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DURABILITY OF LOW-EMISSIONS SMALL OFF-ROAD ENGINES

Prepared by

Chad C. Lela
Jeff J. White

INTERIM REPORT

Prepared for

CALIFORNIA AIR RESOURCES BOARD
Mobile Sources Operations Division
9528 Telstar Ave.
El Monte, CA 91731

May 30, 2003

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6220 Culebra Road P.O. Drawer 28510
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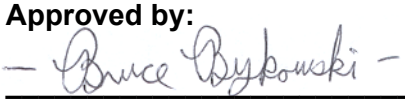

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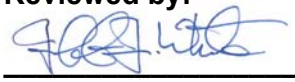

Jeff J. White, Manager

DEPARTMENT OF EMISSIONS RESEARCH
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MECA-member catalyst companies supplying samples for the engines.

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LIST OF ABBREVIATIONS

Appl	Application
BS	Brake-Specific
BSLN	Baseline
CARB	California Air Resources Board
CO	Carbon monoxide
CO_2	Carbon dioxide
CPSI	Cells per square inch
CVS	Constant Volume Sampling
DER	Department of Emissions Research at Southwest Research Institute
EGO	Exhaust Gas Oxygen sensor
FID	Flame Ionization Detector
GEN	Generator
G	Grams
HC	Hydrocarbons
Hr	Hour
hp	Horsepower
MECA	Manufacturers of Emission Controls Association
Mfg	Manufacturer
mm	Millimeter
NDIR	Non-Dispersive Infrared
NH_3	Ammonia
NO_x	Oxides of nitrogen
OPEI	Outdoor Power Equipment Institute
O_2	Oxygen
PII	California Phase II gasoline
RPM	Revolutions per minute
SAI	Secondary air injection or secondary air induction
SORE	Small Off-Road Engine
TWC	Three-Way Catalyst
WBM	Walk-Behind Mower

I. INTRODUCTION

The California Air Resources Board (CARB) contracted with Southwest Research Institute (SwRI®) to demonstrate useful-life durability of six low-emission developed small off-road engines (SORE). SOREs are a relatively high source of hydrocarbon pollutants in California producing approximately 85 tons per day[1].

The objective of this program was to develop six non-handheld SOREs in low-emission configurations, and then age the engines through their useful life. Four of the engines are used in walk-behind mower (WBM) applications, one is used in a riding mower, and one is used in constant-speed/generator applications. The goal was to reduce the tailpipe-out hydrocarbon (HC) plus oxides of nitrogen (NO_x) emissions to 50% or less of the current useful life standard of 12 $^{g}/_{hp\text{-}hr}$ for Class I engines, or 10 $^{g}/_{hp\text{-}hr}$ for Class II engines. Low-emission engines were developed using three-way catalytic converters, passive secondary-air induction (SAI) systems, and enleanment, when needed. Catalysts were provided by members of the Manufacturers of Emission Controls Association (MECA).

Evaporative emission reduction technologies were also evaluated on two SOREs. The goal was to reduce evaporative emissions by incorporating low-permeation fuel delivery components and pressure relief systems.

[1] Salardino, D., "Small Engine Workshop" Presentation, California Air Resources Board, Nov. 13, 2002.

II. DESCRIPTION OF PROGRAM

A. Project Engines

Six engines meeting current Tier II standards were selected by CARB, based on application and market share information. Table 1 lists the engines tested in the program. All engines are naturally aspirated, air-cooled, four-stroke, carbureted engines with an overhead valve train. All engines, with the exception of the Kawasaki, are single cylinder.

Originally, two identical Briggs and Stratton Intek engines were selected so that a comparison could be made between a high-loaded and a low-loaded catalyst for the same engine calibration. The needed catalysts, however, were not available in time to perform this experiment. Therefore, the second Briggs and Stratton engine was developed separately from the first engine, with an alternative catalyst and a more refined passive SAI system. Engines tested are shown in Figures 1-4.

TABLE 1. PROJECT ENGINES

Engine No.	Class	Mfg.	Appl.	Family/Model	Displacement, cc	Rated Power, hp
1	I	Briggs	WBM	YBSXS.1901VE Intek	190	6.5
2	I	Briggs	WBM	YBSXS.1901VE Intek	190	6.5
3	I	Tecumseh	WBM	YTPXS.1951AA OVRM 120	195	6.5
4	I	Honda	WBM	2HNXS.1611AK GCV160	160	5.5
5	II	Kawasaki	Rider	YKAX6752QA FH601V	675	19
6	II	Honda	GEN	2HNXS.3892AK GX-340QA2	340	11

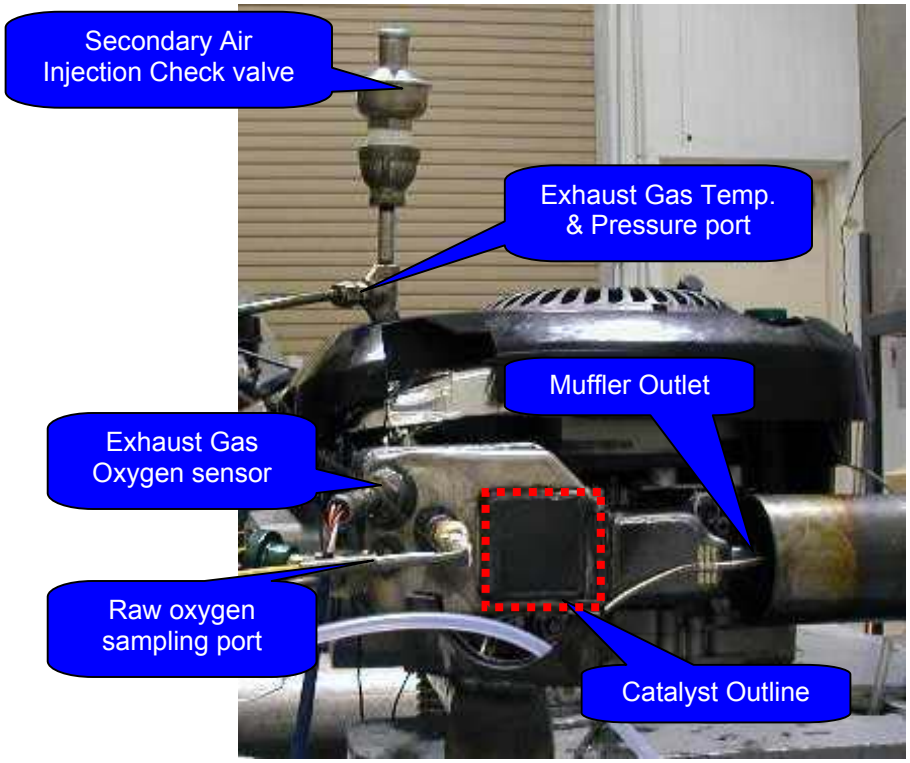

FIGURE 1. BRIGGS AND STRATTON ENGINE NO.1 WITH CATALYST C INTEGRATED IN MUFFLER

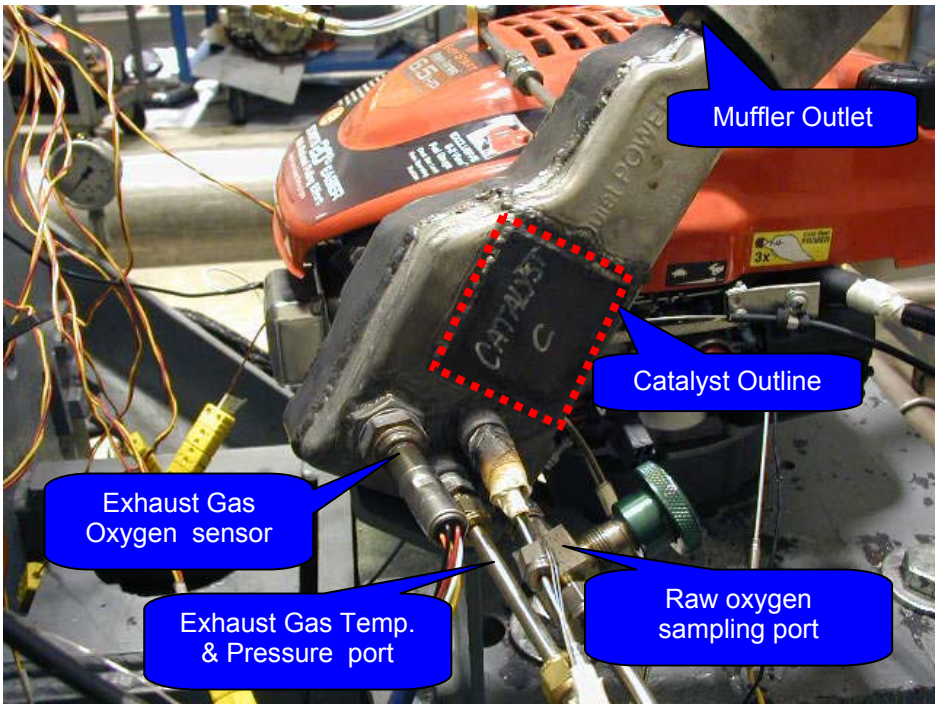

FIGURE 2. TECUMSEH OVRM120 ENGINE WITH CATALYST C INTEGRATED IN MUFFLER

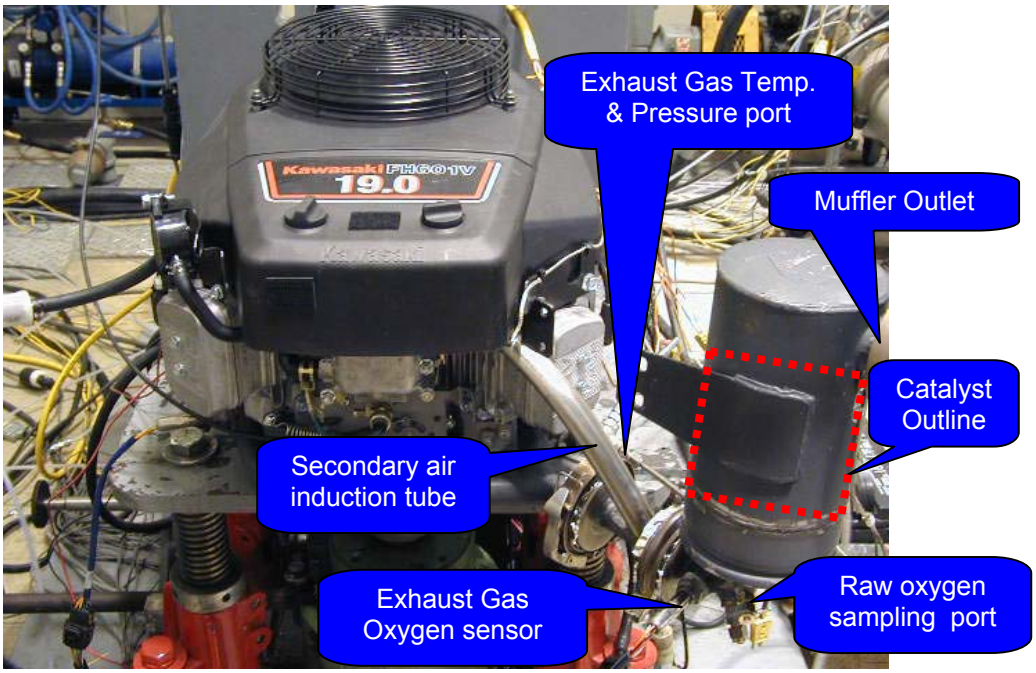

FIGURE 3. KAWASAKI FH601V ENGINE WITH CATALYST E INTEGRATED IN MUFFLER

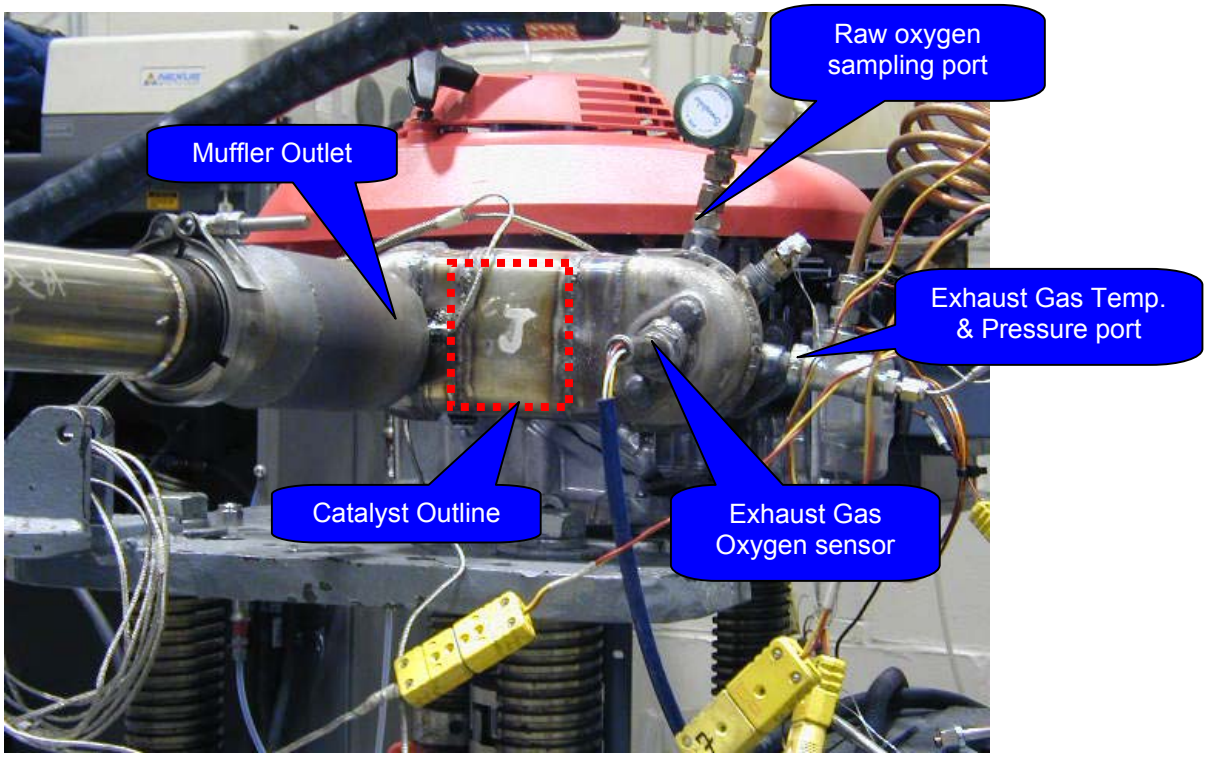

FIGURE 4. HONDA GCV160 ENGINE WITH CATALYST J INTEGRATED IN MUFFLER

Table 2 outlines the test cycle for the Class I walk-behind mower engines, which use an intermediate speed of 3060 RPM for testing. Table 3 outlines the duty cycle for generator engines, which run at a rated speed of 3600 RPM with no idle mode. For this program, the Briggs and Stratton engines used a 5-mode cycle with an intermediate speed of 3060 RPM consistent with manufacturers' certification procedures, as shown in Table 4.

TABLE 2. CARB 6-MODE SORE TEST CYCLE (TECUMSEH OVRM120, HONDA GCV160, AND KAWASAKI FH601V)

	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6
Speed (% rated)	85	85	85	85	85	Idle
Load (%)	100	75	50	25	10	0
Weight Factor (%)	9	20	29	30	7	5

TABLE 3. CARB 5-MODE GENERATOR TEST CYCLE (HONDA GX340)

	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
Speed (% rated)	100	100	100	100	100
Load (%)	100	75	50	25	10
Weight Factor (%)	9	21	31	32	7

TABLE 4. TEST CYCLE USED FOR BRIGGS AND STRATTON ENGINES

	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
Speed (% rated)	85	85	85	85	85
Load (%)	100	75	50	25	10
Weight Factor (%)	9	21	31	32	7

Engines were operated repetitively using the above test cycles to age the engines through their useful life. Durability modes were run based on the modal weight percentage over one-hour. The Briggs and Stratton, Tecumseh, and Honda GCV160 engines were aged 250 hours with emissions testing performed at 0, 125, and 250 hours. The Kawasaki and Honda GX340 engines were aged 500 hours with emissions testing at 0, 125, 250, and 500 hours.

B. Project Catalysts

At the beginning of the program, participating MECA members were each assigned an engine for which they were to provide a three-way catalyst (TWC). Catalysts were chosen by manufacturers based on prior small off-road engine experience, program objectives, and data specific to each engine. Actual test data, including exhaust temperatures, baseline air-fuel ratios, and mass emission rates were not available at the time of catalyst selection. Table 5 outlines the catalysts that were

used in final, developed configurations. All catalysts are of three-way formulation with metallic substrates. An attempt has been made to integrate all of the catalysts in modified stock mufflers for their respective engines. Figures 5-10 show the selected catalysts.

