the Dilution Bench. The CVS Inlet Temperature Sensor is located on the Critical Flow Venturi inside the Dilution Bench cabinet.

1. Go to **ANALOG CALIBRATION** on the Main Menu
2. Select Channel 10, **CVS IT**.
3. You will be asked what the **ENGINEERING UNITS** are.
4. Set the Altec Model 222A to **SOURCE** mode.
5. Set temperature value to 60 F.
6. The **ENGINEERING UNITS** for the first point will be 60 F.
7. When the value is 60 F press the **ENTER** key.
8. Press **ACCEPT**
9. Repeat steps 3 – 8 for temperatures of 20 F increments until you reach 180 F.
10. For the 200 F point conduct steps 3-7.
11. When asked if you want to **ACCEPT, REPEAT or END**, type E for End.
12. **DEGREE OF EQUATION** = 2nd
13. **FORCE CURVE THROUGH 0** = No
14. Press **ENTER**.
15. **STORE RESULTS** to C

MNCAR EMISSIONS SYSTEM POTENTIOMETER ZERO / SPAN

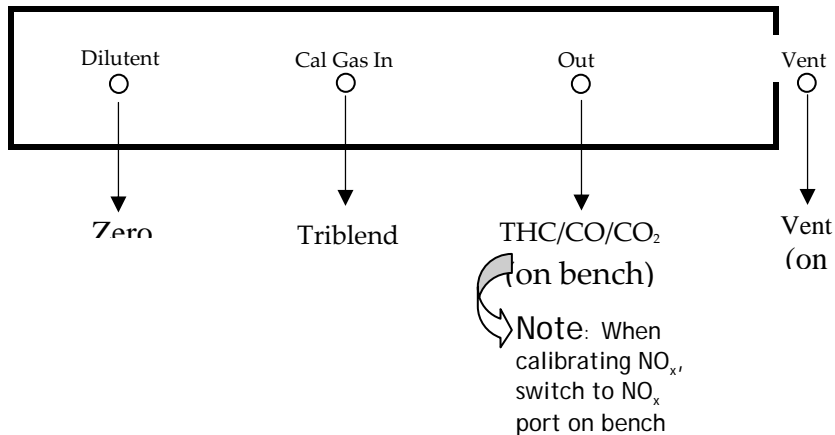
Description: This procedure is used to set the Zero and Span points of the calibration curve before an analyzer calibration or emission test is conducted.

The procedure involves isolating the analyzers from the computer stored calibration curves so the Zero and Span points can be set. With the analyzers isolated, Zero Air or the selected Calibration Gas is flowed through the analyzer and the potentiometers on the front panel are adjusted until the readout of each analyzer matches the appropriate value on the bottle. This procedure matches the Zero and Span points of each analyzer with the correct electrical output that will be sent to the computer.



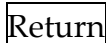


1. Get to test screen. (The screen that has the Driver's Trace)
2. Type **SHIFT** + **F 3** -- No zero span at bottom of screen will turn yellow. This takes the computer zero offset compensation away so it does not try to correct.
3. Type **F 2** with THC and NO_x knobs set on range 1 – adjust zero pots to zero. This is to be done for each analyzer (HC, CO, CO₂, and NO_x)
4. Type **F 3** set both THC and NO_x knobs on range 2 and adjust span pots to match bottle value. This is to be done for each analyzer (HC, CO, CO₂, and NO_x)
5. Type **F 5** – Low range to high range correlation. Set THC and NO_x knobs to Range 6
6. **DO NOT** adjust pots....just verify that values you are reading are close to low range on bottles. You are flowing the Range 1 gas through the system and measuring it on Range 2. This is a check of the linearity of the analyzer's measurements from Zero to Span. The value on each analyzer should be within 10% of the bottle value.