TABLE 5. CATALYSTS USED IN FINAL DEVELOPMENT CONFIGURATIONS FOR SMALL OFF-ROAD ENGINES

Engine	Catalyst ID	Diameter, mm	Length, mm	Cell Density, cpsi
Briggs and Stratton No. 1	C	60.0	50.8	200
Tecumseh OVRM120	C	60.0	50.8	200
Kawasaki FH601V	E	118	115	400
Honda GCV160	J	60.0	50.8	400

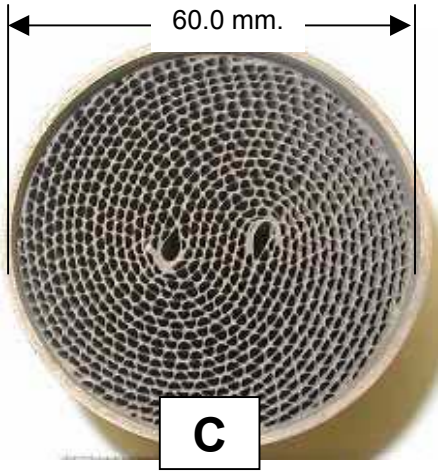

FIGURE 5. CATALYST C (CROSS-SECTIONAL VIEW)

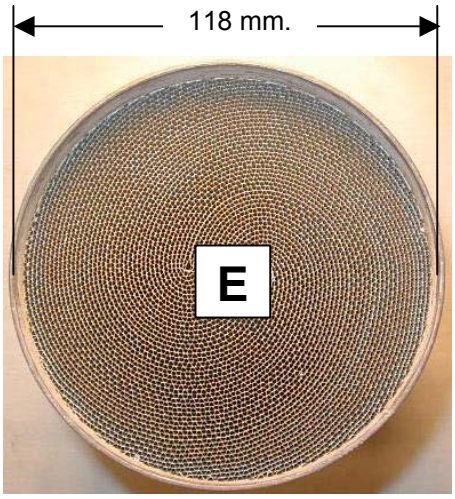

FIGURE 6. CATALYST E (CROSS-SECTIONAL VIEW)

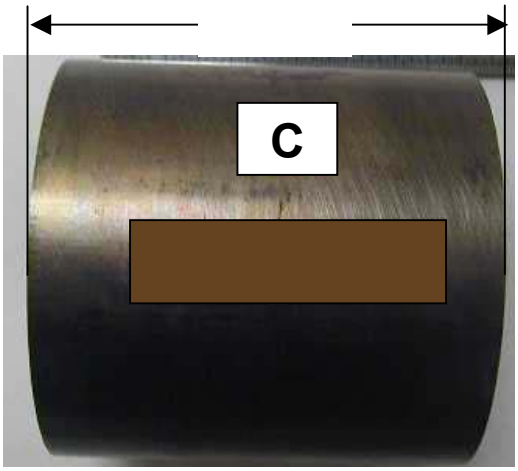

FIGURE 7. CATALYST C (AXIAL VIEW)

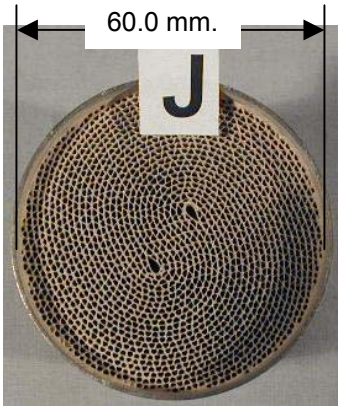

FIGURE 8. CATALYST J (CROSS-SECTIONAL VIEW)

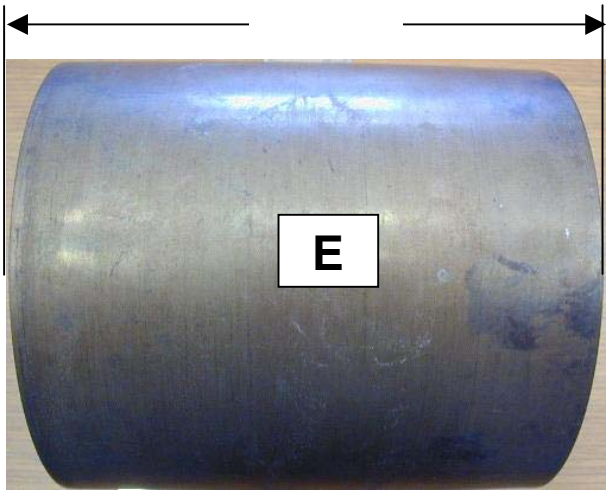

FIGURE 9. CATALYST E (AXIAL VIEW)

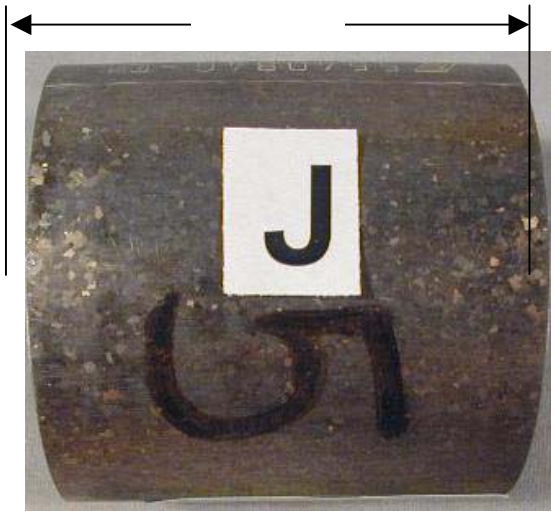

FIGURE 10. CATALYST J (AXIAL VIEW)

C. Exhaust Emissions Development

Emissions development was performed in several steps. After an engine was run-in for two-hours and baseline emission tested, a suitable catalyst was coupled to the engine to observe the performance of the system with “bolt-on” aftertreatment. Next, a controlled amount of air was injected into the exhaust system upstream of the catalyst. Since these engines all employ rich, base calibrations, additional air is needed to achieve the target HC reduction level. If the catalyst was able to meet the emission reduction target, a passive secondary-air induction system was developed.

The passive SAI system used the venturi principle to add supplemental air upstream of the catalyst, without connection to an external air supply. A schematic of the passive SAI system is shown in Figure 11. Similar SAI systems were incorporated on the Tecumseh, Kawasaki, and Honda GCV160 engines. The SAI system is designed to capture air circulated above the engine from the flywheel impeller, and direct it into the exhaust pipe through the use of a transfer tube and dampening chamber. The dampening chamber traps exhaust that escapes the SAI orifices, and allows it to be mixed with fresh air from the flywheel impeller, thereby redirecting it into the exhaust. To reduce exhaust scavenging through the orifices, a venturi is designed into the pipe to create a low-pressure region. Figure 12 shows the SAI system on the Tecumseh engine.

For the Kawasaki and first Briggs and Stratton engines, sufficient emission reductions were not achievable with baseline engine calibrations because the engines were running too rich. These engines were conservatively enleaned to achieve higher catalyst performance, adhering to manufacturer recommended guidelines for safe operation. Figure 13 shows the zero-hour air-fuel ratio profiles of the five engines tested to date in baseline and low-emission developed configurations. No enleanment was performed on the Tecumseh or Honda GCV160 engines.

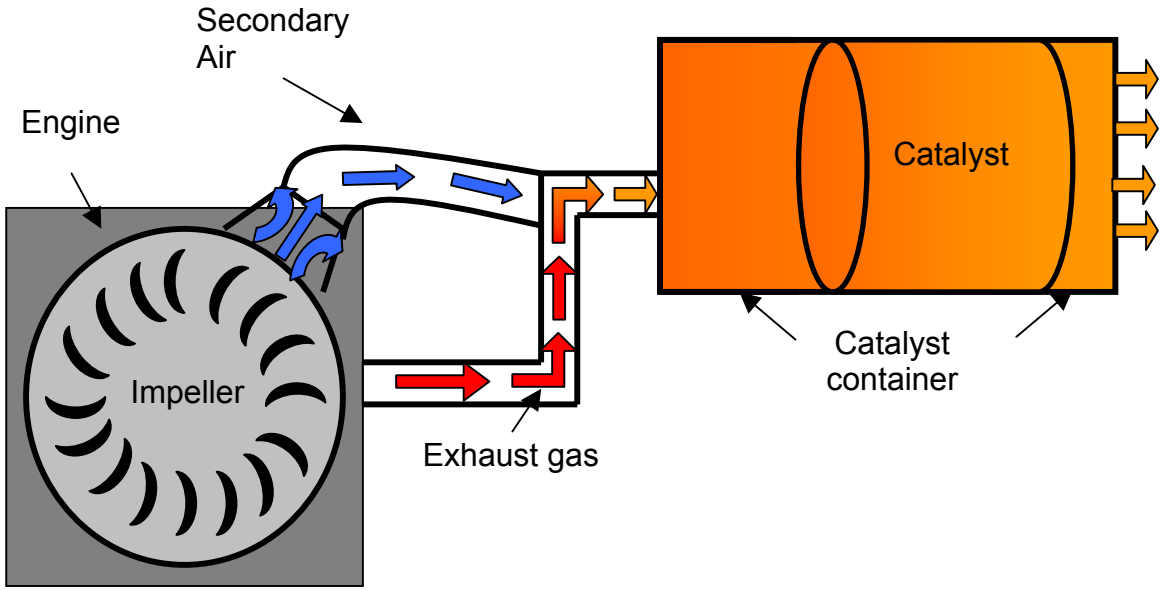

FIGURE 11. SCHEMATIC OF DEVELOPED PASSIVE SAI

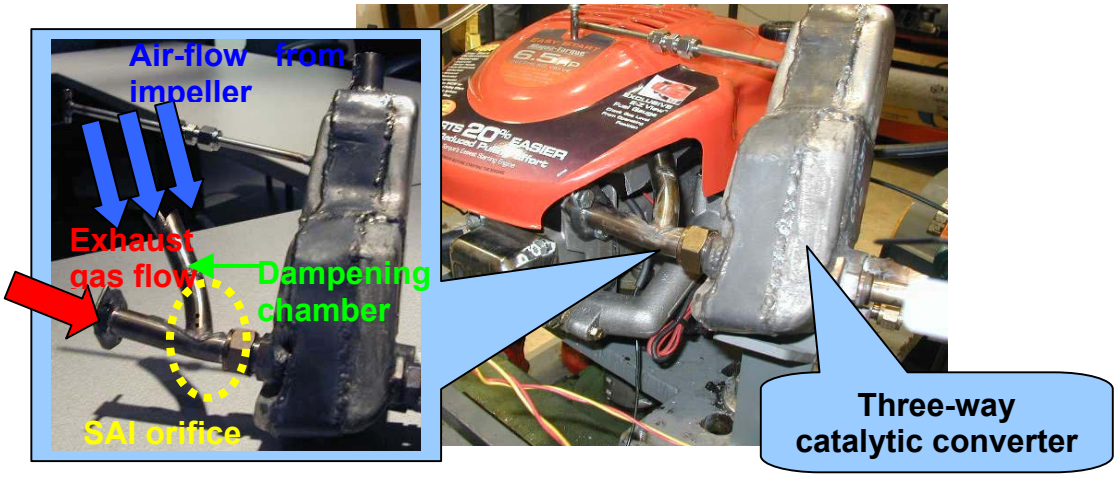

FIGURE 12. PASSIVE SAI SYSTEM ON TECUMSEH OVRM120 ENGINE

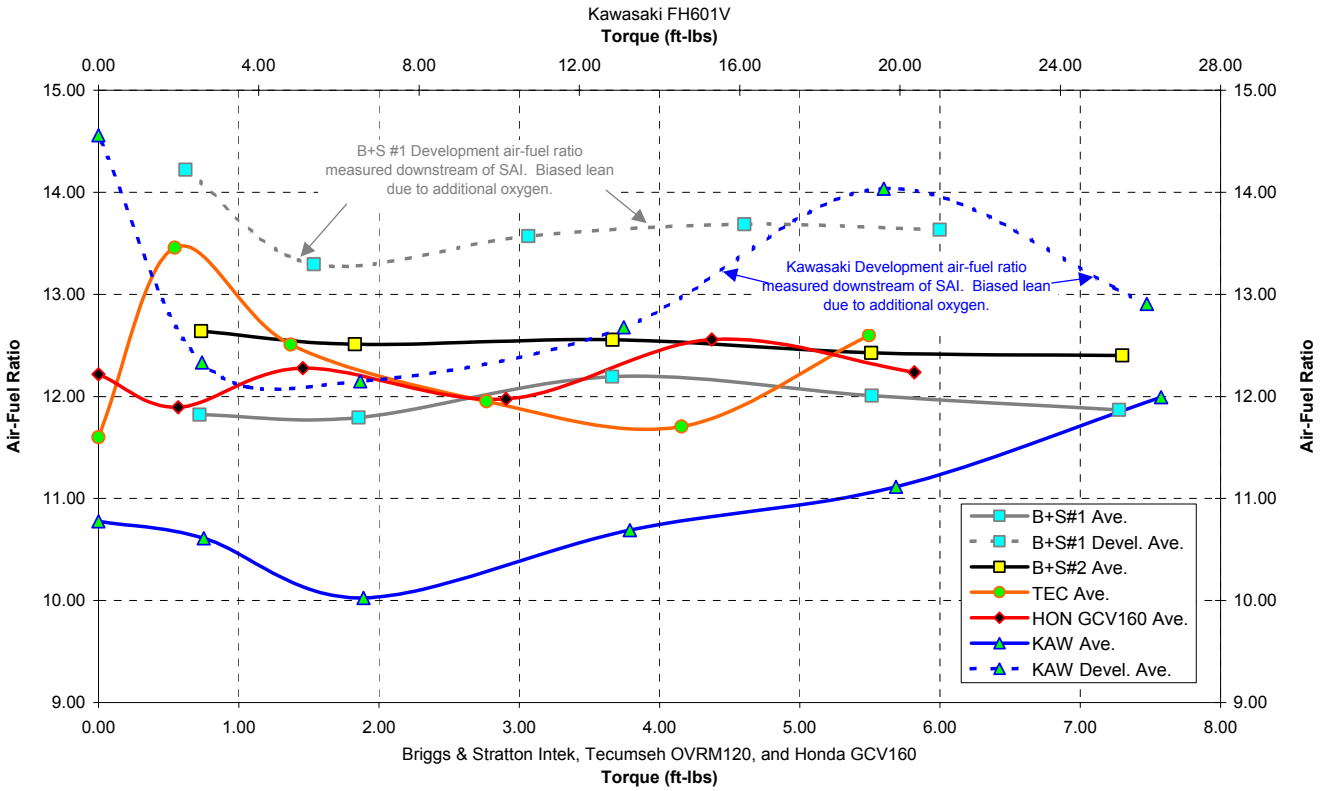

FIGURE 13. AVERAGE BASELINE AIR-FUEL RATIOS OF SMALL OFF-ROAD ENGINES

D. Emissions Testing

Emissions testing was performed on the Department of Emissions Research (DER) small off-road engine test stand. It includes a 20-hp eddy-current dynamometer on a movable stand that can accommodate both horizontal and vertical-shaft engines. Emissions measurement was performed using a Horiba MEXA 7200D emissions bench. Hydrocarbon emissions were measured using a multi-range heated flame ionization detector (HFID), oxides of nitrogen (NO_x) were measured using a chemiluminescent analyzer, and carbon monoxide (CO) and carbon dioxide (CO_2) emissions were measured using non-dispersive infrared analyzers (NDIR). Exhaust was collected using an 8-inch dilution tunnel with bag sampling of diluted exhaust. Bags were sampled after each mode.

All emissions testing was performed with the same batch of California Phase II gasoline. Table 6 presents the properties of the fuel used.

TABLE 6. CALIFORNIA PHASE II GASOLINE FUEL PROPERTIES (EM-4749-F)

Fuel Property	Method	Phase II RFG
Specific Gravity	ASTM D4052	0.7383
Aromatics, vol.%	ASTM D1319	23.9
Olefins		4.8
Saturates		60.4
Carbon, wt.%	ASTM D5291	84.29
Hydrogen, wt.%		13.31
Nitrogen Content (ppm)	ASTM D4629	4.9
RON	ASTM D2699	96.6
MON	ASTM D2700	87.5
Oxygenates	ASTM D4815	
tBa-vol%		0.06
tBa-wt%		0.06
MTBE-vol%		10.82
MTBE-wt%		10.95
Distillation, ^{o}F	ASTM D86	
IBP		101
10%		136
20%		155
30%		171
40%		187
50%		205
60%		223
70%		241
80%		263
90%		298
FBP		377
Recovery, %		96.5
Residue, %		1.0
Loss, %		2.5

The Briggs and Stratton, Tecumseh, and Kawasaki user manuals recommend 30W engine oil for operation in the temperature range observed in the laboratory. For consistency, Briggs and Stratton 30W engine oil was used in these engines. The Honda engines were lubricated using a multi-grade oil, as specified in the user manuals. Table 7 shows the properties of the Briggs and Stratton and multi-grade oils.

TABLE 7. ENGINE OIL PROPERTIES

Oil Property	Method	Briggs and Stratton 30W engine oil	Castrol GTX 10W30 engine oil*
Specific Gravity	ASTM D4052	0.88	
Viscosity @ 25 °C, cSt	ASTM D455	202.16	
Viscosity @ 40 °C, cSt	ASTM D455	85.78	
Viscosity @ 100 °C, cSt	ASTM D455	11.00	
Flash Point, °C (open cup)	ASTM D92	230	
Total Base Number	ASTM D4739	6.53	
Total Acid Number	ASTM D664	1.39	
Carbon, mass % Hydrogen, mass %	ASTM D5291	85.09 13.42	
Ba, ppm Ca, ppm Mg, ppm Mn, ppm Na, ppm P, ppm Zn, ppm	ASTM D5185	<1 1231 419 <1 516 986 1038	
Distillation by GC, °C IBP 10% 20% 30% 40% 50% 60% 70% 80% 90% FBP	ASTM D6352	 284.9 394.6 417.4 432.8 446.9 460.2 474.8 494.4 545.7 619.9 760.6	
* Data are not yet available			

At zero-hours, the first Briggs and Stratton and Tecumseh engines were evaporative emissions tested in a vehicle SHED. Testing included a one-hour hot soak following a 15 minute warm-up, and a 24-hr. diurnal test. CARB discontinued testing of these prototype evaporative emissions control devices due to vapor leaks in the fuel tank cap.

E. Durability Testing

Engine service accumulation was performed at SwRI's Engine and Vehicle Research Division. The durability site included two 30-hp eddy current dynamometers. Each dynamometer was fully automated including safety system monitoring. Safeties

were defined for certain engine parameters with automated engine shutdown. These parameters are listed in Table 8. Engines were fueled with California Phase II gasoline. With the exception of the first Briggs and Stratton and Tecumseh engines through 125 hours, maintenance was performed during the service accumulation periods according to manufacturer recommended procedures, including oil changes, air filter cleaning and replacement, and spark plug cleaning and replacement.

TABLE 8. PARAMETERS MONITORED FOR AUTOMATED SAFETY SHUTDOWN DURING DURABILITY

Engine Speed (RPM)
Cylinder Head Temperature (^{o}F)
Oil Temperature (^{o}F)
Exhaust Gas Temperature (^{o}F)
Catalyst Mid-Bed Temperature (^{o}F)

III. RESULTS AND DISCUSSIONS

A. Briggs and Stratton Intek Engine No. 1

Briggs and Stratton Engine No. 1 was baseline tested and then developed to a low-emissions configuration. During development, the engine showed signs of power loss and emissions deterioration. After inspection of the engine with Briggs and Stratton personnel, it was decided to continue to use the engine for the program. Baseline, engine-out, and fully developed emissions results are presented in Table 9. Individual test data sheets are presented in Appendix A.

The final low-emissions configuration incorporated catalyst C with a lean fixed carburetor jet (Jet #2-0.027 in.), and a passive secondary air induction system utilizing a 4-hole venturi and a check valve. The throat of the venturi was shrouded so a portion of the flywheel impeller cooling air was directed into the venturi throat. This augmented the supplemental air at the catalyst inlet, improving HC and CO conversion.

Figure 14 shows the exhaust pipe with the SAI system. The engine calibration change was conservative, remaining within the not-to-exceed engine operating limits defined by Briggs and Stratton. On average at zero-hours, the developed configuration generated 3.67 $^{g}/_{hp\text{-}hr}$ HC, 0.47 $^{g}/_{hp\text{-}hr}$ NO_x, and 91 $^{g}/_{hp\text{-}hr}$ CO.

TABLE 9. BRIGGS AND STRATTON ENGINE NO. 1 EMISSION RESULTS

Test No.	Mode 1 Power, hp	Catalyst	Carburetor Jetting	g/hp-hr				
				THC	NMHC	NO_x	THC+NO_x	CO
Baseline Emissions								
B+S#1 BSLN5	4.24	None	Stock-fixed	7.88	NA	2.06	9.94	304
B+S#1 BSLN6	4.32	None	Stock-fixed	8.04	7.25	1.96	10.00	303
BSLN Ave.	**4.28**			**7.96**	**7.25**	**2.01**	**9.97**	**304**
Development Emissions (0-Hour)								
B+S#1 BSLN-JET#2	3.43	None	Fixed Jet #2	10.26	NA	4.46	14.73	224
B+S#1 CAT-C-BSLN3	3.59	Cat. C	Fixed Jet #2	3.48	2.96	0.40	3.88	86
B+S#1 CAT-C-BSLN4	3.48	Cat. C	Fixed Jet #2	3.85	NA	0.55	4.40	96
125-hour Emissions								
B+S#1-125-BSLN	3.18	None	Fixed Jet #2	15.63	NA	4.73	20.35	235
B+S#1-125-STK-BSLN	3.25	None	Stock-fixed	17.46	NA	2.21	19.67	353
B+S#1-125-#1	3.16	Cat. C	Fixed Jet #2	7.27	6.33	0.85	8.12	144
B+S#1-125-#2	3.26	Cat. C	Fixed Jet #2	7.51	6.63	0.94	8.45	146
250-hour Emissions								
No 250-hour testing was performed on Briggs and Stratton engine no. 1								

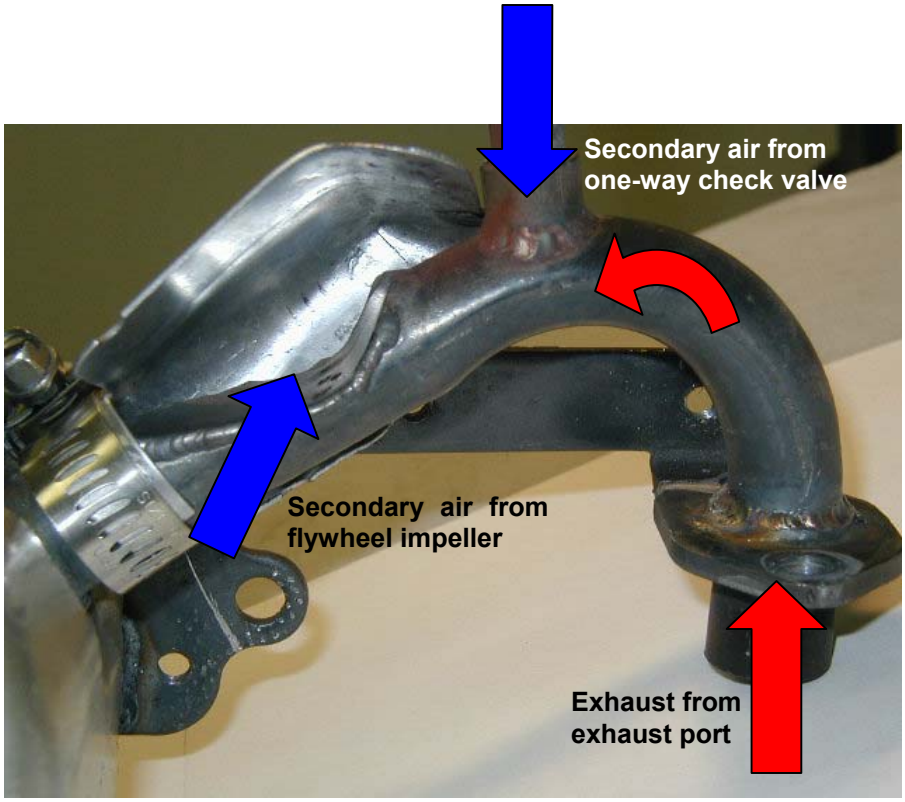

FIGURE 14. SECONDARY AIR INDUCTION SYSTEM ON BRIGGS AND STRATTON ENGINE NO. 1 MUFFLER

Figure 15 shows the zero-hour emissions of four configurations: baseline, stock carburetion with catalyst C and secondary air, engine-out with stock muffler and fixed jet #2, and fully developed configurations. Overall, HC+NO_x emissions were reduced by 58%, HC emissions by 54%, NO_x emissions by 76%, and CO emissions by 70% compared to the baseline configuration.

After completing the 125-hour service accumulation, the engine was emissions tested. During durability, the engine stopped running on ten separate occasions. After service checks were performed, the problem was determined to be caused by misfiring due to a bad spark plug. After a change of spark plug, the problem was no longer experienced. At 125 hours, the engine's stock-baseline emissions increased significantly from those at zero hours. Figure 16 presents a comparison between 0-hour and 125-hour emissions data. Engine-out (no catalyst) emissions have significantly increased at 125-hours while catalyst performance held up reasonably well. On average at 125 hours, compared to zero-hour baseline emissions, the fully developed configuration reduced HC+NO_x emissions by 17%, HC emissions by 7%, NO_x emissions by 56%, and CO emissions by 52%. The catalyst reduced HC+NO_x emissions by 70% at zero-hours and by 58% at 125 hours. The reduction in HC+NO_x conversion may be due to the increase of engine-out HC emissions and a lack of sufficient oxygen to completely oxidize these hydrocarbons. The misfire/engine shutdown episodes during durability may also have caused some loss in catalyst efficiency.

After review of the 125-hour emissions data, CARB decided to remove Briggs and Stratton Engine No. 1 from the program due to engine deterioration. No additional

emissions tests or durability was performed on this engine. From results presented in Table 9, a set of multiplicative deterioration factors (DF) were calculated for a useful life of 125 hours based on the standard least squares curve fit method and the equation below. The DFs are presented in Table 10 for the three different engine configurations.

$$DF = \frac{E_{UL}}{E_o}$$

E_{UL} = Useful life emission level calculated from least squares trendline equation

E_o = Baseline emission level of stabalized engine

TABLE 10. CALCULATED DETERIORATION FACTORS FOR BRIGGS AND STRATTON ENGINE NO. 1 THROUGH 125 HOURS

Configuration	0-Hour Test No.	125-Hour Test No.	Deterioration Factors			
			$HC+NO_x$	HC	NO_x	CO
Stock-Baseline	B+S#1 BSLN5 & 6	B+S#1-125-STK-BSLN	1.97	2.19	1.10	1.16
Engine-Out	B+S#1 BSLN-JET#2	B+S#1-125-BSLN	1.38	1.52	1.06	1.05
Developed	B+S#1 CAT-C-BSLN3 & 4	B+S#1-125-#1 & #2	2.00	2.02	1.87	1.59

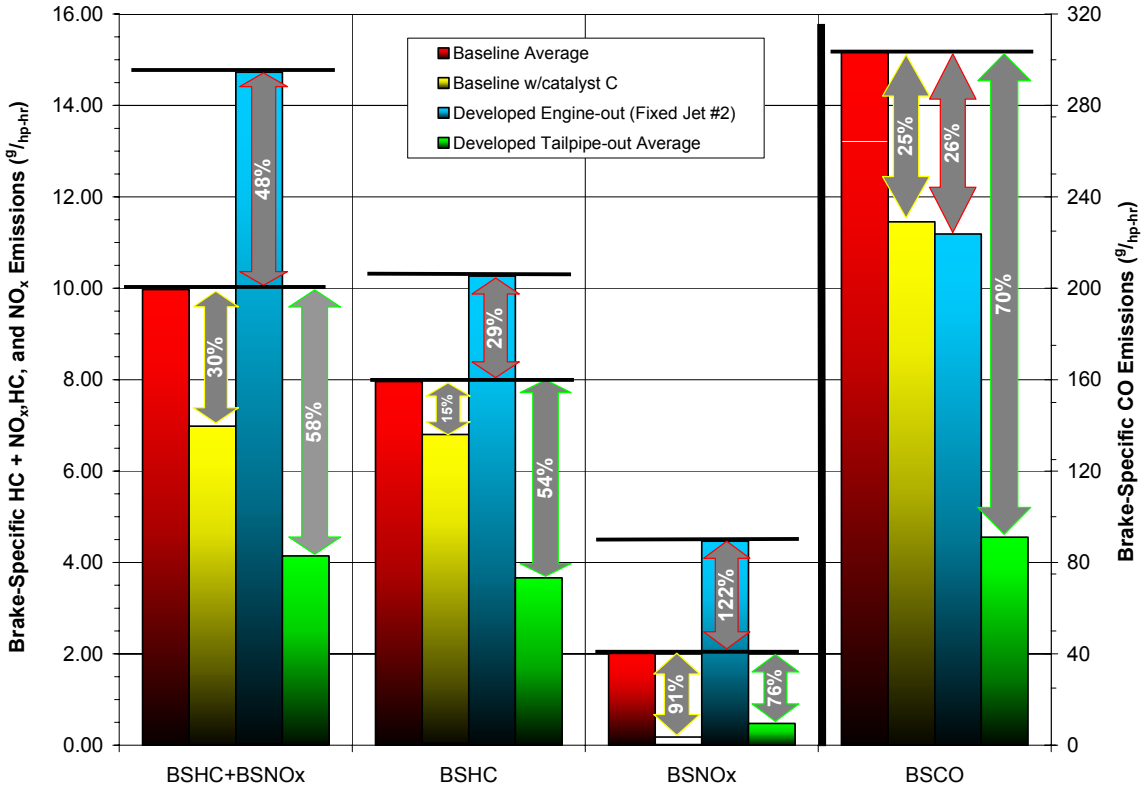

FIGURE 15. BRIGGS AND STRATTON ENGINE NO. 1-- ZERO-HOUR EMISSIONS

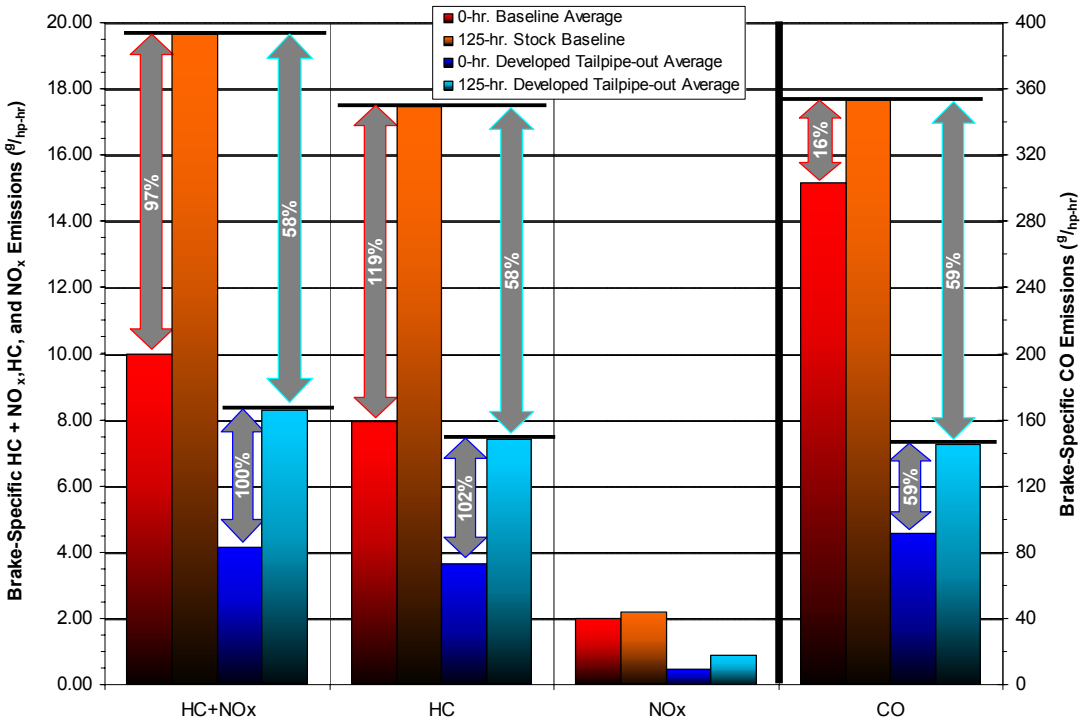

FIGURE 16. BRIGGS AND STRATTON ENGINE NO. 1— ZERO-HOUR AND 125-HOUR EMISSIONS

B. Briggs and Stratton Intek Engine No. 2

Briggs and Stratton Engine No. 2 was baseline tested following baseline testing of the first Briggs and Stratton engine. Table 11 shows emission results for Briggs and Stratton Engine No. 2. Engine No. 2 emits 19% less HC+NO_x than Engine No. 1 in the baseline configuration. Individual test data sheets are presented in Appendix B.

TABLE 11. BRIGGS AND STRATTON ENGINE NO. 2 EMISSION RESULTS

Test No.	Mode 1 Power, hp	Catalyst	Carburetor Jetting	g/hp-hr				
				THC	NMHC	NO_x	THC+NO_x	CO
Baseline Emissions								
B+S#2 BSLN1	4.31	None	Stock-fixed	6.75	NA	1.48	8.23	326
B+S#2 BSLN2	4.29	None	Stock-fixed	6.64	NA	1.62	8.26	322
B+S#2 BSLN3	4.35	None	Stock-fixed	6.08	5.30	1.67	7.75	312
BSLN Ave.	**4.32**			**6.49**	**5.30**	**1.59**	**8.08**	**320**
Development Emissions								
Development has not yet occurred								
125-hour Emissions								
Development has not yet occurred								
250-hour Emissions								
Development has not yet occurred								

C. Tecumseh OVRM120 Engine

Tecumseh OVRM120 engine testing and development followed development of the first Briggs and Stratton engine. Upon review of the initial baseline results, Tecumseh and SwRI felt that the engine was not operating as it should. The engine was running slightly leaner than expected, resulting in higher NO_x emissions and elevated combustion temperatures. Checks were performed to verify proper fuel delivery, carburetor setup, and full throttle operation. Diagnostics were also performed to verify intake and exhaust valve lash, as well as to check for leakage past the piston rings. All checks verified correct setup and normal operation. To determine whether the problem was due to a faulty carburetor, a replacement carburetor was installed and tested. The engine ran leaner with the replacement carburetor, and it was concluded that a problem existed in the engine. It was decided to replace the Tecumseh engine with an identical engine ARB had previously used for evaporative emissions testing.