MNCAR EMISSIONS SYSTEM ANALOG CALIBRATION

Requirements → Calibration Cart → 30 minute warm-up
 Zero Air Bottle
 Triblend



*Select Analog calibration from Menu

1. 
2. Channel select
3. 
4. 
5.  
6. Type in value that corresponds to the tank value. **IMPORTANT!** For HC calibration multiply the tank value by 3 for engineering units. i.e. for our bottles:
 $148 \times 3 = 444 \text{ ppm}$
 $599 \times 3 = 1797 \text{ ppm}$
7. Zero – Set range on gas divider to 0% and adjust pot to read 0 on X value.

8. Span – Set range on gas divider to 100% and adjust pot to read the correct % on full scale.

Example: for HC range 2 with 599 ppm in bottle

Engineering units = $599 \times 3 = 1797$

at 100% of full scale then:

$$(1797-2000) \div 2000 = -.1015 + 1 = .8985 \times 100 = \boxed{89.85\%}$$

9. Back to zero and hit **ENTER** when you are at zero.
10. **A** to accept zero.
11. Hit **ENTER**
12. Next point 179 ppm or 10% on gas divider
13. Next point 179 ppm or 20% on gas divider
14. Continue each point on gas divider calculating the engineering value based on the percent point of full range.

*If not correct hit **R** for retry

*If calibration is incorrect it could be due to - drift in span
 - divider cart problem
 - analyzer

15. When you do the last point (10) and accept the value, type **E** for end.
16. You have a choice in the degree of equation from 1 to 4. the smaller the better. HC should be 1 but CO₂ will be higher.
17. Forcing the curve through Point (0,0) is optional.
18. The percent difference must be $\pm 2\%$ of each of the 10 points. If not, change the degree of the equation.

19. Once the fall into, $\pm 2\%$ type 5 for store and select the "C" drive.
20. Do for all other gasses.

MNCAR EMISSIONS SYSTEM PROPANE VERIFICATION TEST

Description: This test uses a calibration grade propane bottle that is 99.5% propane. Propane is injected into the system while you are in the test mode and the bench compares the value it measures with the known value of the gas. The readings must be within 5% of the known value to pass this test.

Setup: Attach the stainless steel braided hose with the round "fogger" end to the propane verification cart (PVC) and place the round end in the sample hose

Steps:

1. From the **Main Menu** select **Zero/Span Calibration** and hit **Enter**.
2. Follow the instructions on the screen. If you get a "Bad Calibration" message, stop at this point and get Dr. Jones. You will not be able to proceed.
3. After completing the **Zero/Span Calibration**, set the FID to "Range 2"
4. Zero the large orifice pressure gauge on the front of the PVC.
5. Turn the gas bottle and regulator on in the bottom of the PVC and make sure the regulator is set to 60 psi.
6. Install braided propane hose into "Propane Out" port on PVC and place the other end into the sample hose.
7. Select **Run Dat42EIM** from main menu.
8. Select **Run ETC42EIM** from next screen.

9. Select **N** in response to Motorcycle question
10. Select **N** in response to ASM test question.
11. Select **Y** in response to inertia weight question.
12. Hit the left arrow to select the test # showing in upper left of screen.
13. Scroll through test options using the “up and down arrow keys” and select **PRP Trace**.
14. Select **One Bag**
(NEXT PAGE)
15. Select **Auto**
16. Scroll through test fuels and select **LPG**
17. Hit the “left arrow” key until the blower starts.
18. After the **READY** message is on the test screen turn the propane knob on located in the upper right corner of the PVC.
19. Adjust pressure to 27 psi for the 350 cfm venturi and 65 psi for the 700 cfm venturi.
20. Wait 5 minutes making fine adjustments to the pressure.
21. Hit the pendent button to begin the test.
22. The actual test takes 60 seconds, but there is another 20-second test after due to the 20-second modal response time.
23. After the 20 second test turn the propane off.
24. To end the test hit the “up arrow” key.
25. Answer the questions on the screen. The BP will be a value already on the screen approximately 700 (just hit enter). Enter the temperature from the display on the PVC. The gauge pressure will be the value from the PVC (should be 27 psi with 350 cfm venturi or 65 with the 700 cfm venturi).
26. After you enter the gauge psi the results will be analyzed and printed out.