The replacement engine was baseline emissions tested and then developed in its low-emission configuration. Table 12 presents engine emission results. Individual test data sheets are presented in Appendix C. The developed Tecumseh engine utilized catalyst C integrated inside a muffler, with a passive SAI system. Enleanment was not needed. The layout is shown earlier in Figure 12. On average, the final zero-hour developed configuration reduced HC+NO_x emissions by 63%, HC emissions by 58%, NO_x emissions by 84%, and CO emissions by 53%. The final, average zero-hour emissions for the developed configuration were 2.54 $^{g}/_{hp\text{-}hr}$ HC, 0.26 $^{g}/_{hp\text{-}hr}$ NO_x, and 169 $^{g}/_{hp\text{-}hr}$ CO. Zero-hour emission results are shown in Figure 17.

The engine was emissions tested after completing the 125-hour service accumulation. No problems were experienced during the durability period. At 125 hours, the engine was tested in the stock-baseline and fully developed configurations, before and after scheduled maintenance. Maintenance included an oil change, air filter replacement, and spark plug replacement. Emissions after maintenance were higher than emissions prior to maintenance. The reason for this is unknown. At 125 hours, the engine's stock-baseline HC+NO_x emissions increased by 42% compared to zero-hour data. Compared to zero-hour baseline levels, at 125 hours the fully developed configuration reduced HC+NO_x emissions by 33%, HC emissions by 22%, NO_x emissions by 76%, and CO emissions by 30%. Catalyst reduction performance at 125 hours was on the order of 50% for HC+NO_x, 46% for HC, 73% for NO_x, and 36% for CO. After maintenance during the 125-hour emissions test, an oil leak was noticed near the head of the cylinder past the 'flange' gasket, as well as a leak around the o-ring at the bottom of the oil fill tube. Tecumseh mentioned that oil leakage past the 'flange' gasket has been observed on OVRM120s in the past. The leak past the oil fill tube may have been due to slightly higher crankcase pressures resulting from excess oil in the sump.

After completing the second and final durability interval, the engine was tested at 250 hours. No problems were experienced during the durability period. As at 125 hours, the engine was tested before and after scheduled maintenance in both the fully

developed and stock-baseline configurations. As observed at 125 hours, tests after maintenance generated higher emissions than tests prior to maintenance, mostly from increased HC emissions. As shown in Figure 18, testing of the Tecumseh engine at 250 hours demonstrated an average reduction of 50% for HC+NO_x emissions, 42% for HC emissions, 78% for NO_x emissions, and 30% for CO emissions, compared to zero-hour baseline results. Catalyst performance at 250 hours was 64% for HC+NO_x, 61% for HC, 78% for NO_x, and 40% for CO. Figures 19 and 20 show emissions results in baseline and developed configurations, respectively, at each test interval. From these figures, it is noted that the durability data do not fall on a straight line, due to variability in engine operation. Using the least squares method, a set of deterioration factors was calculated for the Tecumseh engine at 125 and 250 hours. Deterioration factors are presented in Table 13.

TABLE 12. REPLACEMENT TECUMSEH OVRM120 ENGINE EMISSION RESULTS

Test No.	Mode 1 Power, hp	Catalyst	Carburetor Jetting	g/hp-hr				
				THC	NMHC	NO_x	THC+NO_x	CO
Baseline Emissions								
TEC2 BSLN#1	3.26	None	Stock (174)	5.45	4.74	1.58	7.03	337
TEC2 BSLN#2	3.33	None	Stock (174)	6.05	NA	1.65	7.70	342
TEC2 BSLN#3	3.00	None	Stock (174)	6.48	NA	1.54	8.02	405
BSLN Ave.	**3.20**			**5.99**	**4.74**	**1.59**	**7.58**	**361**
Development Emissions (0-Hour)								
TEC2-C-BSLN1m	3.58	Cat. C	Stock (174)	2.77	2.22	0.21	2.98	184
TEC2-C-BSLN2m	3.59	Cat. C	Stock (174)	2.31	NA	0.30	2.61	153
125-hour Emissions								
TEC2-125-STK-#1*	3.15	None	Stock (174)	8.07	7.08	1.33	9.40	375
TEC2-125-STK-#2	2.96	None	Stock (174)	9.27	8.20	1.49	10.76	411
TEC2-125-#1*	3.36	Cat. C	Stock (174)	4.47	3.69	0.27	4.74	256
TEC2-125-#2	3.21	Cat. C	Stock (174)	4.80	NA	0.47	5.27	247
TEC2-125-#3	3.18	Cat. C	Stock (174)	4.84	4.03	0.41	5.25	256
250-hour Emissions								
TEC2-250-STK-#1*	3.01	None	Stock (174)	8.43	7.34	1.49	9.93	397
TEC2-250-STK-#2	2.89	None	Stock (174)	9.58	8.38	1.70	11.28	457
TEC2-250-#1*	3.32	Cat. C	Stock (174)	3.32	2.64	0.33	3.65	230
TEC2-250-#2*	3.30	Cat. C	Stock (174)	3.55	2.76	0.31	3.86	250
TEC2-250-#3	3.19	Cat. C	Stock (174)	3.79	2.91	0.36	4.15	286
TEC2-250-#4	3.15	Cat. C	Stock (174)	3.24	2.43	0.40	3.64	252
* Testing prior to maintenance								

TABLE 13. CALCULATED DETERIORATION FACTORS FOR TECUMSEH OVRM120 ENGINE THROUGH 250 HOURS

Time (hrs.)	Configuration	0-Hour Test No.	Interval Test No.	Deterioration Factors			
				HC+NO_x	HC	NO_x	CO
125	Stock-Baseline	TEC2 BSLN#1, #2, & #3	TEC2-125-STK-#1 & #2	1.24	1.32	0.96	1.09
125	Developed	TEC2-C-BSLN1m & 2m	TEC2-125-#1, #2, & #3	1.40	1.41	1.29	1.33
250	Stock-Baseline	TEC2 BSLN#1, #2, & #3	TEC2-250-STK-#1 & #2	1.44	1.57	0.97	1.18
250	Developed	TEC2-C-BSLN1m & 2m	TEC2-250-#1, #2, #3, #4	1.58	1.59	1.48	1.59

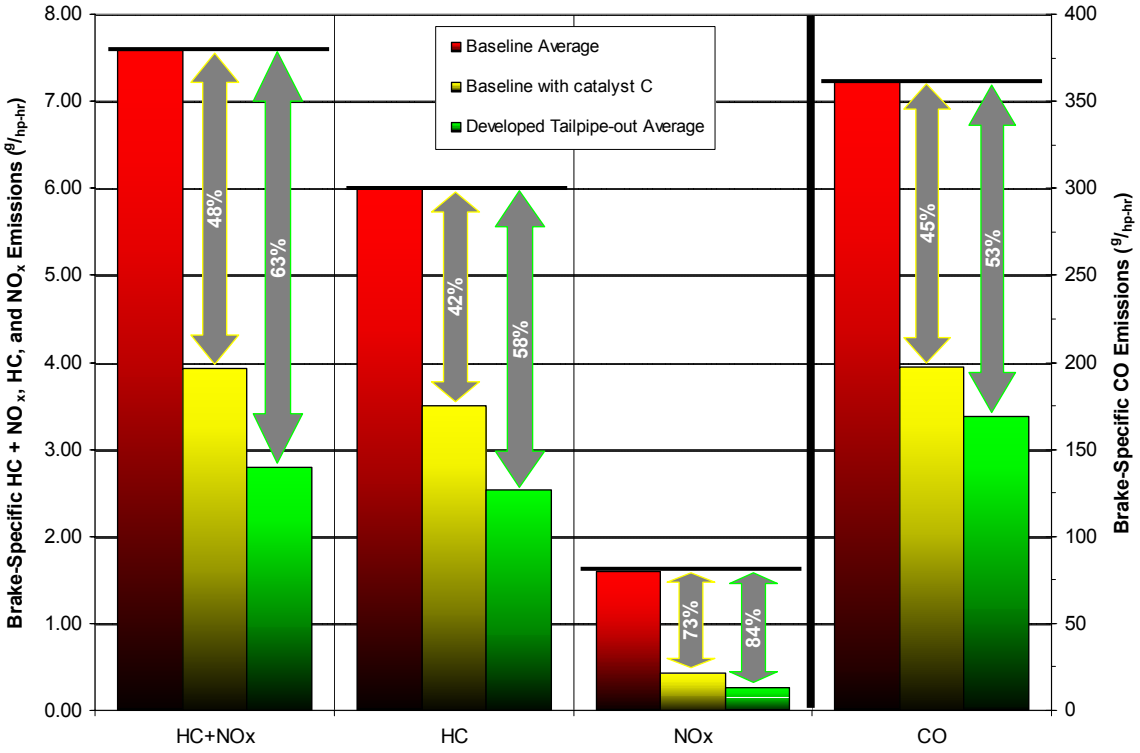

FIGURE 17. TECUMSEH OVRM120 ENGINE-- ZERO-HOUR EMISSIONS

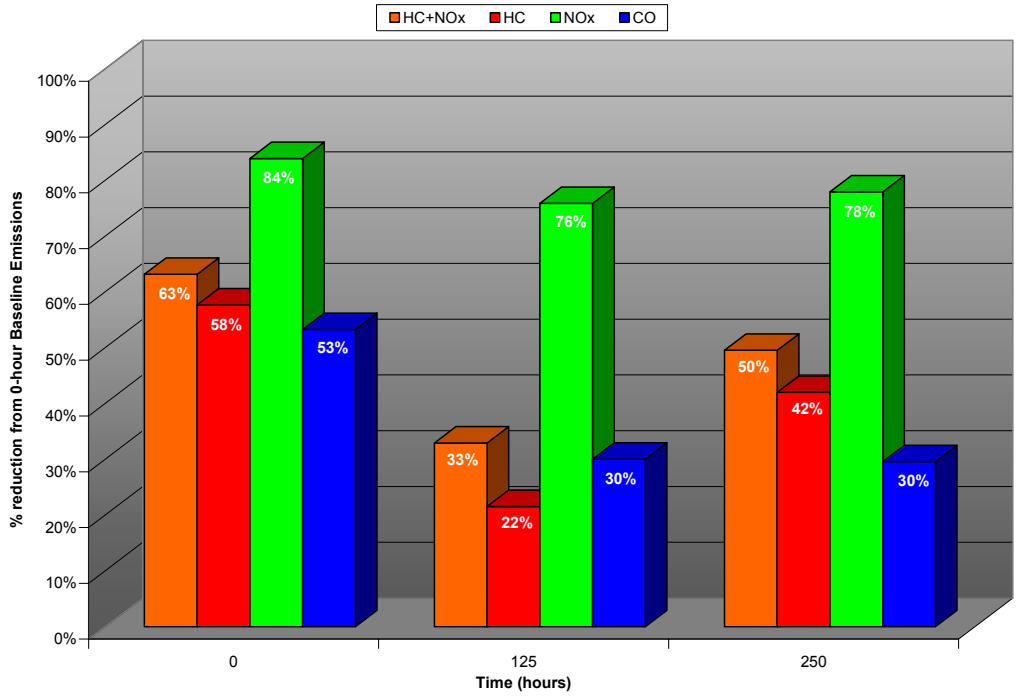

FIGURE 18. TECUMSEH OVRM120 ENGINE EMISSIONS—DEVELOPED CONFIGURATION PERCENT REDUCTION THROUGH 250 HOURS (COMPARED TO 0-HOUR BASELINE EMISSIONS)

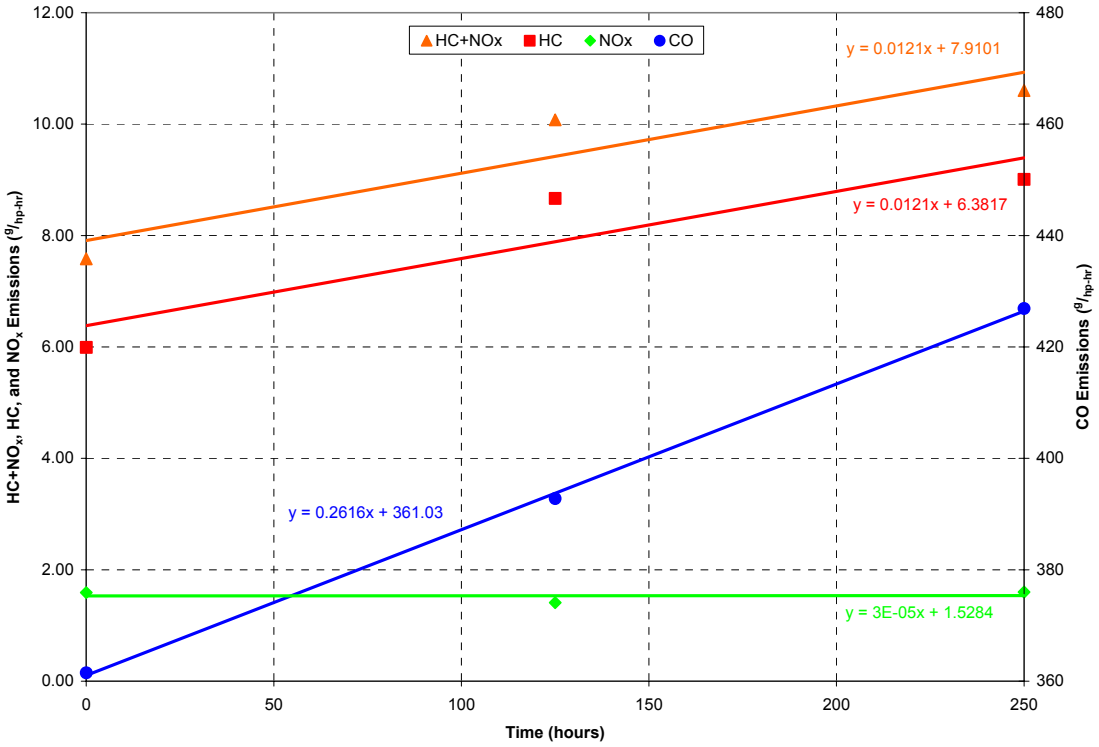

FIGURE 19. TECUMSEH OVRM120 EMISSIONS FOR STOCK CONFIGURATION

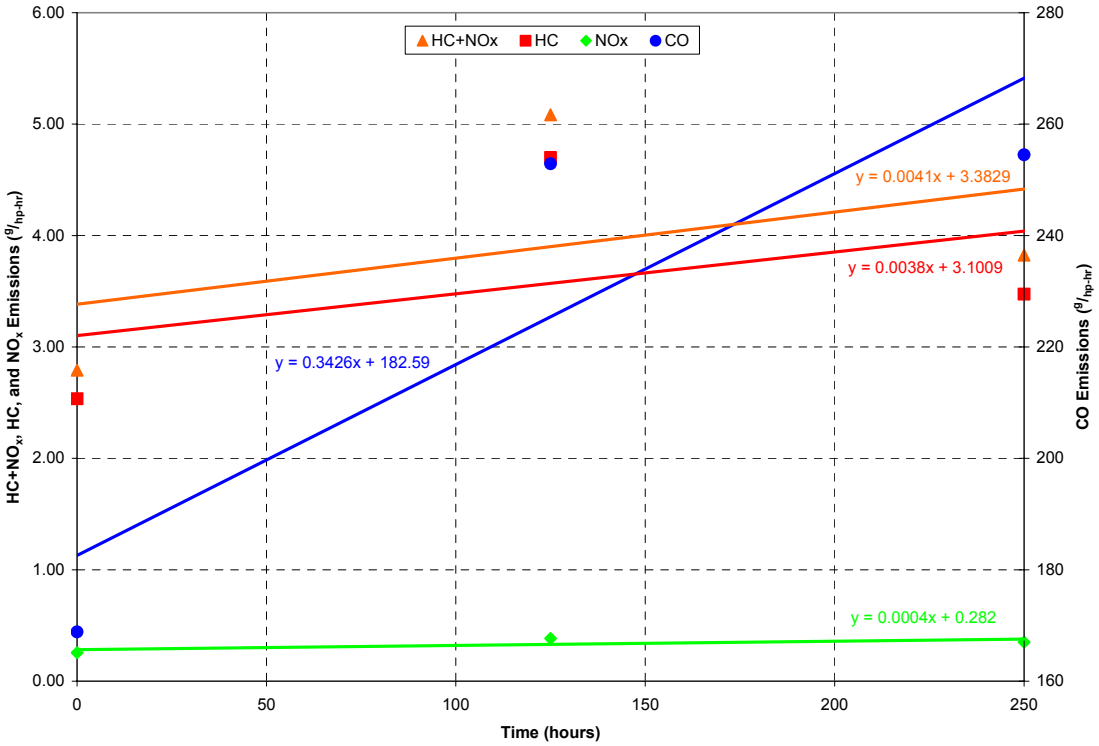

FIGURE 20. TECUMSEH OVRM120 EMISSIONS FOR DEVELOPED CONFIGURATION

D. Honda GCV160 Engine

It was originally planned to develop a small displacement horizontal-shaft generator engine. CARB decided, however, to replace the horizontal-shaft Honda GX160 engine with a similar displacement GCV160 vertical-shaft engine that is used in walk-behind lawnmowers. The Honda GCV160 engine was baseline emissions tested in its stock configuration, then developed and durability tested. Results are summarized in Table 14. Individual test data sheets are presented in Appendix D.

TABLE 14. HONDA GCV160 ENGINE EMISSION RESULTS

Test No.	Mode 1 Power, hp	Catalyst	Carburetor Jetting	g/hp-hr				
				THC	NMHC	NO_x	THC+NO_x	CO
Baseline Emissions								
HON-160-BSLN#1	3.41	None	Stock-fixed	6.45	5.81	2.26	8.71	296
HON-160-BSLN#2	3.37	None	Stock-fixed	6.80	NA	2.17	8.97	303
HON-160-BSLN#3	3.54	None	Stock-fixed	6.20	NA	2.48	8.69	280
BSLN Ave.	**3.44**			**6.48**	**5.81**	**2.30**	**8.79**	**293**
Development Emissions (0-Hour)								
HON-160-J-BSLN#1	3.73	Cat. J	Stock-fixed	2.23	1.83	0.25	2.48	105
HON-160-J-BSLN#2	3.58	Cat. J	Stock-fixed	2.19	1.82	0.34	2.53	110
125-hour Emissions								
HON-160-STK-125-#1	3.18	None	Stock-fixed	5.16	4.78	5.46	10.62	157
HON-160-STK-125-#2	3.13	None	Stock-fixed	5.43	5.04	5.40	10.83	161
HON-160-J-125-#1	3.40	Cat. J	Stock-fixed	1.52	1.29	0.47	1.99	66
HON-160-J-125-#2	3.35	Cat. J	Stock-fixed	1.52	1.27	0.58	2.10	64
250-hour Emissions								
HON-160-STK-250-#1	3.28	None	Stock-fixed	5.57	5.14	6.14	11.71	150
HON-160-STK-250-#1	3.40	None	Stock-fixed	4.95	4.57	6.01	10.96	141
HON-160-J-250-#1	3.55	Cat. J	Stock-fixed	2.54	2.27	0.36	2.90	72
HON-160-J-250-#2	3.47	Cat. J	Stock-fixed	1.97	NA	0.44	2.41	78

The developed GCV160 engine utilized catalyst J integrated inside a modified GCV160 muffler, with a passive SAI system. The low-emission developed engine is shown in Figure 4. Catalysts K and L were also evaluated during development, however, catalyst J was chosen due to its enhanced performance. The engine was not enleaned due to engine manufacturer concerns with startability in certain applications. On average, the zero-hour developed configuration reduced HC+NO_x emissions by 71%, HC emissions by 66%, NO_x emissions by 87%, and CO emissions by 63%. The final, average zero-hour emissions for the developed configuration were 2.21 $^{g}/_{hp\text{-}hr}$ HC, 0.30 $^{g}/_{hp\text{-}hr}$ NO_x, and 108 $^{g}/_{hp\text{-}hr}$ CO. Figure 21 presents zero-hour emissions in the stock-baseline, baseline with catalyst J, and fully developed configurations (catalyst J with SAI).

The Honda GCV160 engine was emissions tested after completing the first 125-hour service accumulation. No problems were experienced during the durability period. At 125 hours, the engine was tested in the stock-baseline and fully developed configurations. Scheduled maintenance was performed every 50 hours during durability, including oil changes, air filter cleaning and replacement, and spark plug

cleaning and regapping. On average at 125 hours, the developed configuration produced 2.04 $^{g}/_{hp\text{-}hr}$ of HC+NO_x, 1.52 $^{g}/_{hp\text{-}hr}$ of HC, 0.52 $^{g}/_{hp\text{-}hr}$ of NO_x, and 64 $^{g}/_{hp\text{-}hr}$ of CO, thus reducing HC+NO_x emissions by 77%, HC emissions by 77%, NO_x emissions by 77%, and CO emissions by 78%, compared to zero-hour baseline results. At 125 hours, catalyst percent conversions were 81% HC+NO_x, 71% HC, 90% NO_x, and 60% CO. The engine was running leaner at 125 hours than during baseline and development testing, resulting in increased NO_x emissions and reduced HC and CO emissions. It is believed that the increase in stock HC emissions at 125 hours was mostly from higher HC emissions at idle, due to leaner operation with potentially incomplete combustion. Also, the engine was harder to start, requiring the use of the choke, and idle operation was erratic.

The engine was tested at 250 hours after completing the second durability interval. No problems were experienced during durability. Similar starting difficulty and erratic idle operation were observed as at 125 hours. As shown in Figure 22, testing of the Honda GCV160 engine at 250 hours demonstrated an average reduction of 70% for HC+NO_x emissions, 65% for HC emissions, 83% for NO_x emissions, and 74% for CO emissions, compared to zero-hour baseline results. On average at 250 hours, the developed configuration produced 2.66 $^{g}/_{hp\text{-}hr}$ of HC+NO_x, 2.26 $^{g}/_{hp\text{-}hr}$ of HC, 0.40 $^{g}/_{hp\text{-}hr}$ of NO_x, and 75 $^{g}/_{hp\text{-}hr}$ of CO. Catalyst performance at 250 hour was 77% for HC+NO_x, 57% for HC, 93% for NO_x, and 48% for CO. Figures 23 and 24 show emissions results in stock and developed configurations, respectively, at each test interval. Using the least squares method, a set of deterioration factors was calculated for the Honda GCV160 engine at 125 and 250 hours, as shown in Table 15.

After completing 250-hour testing, carburetor maintenance was performed on the Honda GCV160 engine in an attempt to improve idle operation and startability. The carburetor was removed from the engine and cleaned according to Honda specified procedures. Upon removing the carburetor from the engine, a warn gasket was found between the carburetor and the intake port. The carburetor was thoroughly cleaned and reassembled, and a new gasket was fitted between the carburetor and the engine. A repeat set of tests was performed. Overall, composite emissions were only slightly affected by the carburetor maintenance. However, idle operation was less erratic and the engine did not run as lean at idle.

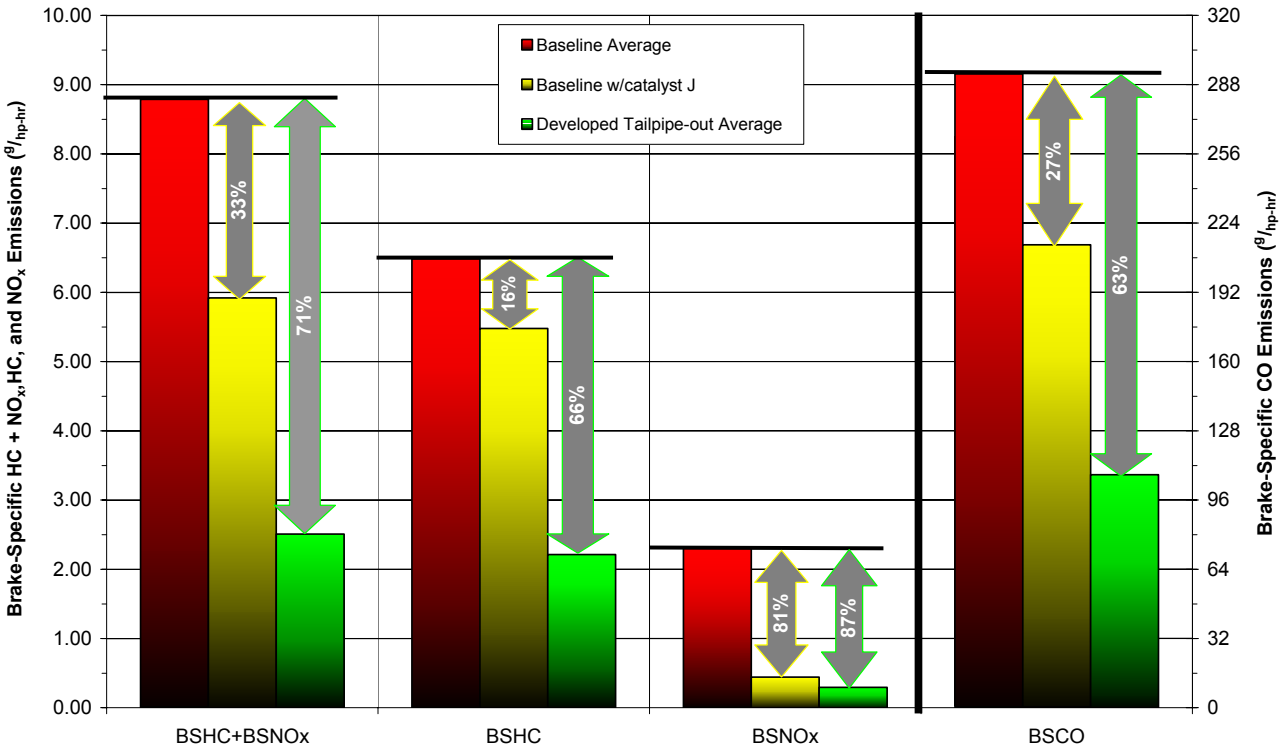

FIGURE 21. HONDA GCV160 ENGINE—ZERO-HOUR EMISSIONS

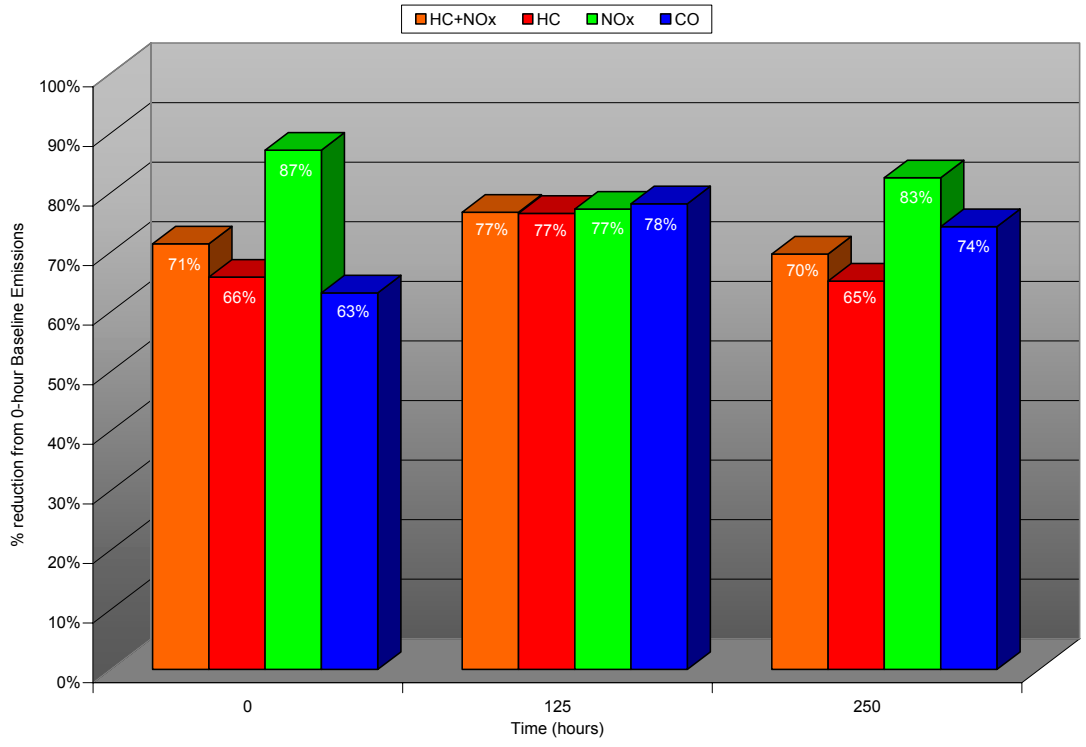

FIGURE 22. HONDA GCV160 ENGINE EMISSIONS—DEVELOPED CONFIGURATION PERCENT REDUCTION THROUGH 250 HOURS (COMPARED TO 0-HOUR BASELINE EMISSIONS)

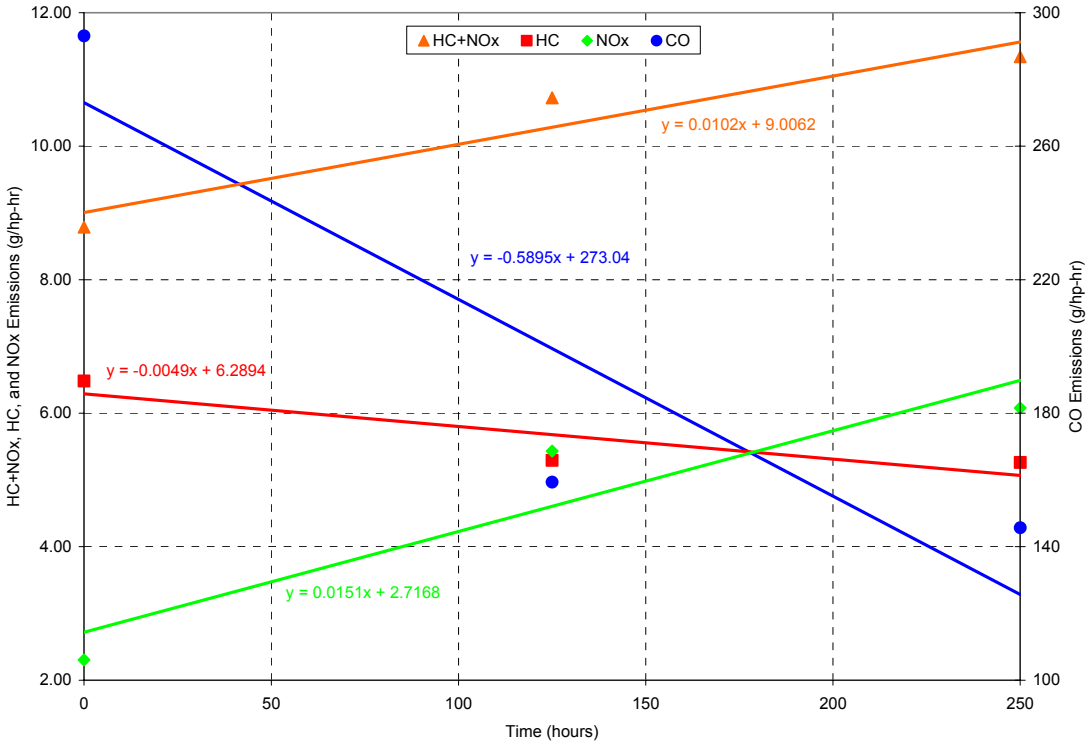

FIGURE 23. HONDA GCV160 EMISSIONS FOR STOCK CONFIGURATION

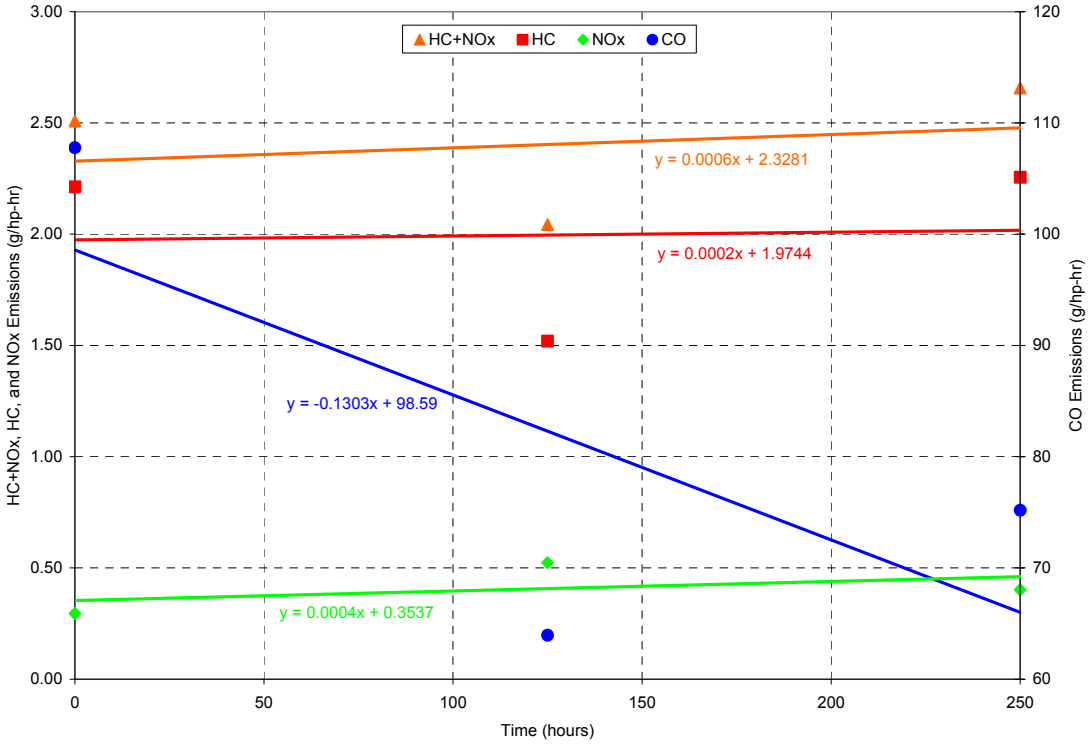

FIGURE 24. HONDA GCV160 EMISSIONS FOR DEVELOPED CONFIGURATION

TABLE 15. CALCULATED DETERIORATION FACTORS FOR HONDA GCV160 ENGINE THROUGH 250 HOURS

Time (hrs.)	Configuration	0-Hour Test No.	Interval Test No.	Deterioration Factors			
				$HC+NO_x$	HC	NO_x	CO
125	Stock-Baseline	HON-160-BSLN-#1, #2, & # 3	HON-160-STK-125-BSLN#1, & #2	1.17	0.88	2.00	0.68
125	Developed	HON-160-J-BSLN#1, & #2	HON-160-J-125-#1, & #2	0.96	0.90	1.38	0.76
250	Stock-Baseline	HON-160-BSLN-#1, #2, & # 3	HON-160-STK-250-#1, & #2	1.32	0.78	2.82	0.43
250	Developed	HON-160-J-BSLN#1, & #2	HON-160-J-250-#1, & #2	0.99	0.91	1.56	0.61

E. Kawasaki FH601V Engine

After completion of a two-hour break-in, the Kawasaki engine was found to be running noticeably leaner at high loads and richer at low loads, as compared to Kawasaki-supplied historical data. This was observed in exhaust gas oxygen sensor readings as well as in engine-out emission data. It was suspected that there was a problem with the fuel system (filter and pump) or the carburetor, resulting in inadequate fueling at wide-open throttle and excess fueling at idle. A replacement carburetor from Kawasaki was installed. It exhibited similar performance, except with more reasonable fuel control at lower loads. From this data, it was suspected that there was an engine fuel delivery malfunction. A replacement engine was procured for testing.