27. The values should be less than +/- 5%. If the values are not in range either repeat the test or get Dr. Jones.
28. Turn the gas bottle off on the PVC.
29. Remove hose and put in the bottom of the PVC.

MNCAR EMISSIONS SYSTEM TEST SET-UP PROCEDURE

Complete START-UP and WARM-UP PROCEDURES and be sure the FID has been on for 1 hour.

FROM BOOT-UP MENU

1. Select RETURN TO MAIN MENU and ENTER .
2. The MONITOR will respond with the MAIN MENU. Select START VEHICLE TEST and ENTER . The ROLL LIFT on the CHASSIS DYNO ROLLS will come up and the monitor screen will say

DRIVE VEHICLE ONTO ROLLS
PRESS PENDANT WHEN FINISHED

3. Drive the vehicle onto the rolls unless you are doing a FTP test with a cold start and press the BLACK BUTTON on the yellow handled PENDANT (on the DRIVER'S AID COMPUTER stand). This will lower the ROLL LIFT. The MONITOR will now say

CENTER VEHICLE ON ROLLS
PRESS ENTER WHEN FINISHED?

Start the vehicle, put in low gear and drive at 3-5 mph for 5-10 seconds unless you are doing a FTP test with a cold start. This centers the car on the rolls. Then place the wheel chocks firmly under the non-drive wheels, chain down (FWD = cross chained and loose) and press ENTER on the KEYBOARD.

IMPORTANT NOTE: Do not use the F5, F6, or ESC keys as indicated on the MONITOR for Steps 4-7.

4. The MONITOR will ask you to select a passenger vehicle or one of two truck weight categories. Select your choice and then ENTER .
5. The MONITOR will ask you to select the year. Do not select a year later than 1996. If the vehicle is newer than 1996, select 1996. Select your choice and then ENTER .
6. The MONITOR will now ask you to select the make of the vehicle. Select your choice and ENTER .
7. The MONITOR will now ask you to select the model. Select your choice and ENTER .
8. Enter all the requested data for your vehicle and then F10 when done.

NOTE:

If it has been more than 72 hours since the last full gas calibration, the MONITOR will ask

DO YOU WANT TO DO A GAS CALIBRATION (Y or N)? N

Type Y ENTER

NOTE:

If you are doing a full gas calibration the MONITOR will say

TURN ON ALL THE CALIBRATION CYLINDERS ON
PLEASE
PRESS ENTER WHEN TURNED?

Turn on tanks #3, 4, 5 and 6(1 and 2 are already on). Remember to record all tank pressures and also check to see that the regulator pressures are near 40 PSI. Then hit ENTER

The MONITOR will now respond with

SET FID TO RANGE 2
SET CLD TO RANGE 2

Do this using the same knobs as in Step 10. This will span analyzers in the high range.

After 30 seconds, the MONITOR will respond with

SET FID TO RANGE 1
SET CLD TO RANGE 1

Once again turn the two knobs to Range 1. This will span the analyzers in the low range. This will again take 30 seconds.

9. The MONITOR SCREEN will now ask you to

SET FID TO RANGE 2
SET CLD TO RANGE 2

Do this using the rotary switches on the HC and Nox ANALYZERS. This zeros the Analyzers in the high range.

10. After 30 seconds the MONITOR screen will ask you to

SET FID TO RANGE 1
SET CLD TO RANGE 1

Do this using the same knobs as in Step 9. This zeros the analyzers in the low range.

11. After 30 seconds the MONITOR will respond with

MOTORCYCLE (Y or N)?

Type Y only if you are going to test a motorcycle, or N if you are going to test a car or truck, then ENTER .

12. After 30 seconds the MONITOR will respond with

ASM TEST (Y or N)?

Type Y only if you are going to conduct an ASM Test. If you are going to run a test other than ASM, type N, then ENTER .

13. Monitor will respond with

USE EPA INERTIA WEIGHT AND HORSEPOWER (Y or N)?