The replacement engine was broken-in for two hours and then baseline tested. A set of four tests was run on this engine in its stock configuration. Consecutive tests were run on one day (*KAW2-BSLN#1* and *KAW2-BSLN#2*), and a second set of tests (*KAW2-BSLN#3* and *KAW2-BSLN#4*) were run the following day. Test #2 was considered invalid because of an emission measurement error during the idle mode, and was not used in the calculation of the baseline average. Emission results are summarized in Table 16. Individual test data sheets are presented in Appendix E.

Baseline results indicated variability in engine operation and emissions. To understand why this was observed, experiments were run at wide-open throttle with varied intake air temperatures. These experiments showed that fuel control and emissions for this engine are very sensitive to changes in intake air conditions (temperature and humidity). Test procedures were subsequently adjusted to more consistently maintain intake air temperature, however, intake air humidity could not be readily controlled.

TABLE 16. KAWASAKI FH601V ENGINE EMISSION RESULTS

Test No.	Mode 1 Power, hp	Catalyst	Carburetor Jetting	g/hp-hr				
				THC	NMHC	NO_x	THC+NO_x	CO
Baseline Emissions								
KAW2-BSLN#1	15.38	None	Stock (136/140)	6.63	5.49	1.27	7.90	418
KAW2-BSLN#3	16.12	None	Stock (136/140)	5.21	NA	2.08	7.29	386
KAW2-BSLN#4	15.60	None	Stock (136/140)	4.69	3.97	2.46	7.15	338
BSLN Ave.	**15.70**			**5.51**	**4.73**	**1.94**	**7.45**	**380**
Development Emissions								
KAW2-EO3-#1	15.23	None	Tier 3 (116/120)	3.55	NA	3.89	7.43	226
KAW2-E-DEV-FNL#1	15.56	Cat. E	Tier 3 (116/120)	1.45	1.06	0.07	1.52	111
KAW2-E-DEV-FNL#2	15.35	Cat. E	Tier 3 (116/120)	1.32	NA	0.05	1.37	101
125-hour Emissions								
KAW2-125-STK-#1	15.22	None	Stock (136/140)	5.70	5.25	0.86	6.55	410
KAW2-125-STK-#2	15.16	None	Stock (136/140)	6.08	5.24	0.76	6.84	435
KAW2-125-EO3-#1	15.16	None	Tier 3 (116/120)	3.77	NA	4.16	7.93	199
KAW2-125-E-#1	15.39	Cat. E	Tier 3 (116/120)	1.67	1.23	0.10	1.77	128
KAW2-125-E-#2	15.34	Cat. E	Tier 3 (116/120)	1.52	1.09	0.07	1.59	119
250-hour Emissions								
KAW2-250-STK-#1	15.00	None	Stock (136/140)	7.54	6.47	0.85	8.39	435
KAW2-250-STK-#2	14.96	None	Stock (136/140)	7.70	NA	0.83	8.53	431
KAW2-250-EO3-#1	14.93	None	Tier 3 (116/120)	4.10	NA	4.55	8.65	187
KAW2-250-EO3-#2	14.91	None	Tier 3 (116/120)	4.28	3.84	4.57	8.85	190
KAW2-250-E-#1	14.97	Cat. E	Tier 3 (116/120)	1.83	1.38	0.11	1.94	126
KAW2-250-E-#2	14.79	Cat. E	Tier 3 (116/120)	1.77	1.32	0.10	1.87	126
KAW2-250-E-#3	14.94	Cat. E	Tier 3 (116/120)	1.78	NA	0.11	1.89	120
500-hour data are not yet available								

The developed configuration included catalyst E integrated inside a Kawasaki muffler, passive secondary air induction (SAI), and enleanment using fixed jets manufactured by Kawasaki for “Tier 3" lean settings. On average, the zero-hour developed configuration produced 1.45 $^{g}/_{hp\text{-}hr}$ HC+NO_x, 1.39 $^{g}/_{hp\text{-}hr}$ HC, 0.06 $^{g}/_{hp\text{-}hr}$ NO_x, and 106 $^{g}/_{hp\text{-}hr}$ CO. Overall, the developed configuration reduced HC+NO_x emissions by 81%, HC by 75%, NO_x by 97%, and CO by 72%, as compared to average baseline results. Figure 25 summarizes emissions in baseline, baseline with catalyst E, developed engine-out, and developed configurations.

The engine was emission tested after 125 hours of service accumulation. No problems were experienced during durability. Scheduled maintenance was performed, including oil changes, air filter cleanings, and spark plug checks. It was noted that the engine was running leaner at idle compared to baseline testing. Following aging, the engine was tested at 125 hours in the fully developed configuration, engine-out configuration (‘Tier 3’ jets with SAI system), and stock-baseline configuration. On average at 125 hours, the developed configuration produced 1.69 $^{g}/_{hp\text{-}hr}$ of HC+NO_x, 1.60 $^{g}/_{hp\text{-}hr}$ of HC, 0.09 $^{g}/_{hp\text{-}hr}$ of NO_x, and 123 $^{g}/_{hp\text{-}hr}$ of CO, thus reducing HC+NO_x emissions by 77%, HC emissions by 71%, NO_x emissions by 96%, and CO emissions by 68%, compared to zero-hour baseline results.

After completing the second durability interval, the engine was tested at 250 hours. No problems were experienced during durability. Scheduled maintenance was performed, including oil changes, air filter cleanings, and spark plug checks. As shown in Figure 26, testing of the Kawasaki engine at 250-hours demonstrated an average reduction of 74% for HC+NO_x emissions, 67% for HC emissions, 94% for NO_x emissions, and 67% for CO emissions, compared to zero-hour baseline results. On average at 250 hours, the developed configuration produced 1.91 $^{g}/_{hp\text{-}hr}$ of HC+NO_x, 1.80 $^{g}/_{hp\text{-}hr}$ of HC, 0.11 $^{g}/_{hp\text{-}hr}$ of NO_x, and 124 $^{g}/_{hp\text{-}hr}$ of CO. Catalyst percent conversions at 250 hours were 75% for HC+NO_x, 73% for HC, 89% for NO_x, and 71% for CO. Figures 27 and 28 show emissions results in baseline and developed configurations, respectively, at each test interval. Using the least squares method, a set of deterioration factors was calculated for the Kawasaki FH601V engine at 125 and 250 hours, as shown in Table 17.

As observed with the Honda GCV160 engine, the Kawasaki appeared to be running slightly leaner at idle than during baseline testing and development. A fuel conditioner was run through the engine after 250-hour testing, however, no change in operation was observed. After the 250-hour emissions tests, the ceramic insulators of the original spark plugs appeared to be slightly burned. The spark plugs were replaced prior to beginning the aging through 500 hours.

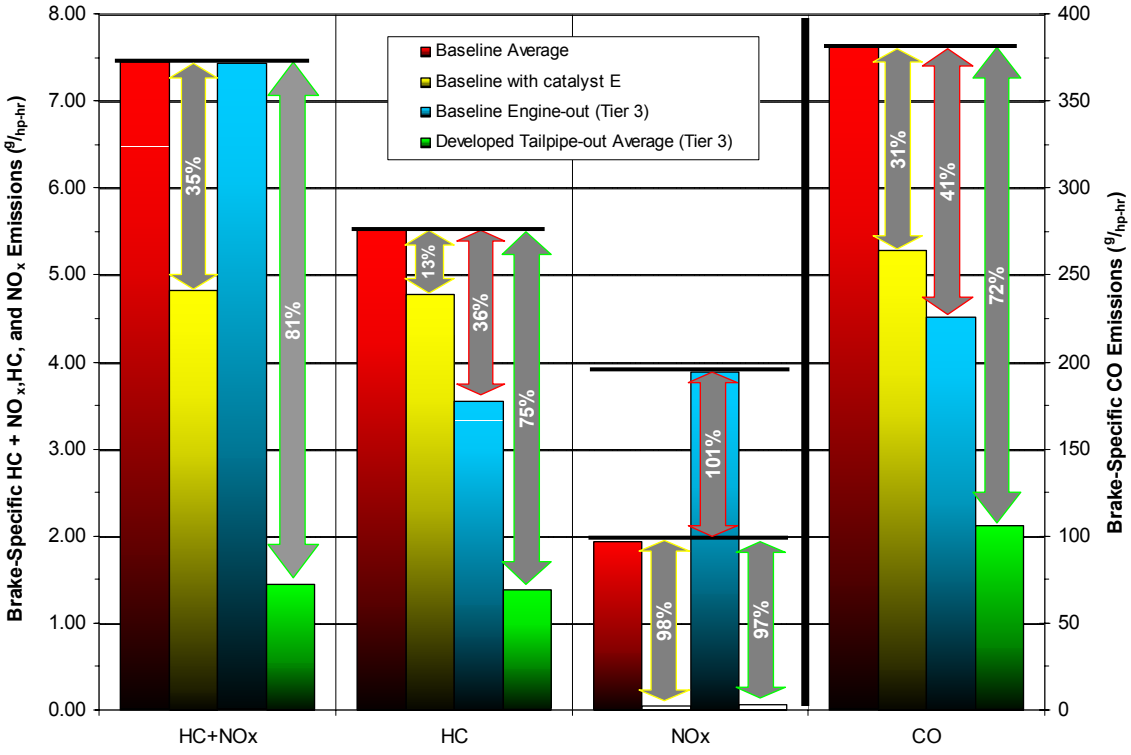

FIGURE 25. KAWASAKI FH601V ENGINE— ZERO-HOUR EMISSIONS

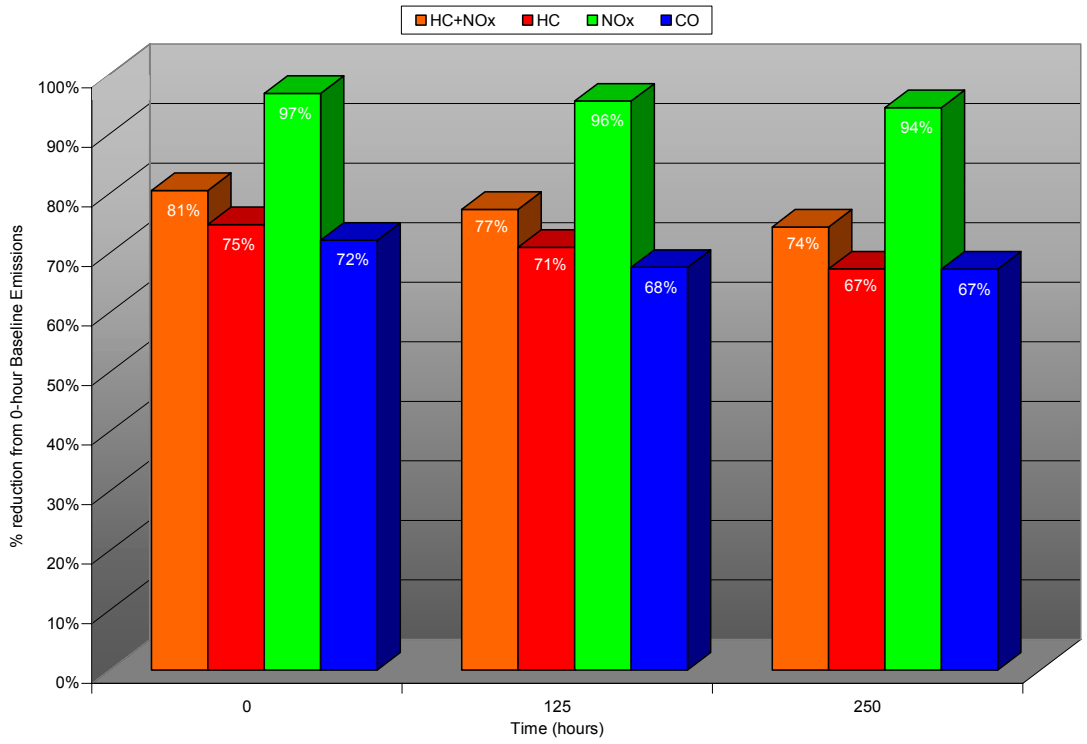

FIGURE 26. KAWASAKI FH601V ENGINE EMISSIONS—DEVELOPED CONFIGURATION PERCENT REDUCTION THROUGH 250-HOURS (COMPARED TO 0-HOUR BASELINE EMISSIONS)

TABLE 17. CALCULATED DETERIORATION FACTORS FOR KAWASAKI FH601V ENGINE THROUGH 250 HOURS

Time (hrs.)	Configuration	0-Hour Test No.	Interval Test No.	Deterioration Factors			
				$HC+NO_x$	HC	NO_x	CO
125	Stock-Baseline	KAW2-BSLN#1, #3, & #4	KAW2-125-STK-#1 & #2	1.01	1.15	0.62	1.08
125	Engine-Out	KAW2-EO3-#1	KAW2-125-EO3-#3	1.08	1.08	1.08	0.91
125	Developed	KAW2-E-DEV-FNL#1, & #2	KAW2-125-E-#1, & #2	1.16	1.15	1.40	1.11
250	Stock-Baseline	KAW2-BSLN#1, #3, & #4	KAW2-250-STK-#1, & #2	1.08	1.34	0.34	1.15
250	Engine-Out	KAW2-EO3-#1	KAW2-250-EO3-#1, & #2	1.17	1.17	1.17	0.82
250	Developed	KAW2-E-DEV-FNL#1, & #2	KAW2-250-E-#1, #2, & #3	1.32	1.30	1.78	1.20

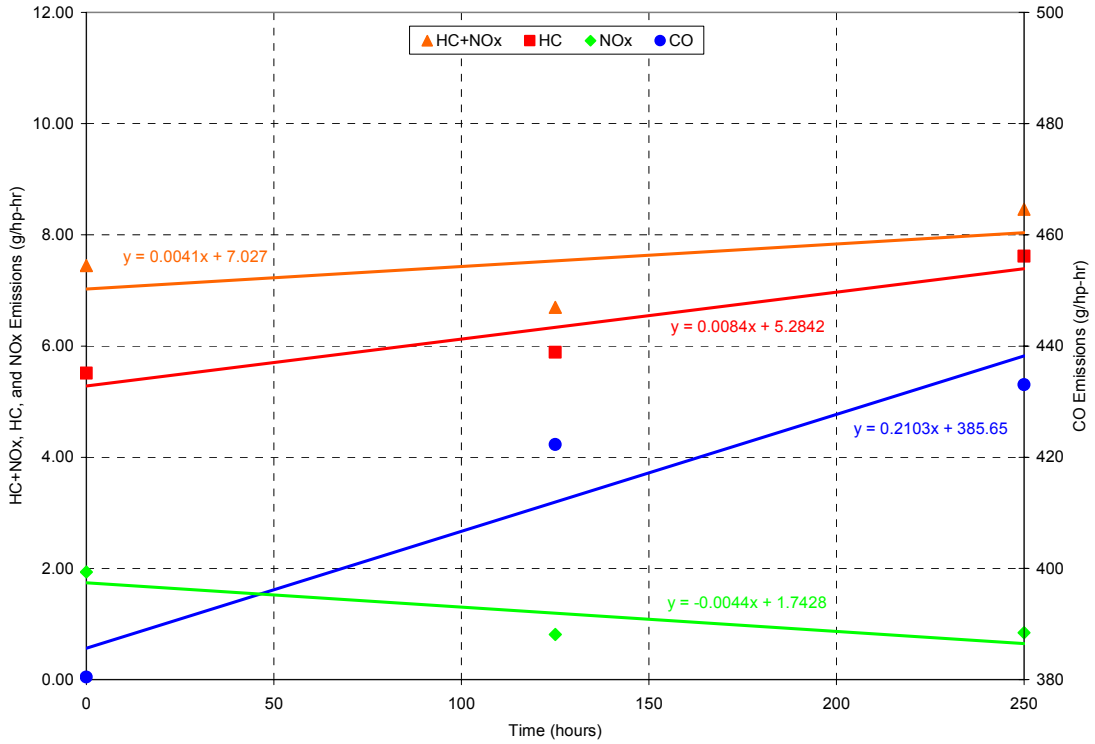

FIGURE 27. KAWASAKI FH601V EMISSIONS FOR STOCK CONFIGURATION

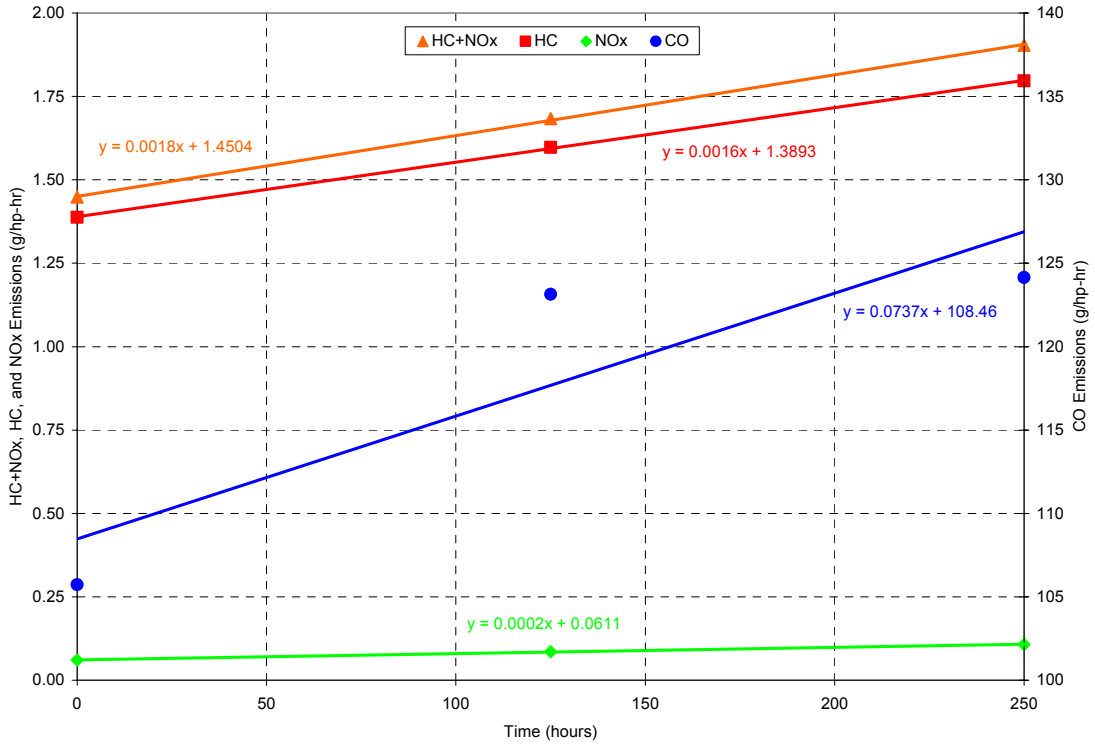

FIGURE 28. KAWASAKI FH601V EMISSIONS FOR DEVELOPED CONFIGURATION

F. Honda GX340 Engine

No testing has taken place on this engine to date.

IV. SUMMARY AND CONCLUSIONS

Six small, off-road engines are being developed in low-emission configurations and aged through their useful lives to demonstrate the effectiveness and durability of catalyst application. Four of the engines are used in walk-behind mower (WBM) applications, one is for a riding mower, and one is used in constant-speed/generator applications. The program goal is to reduce HC+NO_x emissions at the end of the engine's useful life by at least 50% as compared to current CARB standards. Low-emission engines were developed using three-way catalytic converters, passive secondary-air induction (SAI) systems, and enleanment, where needed.

Variability in engine operation and emissions presented additional challenges. One of the developed engines failed and was removed from the program. Two of the the three other engines tested to date were replaced at zero hours due to questions about their operation. Engine fueling characteristics and resulting emissions were observed to shift from one durability interval to the next. Good results were obtained in spite of these difficulties.

Results demonstrate that emissions from these engines can be significantly reduced. The project goal of a 50% minimum HC+NO_x reduction at useful life was successfully demonstrated on three of the four engines tested thus far, as shown in Figure 29.

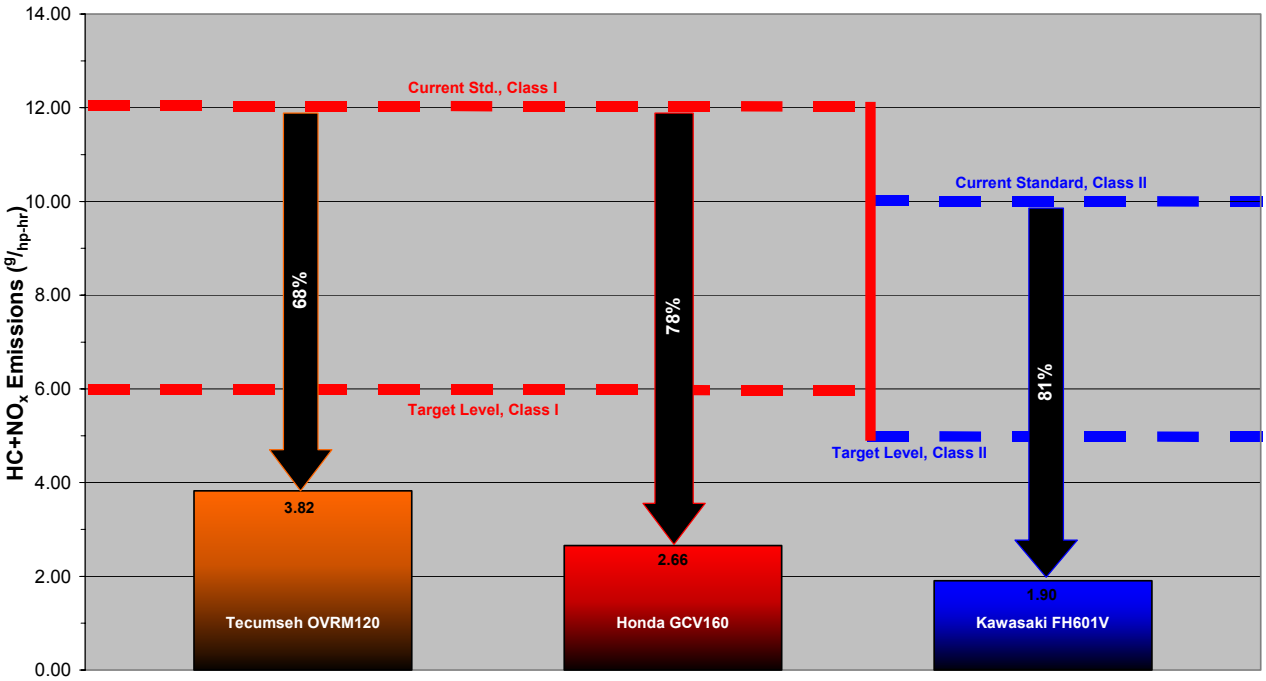

FIGURE 29. DEVELOPED ENGINE EMISSIONS AT 250 HOURS

Emissions were reduced from the first Briggs and Stratton engine using a three-way catalyst, a passive SAI system, and enleanment. The engine was removed from the program after 125 hours due to engine deterioration. Overall emission reductions at 125 hours were poor, primarily due to a large increase in engine-out emissions. In spite of the engine deterioration, the catalyst held up well, reducing engine-out $HC+NO_x$ emissions at 125 hours by 58%, and CO emissions by 59%. While the engine may have been deteriorated by the somewhat leaner calibration employed, there were already indications of engine problems at zero hours, prior to beginning durability. A second Briggs and Stratton engine is being developed with no change to base engine calibration in an attempt to meet the low emissions goal.

The Tecumseh OVRM120 engine successfully completed 250 hours of durability. The developed, low emissions configuration included a three-way catalyst and a passive SAI system. The stock engine air/fuel calibration was not altered. At 250 hours, emissions were reduced by 50% for $HC+NO_x$, 42% for HC, 78% for NO_x, and 30% for CO, as compared to 0-hour baseline emissions. Catalyst performance at 250 hours was 64% for $HC+NO_x$, 61% for HC, 78% for NO_x, and 40% for CO.

The Honda GCV160 engine successfully completed 250 hours of durability. The developed, low emissions configuration included a three-way catalyst and a passive SAI system. As was the case with the Tecumseh engine, the stock engine calibration was not changed. At 250 hours, $HC+NO_x$ emissions were reduced by 70%, HC by 65%, NO_x by 83%, and CO by 74%, as compared to 0-hour baseline emissions. Catalyst performance held up well with 250 hour conversions of 77% for $HC+NO_x$, 57% for HC, 93% for NO_x, and 48% for CO.

To date, the Kawasaki FH601V engine has been tested at 250 hours and is currently being aged to 500 hours. The developed configuration includes a three-way catalyst, passive SAI system, and enleanment. At 250 hours, $HC+NO_x$ emissions were reduced by 74%, HC by 67%, NO_x by 94%, and CO by 67%, as compared to 0-hour baseline emissions. Catalyst percent conversions at 250 hours were 75% for $HC+NO_x$, 73% for HC, 89% for NO_x, and 71% for CO.

Overall reductions in $HC+NO_x$ emissions for the Tecumseh, Honda, and Kawasaki engines, as compared to 0-hour baseline emissions, are shown in Figure 30. Catalyst performance on the three engines is shown in Figure 31, which summarizes percent $HC+NO_x$ conversions at test intervals.

It should be kept in mind that these are prototype systems, developed for the purpose of a demonstration. They are by no means optimized for size or cost. Catalysts were conservatively chosen in order to meet program goals. Solutions employing smaller and less expensive catalysts can likely achieve similar performance with additional development.

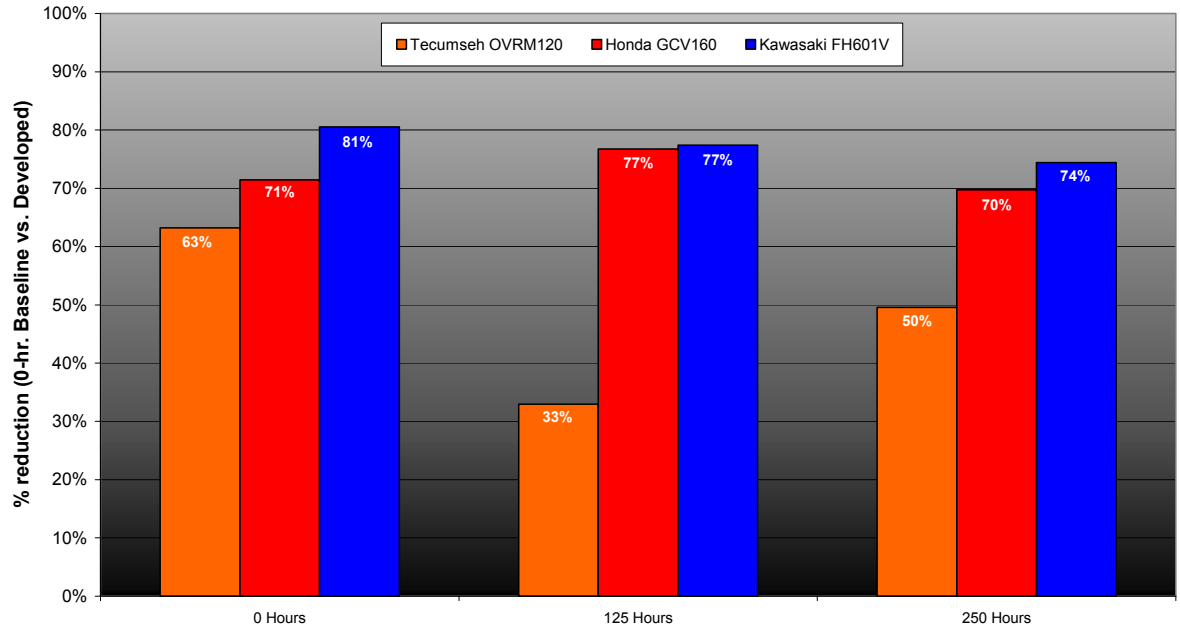

FIGURE 30. EMISSION REDUCTIONS COMPARED TO 0-HOUR BASELINE RESULTS

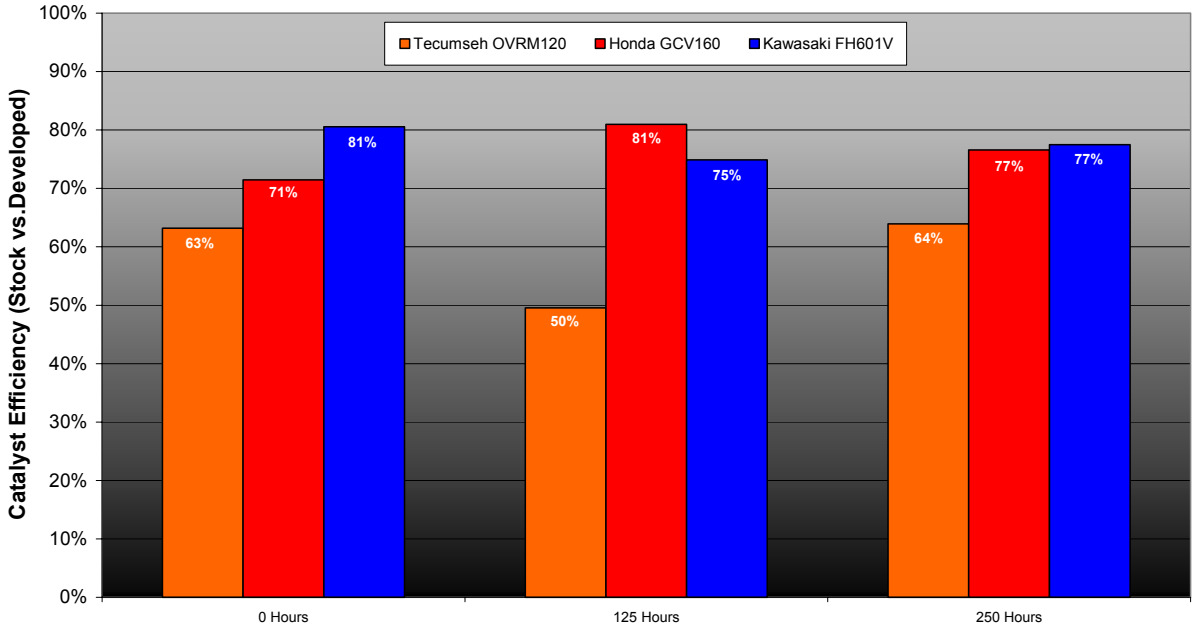

FIGURE 31. CATALYST HC+NO_x PERCENT CONVERSION VS. DURABILITY HOURS

APPENDIX A

BRIGGS AND STRATTON INTEK NO. 1 EMISSION DATA SHEETS

Steady-State SORE Engine Test Information **Engine: B+S #1 6.5HP**

Date: 10/23/02

Test ID: B+S #1 BSLN5

Baseline emissions test with "lighter" governor spring and stock jetting

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07	
DF Mode Interval (sec)	-----		300	300	300	300	300	
Speed Set	%Rated		85	85	85	85	85	
Load Set	%Rated		100	75	50	25	10	
ENGINE DATA								
Obs. Speed	rpm		3041	3061	3060	3063	3019	
Obs. Power	hp		4.24	3.27	2.17	1.08	0.42	
Obs. Torque	ft-lb		7.23	5.53	3.67	1.82	0.73	
Calc. Power (Obs. Torque*Speed)	hp		4.19	3.22	2.14	1.06	0.42	
Work (5 min Interval)	hp-hr		0.354	0.272	0.181	0.090	0.035	
Fuel Flow	lb/hr		2.846	2.428	1.925	1.333	1.080	
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	
Oil	deg F		254	268	244	210	190	
Exhaust Gas (muffler-in/manifold)	deg F		1259	1251	1252	1225	1216	
Exhaust Gas (muffler out)	deg F		766	663	546	406	336	
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	
Intake Air (EPA)	deg F		79	79	78	77	76	
Intake Air DewPoint (EPA)	deg F		61	61	61	61	62	
Cyl Head (Spark Plug)	deg F		449	427	387	330	302	
PRESSURES								
Exhaust BP Before Cat	psig		0.77	0.56	0.35	0.15	0.08	
Barometer	"Hg		29.098	29.096	29.094	29.092	29.095	
F Factor	-----		1.027	1.027	1.027	1.025	1.024	
GASEOUS EMISSIONS			EMISSIONS ARE UNWEIGHTED[1] (ETIS)					
Dilute HC conc (wet)	ppm		145.85	131.55	116.55	118.11	120.41	
Dilute CO conc (dry)	%		0.39	0.32	0.24	0.17	0.13	
Dilute CO_2 conc (dry)	%		0.58	0.51	0.42	0.29	0.24	
Dilute NO_x conc (dry)	ppm		18.07	16.72	10.06	3.50	2.16	
Measured A/F	-----		11.90	12.05	12.16	11.79	11.83	
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	
NO_x Humidity Correction	-----		1.04	1.04	1.04	1.04	1.05	
Raw O_2 conc (dry)$_{measured}$	%		-0.01	0.20	0.18	0.25	0.35	
HC Mass	g/hr		19.38	17.45	15.61	15.97	16.41	
NO_x Mass	g/hr		8.16	7.56	4.60	1.60	1.00	
CO Mass	g/hr		1022.0	843.7	631.7	454.9	363.7	
CO_2 Mass	g/hr		2269	1978	1621	1079	871	
BSHC	g/hp-hr		4.48	5.33	7.19	14.79	37.99	
BSNO_x	g/hp-hr		1.89	2.31	2.12	1.48	2.31	
BSCO	g/hp-hr		236.22	257.72	290.95	421.17	842.23	
BSCO_2	g/hp-hr		524.55	604.10	746.69	999.53	2017.47	