ENTER TYPE Y if the vehicle is 1996 or older and then hit

ENTER TYPE N if the vehicle is 1997 or newer then hit

You will then be asked to enter the INTERTIA WEIGHT and ROAD HORSEPOWER. You will need to find those values for the vehicle you are testing and enter them in.

14. Monitor will respond with the DRIVER TRACE screen.
15. Place EXHAUST SAMPLE HOSE in holder 4 feet above ground for Ambient Air Sample.
16. TN = _____ will be highlighted near the top of the screen to indicate the test number. Use the _____ to select.
17. EPA HWC.TRC will be highlighted.

Choices: 35. TRC
 \ 65. TRC
 HWC.TRC
 IM2.TRC
 LA4.TRC
 PRP.TRC
 ASM.TRC
 HDV.TRC

Choose: Scroll through the choices using the _____ keys until the test you want to conduct is highlighted. Hit _____ to select.

18. CT93 .IM2 will be highlighted.

Choices: IM240 .IM
 IM240 + BG .IM2
 IM240ZS .IM2
 RI95 .IM2
 ZSA240B .IM2
 ZSA240MB .IM2
 CT93 .IM2

Choose: Scroll through the choices using the _____ keys until the test you want to conduct is highlighted. Hit _____ to select.

19. AUTO .I_2 will be highlighted.

Choices: EIM .I_2
(blank)
AUTO .I_2

Choose: EIM .I_2 for manual transmission vehicles and
to select.

(or)
AUTO .I_2 for automatic transmission vehicle
and to select.

20. GASOLINE will be highlighted.

Choices: LPG
M-85
CNG
INDOLENE
DIESEL
M16
M50
E10
E30
E85
GM03
GM04
GM05
GM06
GM07
GM08
GM09
22DMB
M10
GASOLINE

Choose: Highlight the fuel you are using and to select.

21. IW = _ _ _ _ HPr = _ _ . _ will be highlighted. Change only if
needed and then to select.

IMPORTANT NOTICE: On Step 22 use the ENTER key to change lines of the vehicle information in the center of the screen. There is a small rectangular icon that moves to each line. Each time you ENTER you will be moved down the list. At the bottom you will return to the top.

Much of the data will already be entered there will be nothing entered for VEH. REF. #, INSP, OWNER, or REMARKS. To enter this data type in a VEH. REF. # and ENTER . This will clear all the entries except the INERTIA WET and TRLHP SET. Now, fill out the data requested in each area and use the ENTER key to move to the next area.

NOTE: Only the ENTER key works here – the arrow or other keyboard functions will not work.

22. On the left side of the MONITOR screen you will see a list which will include:

VEH. REF. # :
 V.I.N. :
 PLATE # :
 INSP :
 MAKE:
 MODEL :
 YEAR :
 GVWR :
 ODOMETER :
 TRANS :
 CYLINDERS :
 EPA REF :
 OWNER :
 REMARKS :
 INERTIA WET :
 TRLHP SET :

23. Hz DATA will be highlighted.

Choices: No Data
 Hz DATA

Choose: Hz DATA and to select.

24. The EXHAUST FAN will start, then stop then start; screen will say LOW FLOW in a red box and WAIT. LOW FLOW box will go out and Ambient Air Sample will be taken the WAIT will turn to READY.

25. Place EXHAUST SAMPLE HOSE over the vehicle tailpipe.

26. Start and warm up the vehicle (be sure cooling fans are on). Do not start vehicle if you are doing a FTP test with a cold start.

Suggestion: run at 30 MPH for 60 seconds and then return to idle.

27. Sit in vehicle; adjust location of DRIVER AID MONITOR.
28. Push button on yellow Driver SWITCH to begin test.
29. The DRIVER'S TRACE on the DRIVER AID MONITOR will begin to move. Drive the vehicle to follow the trace.
30. When test ends turn off vehicle, go to EMISSION CONSOLE and to end test. The results will print out and the MONITOR will return to the MAIN MENU.
31. If you are making more than one test, choose RUN DAT42EIM and hit ENTER .
32. Select Run ETC42EIM and hit ENTER .
33. You are now at Step 11