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**7.88**	**2.06**	**9.94**	**303.5**	**729.4**	**0.890**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: B+S #1 6.5HP**

Date: 10/23/02

Test ID: B+S #1 BSLN6

Baseline emissions test with "lighter" governor spring and stock jetting (methane test)

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5		
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07		
DF Mode Interval (sec)	-----		300	300	300	300	300		
Speed Set	%Rated		85	85	85	85	85		
Load Set	%Rated		100	75	50	25	10		
ENGINE DATA									
Obs. Speed	rpm		3058	3064	3059	3080	3046		
Obs. Power	hp		4.32	3.25	2.16	1.12	0.42		
Obs. Torque	ft-lb		7.32	5.49	3.65	1.89	0.71		
Calc. Power (Obs. Torque*Speed)	hp		4.26	3.21	2.13	1.11	0.41		
Work (5 min Interval)	hp-hr		0.360	0.271	0.180	0.094	0.035		
Fuel Flow	lb/hr		2.875	2.467	1.856	1.389	1.097		
TEMPERATURES									
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA		
Oil	deg F		239	259	234	203	192		
Exhaust Gas (muffler-in/manifold)	deg F		1264	1250	1258	1237	1223		
Exhaust Gas (muffler out)	deg F		767	651	537	412	337		
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA		
Intake Air (EPA)	deg F		76	77	76	75	75		
Intake Air DewPoint (EPA)	deg F		62	61	61	61	61		
Cyl Head (Spark Plug)	deg F		442	419	380	328	302		
PRESSURES									
Exhaust BP Before Cat	psig		0.74	0.53	0.31	0.14	0.06		
Barometer	"Hg		29.129	29.124	29.123	29.117	29.109		
F Factor	-----		1.022	1.023	1.022	1.021	1.021		
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**						
Dilute HC conc (wet)	ppm		158.40	148.42	112.35	118.65	121.63		
Dilute CO conc (dry)	%		0.40	0.32	0.22	0.17	0.14		
Dilute CO_2 conc (dry)	%		0.58	0.51	0.41	0.30	0.24		
Dilute NO_x conc (dry)	ppm		17.29	15.23	9.49	3.56	1.79		
Measured A/F	-----		11.84	11.97	12.22	11.80	11.81		
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98		
NO_x Humidity Correction	-----		1.05	1.04	1.04	1.04	1.03		
Raw O_2 conc $(dry)_{measured}$	%		0.25	0.34	0.27	0.31	0.34		
HC Mass	g/hr		20.90	19.73	14.90	15.92	16.42		
NO_x Mass	g/hr		7.87	7.04	4.35	1.63	0.81		
CO Mass	g/hr		1043.7	862.1	594.9	472.5	376.8		
CO_2 Mass	g/hr		2270	1996	1585	1128	874		
BSHC	g/hp-hr		4.77	6.07	6.94	14.27	39.11		
$BSNO_x$	g/hp-hr		1.80	2.17	2.02	1.46	1.92		
BSCO	g/hp-hr		238.42	265.20	276.87	423.51	897.49		
$BSCO_2$	g/hp-hr		518.57	613.95	737.82	1011.51	2082.50		

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC $(^{lb}/_{hp\text{-}hr})$
Weighted Specific Emissions[3]	g/hp-hr		**8.04**	**1.96**	**10.00**	**303.4**	**732.1**	**0.892**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: B&S#1 6.5hp**

Date: 11/22/02

Test ID: B&S #1 BSLN-JET#2

Baseline Test with Fixed Jet #2 (.027 in) and STOCK muffler

DESCRIPTION	UNIT		1	2	3	4	5	
Mode	-----		1	2	3	4	5	
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07	
DF Mode Interval (sec)	-----		120	120	120	120	120	
Speed Set	%Rated		85	85	85	85	85	
Load Set	%Rated		100	75	50	25	10	
ENGINE DATA								
Obs. Speed	rpm		3050	3070	3069	3059	3047	
Obs. Power	hp		3.43	2.62	1.74	0.86	0.35	
Obs. Torque	ft-lb		5.83	4.41	2.93	1.46	0.59	
Calc. Power (Obs. Torque*Speed)	hp		3.39	2.58	1.71	0.85	0.34	
Work (5 min Interval)	hp-hr		0.114	0.087	0.058	0.029	0.012	
Fuel Flow	lb/hr		2.417	2.015	1.475	1.146	0.969	
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	
Oil	deg F		276	280	247	223	203	
Exhaust Gas (muffler-in/manifold)	deg F		1309	1264	1221	1181	1204	
Exhaust Gas (muffler out)	deg F		844	698	536	430	389	
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	
Intake Air (EPA)	deg F		88	90	90	89	87	
Intake Air DewPoint (EPA)	deg F		36	36	35	35	35	
Cyl Head (Spark Plug)	deg F		475	435	383	339	319	
PRESSURES								
Exhaust BP Before Cat	psig		0.60	0.39	0.25	0.17	0.14	
Barometer	"Hg		29.370	29.375	29.377	29.377	29.375	
F Factor	-----		1.018	1.021	1.020	1.018	1.016	
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		138.45	155.84	133.87	107.99	96.10	
Dilute CO conc (dry)	%		0.22	0.18	0.13	0.11	0.09	
Dilute CO_2 conc (dry)	%		0.61	0.51	0.38	0.29	0.25	
Dilute NO_x conc (dry)	ppm		53.83	39.11	17.96	4.81	2.29	
Measured A/F	-----		13.08	13.11	13.00	12.71	12.77	
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	
NO_x Humidity Correction	-----		0.83	0.83	0.83	0.83	0.83	
Raw O_2 conc $(dry)_{measured}$	%		NA	NA	NA	NA	NA	
HC Mass	g/hr		18.20	20.82	18.04	14.55	13.00	
NO_x Mass	g/hr		19.56	14.41	6.65	1.75	0.81	
CO Mass	g/hr		583.6	473.5	344.2	304.9	258.3	
CO_2 Mass	g/hr		2412	2014	1469	1081	911	
BSHC	g/hp-hr		5.26	8.01	10.37	16.84	37.36	
$BSNO_x$	g/hp-hr		5.66	5.55	3.82	2.03	2.33	
BSCO	g/hp-hr		168.69	182.26	197.81	352.85	742.14	
$BSCO_2$	g/hp-hr		697.30	775.23	844.34	1250.81	2618.58	

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**10.26**	**4.46**	**14.73**	**223.8**	**899.7**	**0.916**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: B&S#1**

Date: 11/27/02

Test ID: B+S #1 CAT-C-STCK-JET

Catalyst C integrated in stock muffler, 4-hole Venturi and Check Valve SAI, with STOCK Carburetor Jet

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07	
DF Mode Interval (sec)	-----		300	300	300	300	300	
Speed Set	%Rated		85	85	85	85	85	
Load Set	%Rated		100	75	50	25	10	
ENGINE DATA								
Obs. Speed	rpm		3056	3066	3052	3057	3061	
Obs. Power	hp		3.48	2.65	1.76	0.88	0.36	
Obs. Torque	ft-lb		5.90	4.48	2.98	1.48	0.61	
Calc. Power (Obs. Torque*Speed)	hp		3.43	2.61	1.73	0.86	0.36	
Work (5 min Interval)	hp-hr		0.290	0.221	0.146	0.073	0.030	
Fuel Flow	lb/hr		0.000	0.000	0.000	0.000	0.000	
TEMPERATURES								
Catalyst Mid-bed	deg F		1267	1242	1215	1207	1229	
Oil	deg F		307	287	238	210	195	
Exhaust Gas (muffler-in/manifold)	deg F		972	897	797	748	758	
Exhaust Gas (muffler out)	deg F		831	729	615	545	511	
Catalyst/Muffler Surface	deg F		758	710	647	612	599	
Intake Air (EPA)	deg F		93	95	94	91	89	
Intake Air DewPoint (EPA)	deg F		24	25	24	25	25	
Cyl Head (Spark Plug)	deg F		473	435	373	325	309	
PRESSURES								
Exhaust BP Before Cat	psig		1.02	0.67	0.38	0.27	0.23	
Barometer	"Hg		29.445	29.439	29.423	29.436	29.435	
F Factor	-----		1.019	1.022	1.020	1.016	1.014	
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		126.59	107.84	80.20	74.42	57.11	
Dilute CO conc (dry)	%		0.25	0.19	0.12	0.11	0.07	
Dilute CO_2 conc (dry)	%		0.64	0.52	0.40	0.32	0.29	
Dilute NO_x conc (dry)	ppm		3.24	1.79	0.62	0.17	0.15	
Measured A/F	-----		12.57	12.62	12.56	11.88	12.27	
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	
NO_x Humidity Correction	-----		0.79	0.80	0.79	0.79	0.80	
Raw O_2 conc (dry)$_{measured}$	%		0.94	1.10	1.38	1.70	1.90	
HC Mass	g/hr		16.75	14.33	10.69	9.99	7.58	
NO_x Mass	g/hr		1.10	0.61	0.20	0.04	0.03	
CO Mass	g/hr		672.1	504.7	341.9	318.2	215.8	
CO_2 Mass	g/hr		2537	2052	1574	1206	1081	
BSHC	g/hp-hr		4.81	5.41	6.09	11.41	20.87	
BSNO_x	g/hp-hr		0.32	0.23	0.11	0.05	0.09	
BSCO	g/hp-hr		193.05	190.49	194.76	363.21	593.79	
BSCO_2	g/hp-hr		728.63	774.61	896.61	1376.80	2973.92	

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**6.80**	**0.18**	**6.98**	**229.1**	**946.4**	**0.948**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: B+S #1**

Date: 11/27/02

Test ID: B+S #1 CAT-C-BSLN3

Catalyst C integrated in muffler, Jet #2 (0.027 in.), 4-hole Venturi with Check Valve SAI

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5		
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07		
DF Mode Interval (sec)	-----		300	300	300	300	300		
Speed Set	%Rated		85	85	85	85	85		
Load Set	%Rated		100	75	50	25	10		
ENGINE DATA									
Obs. Speed	rpm		3054	3065	3053	3057	3052		
Obs. Power	hp		3.59	2.74	1.82	0.90	0.37		
Obs. Torque	ft-lb		6.09	4.64	3.08	1.53	0.63		
Calc. Power (Obs. Torque*Speed)	hp		3.54	2.71	1.79	0.89	0.36		
Work (5 min Interval)	hp-hr		0.299	0.229	0.151	0.075	0.031		
Fuel Flow	lb/hr		2.388	1.934	1.499	1.179	0.893		
TEMPERATURES									
Catalyst Mid-bed	deg F		1308	1299	1300	1316	1314		
Oil	deg F		304	276	238	205	192		
Exhaust Gas (muffler-in/manifold)	deg F		1100	1037	967	888	896		
Exhaust Gas (muffler out)	deg F		857	756	668	597	510		
Catalyst/Muffler Surface	deg F		771	718	672	634	614		
Intake Air (EPA)	deg F		85	82	82	77	77		
Intake Air DewPoint (EPA)	deg F		23	24	23	23	24		
Cyl Head (Spark Plug)	deg F		483	435	379	330	311		
PRESSURES									
Exhaust BP Before Cat	psig		0.87	0.50	0.31	0.20	0.15		
Barometer	"Hg		29.523	29.550	29.548	29.555	29.555		
F Factor	-----		1.006	1.000	1.001	0.993	0.994		
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**						
Dilute HC conc (wet)	ppm		75.08	59.52	42.95	41.93	12.81		
Dilute CO conc (dry)	%		0.11	0.08	0.05	0.04	0.00		
Dilute CO_2 conc (dry)	%		0.71	0.59	0.47	0.37	0.32		
Dilute NO_x conc (dry)	ppm		6.54	3.86	1.42	0.56	1.08		
Measured A/F	-----		13.63	13.72	13.59	13.31	14.26		
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99		
NO_x Humidity Correction	-----		0.79	0.79	0.79	0.79	0.79		
Raw O_2 conc $(dry)_{measured}$	%		0.98	1.26	1.59	2.20	2.65		
HC Mass	g/hr		9.78	7.77	5.56	5.49	1.42		
NO_x Mass	g/hr		2.24	1.33	0.47	0.16	0.35		
CO Mass	g/hr		303.5	206.0	137.4	115.9	5.4		
CO_2 Mass	g/hr		2837	2361	1867	1453	1238		
BSHC	g/hp-hr		2.70	2.84	3.07	6.11	3.81		
$BSNO_x$	g/hp-hr		0.62	0.49	0.26	0.18	0.95		
BSCO	g/hp-hr		83.77	75.30	75.87	128.81	14.47		
$BSCO_2$	g/hp-hr		783.10	862.77	1030.60	1614.86	3329.66		

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**3.48**	**0.40**	**3.88**	**86.1**	**1075.0**	**0.872**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: B&S#1**

Date: 11/27/02

Test ID: B+S #1 CAT-C-BSLN4

Catalyst C integrated in muffler, Jet #2 (0.027 in.), 4-hole Venturi with Check Valve SAI

DESCRIPTION	UNIT		1	2	3	4	5	
Mode	-----		1	2	3	4	5	
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07	
DF Mode Interval (sec)	-----		300	300	300	300	300	
Speed Set	%Rated		85	85	85	85	85	
Load Set	%Rated		100	75	50	25	10	
ENGINE DATA								
Obs. Speed	rpm		3050	3066	3054	3056	3061	
Obs. Power	hp		3.48	2.71	1.80	0.91	0.36	
Obs. Torque	ft-lb		5.91	4.57	3.05	1.54	0.62	
Calc. Power (Obs. Torque*Speed)	hp		3.43	2.67	1.77	0.90	0.36	
Work (5 min Interval)	hp-hr		0.290	0.226	0.150	0.076	0.030	
Fuel Flow	lb/hr		2.393	2.016	1.518	1.159	0.858	
TEMPERATURES								
Catalyst Mid-bed	deg F		1310	1305	1299	1289	1328	
Oil	deg F		307	288	243	204	194	
Exhaust Gas (muffler-in/manifold)	deg F		1099	1038	967	879	897	
Exhaust Gas (muffler out)	deg F		855	764	665	564	502	
Catalyst/Muffler Surface	deg F		770	724	671	624	614	
Intake Air (EPA)	deg F		83	84	80	83	82	
Intake Air DewPoint (EPA)	deg F		24	25	24	23	23	
Cyl Head (Spark Plug)	deg F		485	443	381	327	313	
PRESSURES								
Exhaust BP Before Cat	psig		0.87	0.53	0.31	0.19	0.15	
Barometer	"Hg		29.476	29.455	29.458	29.459	29.453	
F Factor	-----		1.004	1.006	1.002	1.005	1.004	
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		76.34	71.52	50.52	39.74	13.75	
Dilute CO conc (dry)	%		0.12	0.09	0.06	0.05	0.00	
Dilute CO_2 conc (dry)	%		0.71	0.61	0.47	0.36	0.31	
Dilute NO_x conc (dry)	ppm		7.04	5.61	2.21	0.80	1.02	
Measured A/F	-----		13.63	13.66	13.56	13.28	14.19	
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	
NO_x Humidity Correction	-----		0.79	0.79	0.79	0.79	0.79	
Raw O_2 conc (dry)$_{measured}$	%		1.05	1.27	1.62	2.05	2.43	
HC Mass	g/hr		9.97	9.37	6.63	5.21	1.61	
NO_x Mass	g/hr		2.44	1.93	0.76	0.25	0.33	
CO Mass	g/hr		310.6	235.9	156.3	128.8	0.0	
CO_2 Mass	g/hr		2833	2425	1861	1405	1197	
BSHC	g/hp-hr		2.79	3.46	3.68	5.71	4.48	
BSNO_x	g/hp-hr		0.68	0.71	0.42	0.28	0.93	
BSCO	g/hp-hr		86.87	86.99	86.81	141.26	0.00	
BSCO_2	g/hp-hr		792.16	894.04	1033.72	1540.23	3322.61	

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**3.85**	**0.55**	**4.40**	**96.0**	**1076.4**	**0.885**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: B+S#1 6.5 hp**

Date: 2/6/03

Test ID: B+S#1-125-#1

125-hr. interval emissions testing with orig SAI check valve, fixed jet #2 (0.027in.), and catalyst C

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07	
DF Mode Interval (sec)	-----		300	300	300	300	300	
Speed Set	%Rated		85	85	85	85	85	
Load Set	%Rated		100	75	50	25	10	
ENGINE DATA								
Obs. Speed	rpm		3055	3062	3062	3081	3061	
Obs. Power	hp		3.16	2.39	1.58	0.76	0.31	
Obs. Torque	ft-lb		5.36	4.05	2.66	1.28	0.53	
Calc. Power (Obs. Torque*Speed)	hp		3.12	2.36	1.55	0.75	0.31	
Work (5 min Interval)	hp-hr		0.263	0.200	0.131	0.064	0.026	
Fuel Flow	lb/hr		2.231	1.803	1.464	1.129	0.943	
TEMPERATURES								
Catalyst Mid-bed	deg F		1353	1355	1295	1273	1273	
Oil	deg F		253	228	208	185	177	
Exhaust Gas (muffler-in/manifold)	deg F		1042	998	928	883	867	
Exhaust Gas (muffler out)	deg F		835	788	694	615	578	
Catalyst/Muffler Surface	deg F		769	733	677	634	613	
Intake Air (EPA)	deg F		81	80	78	76	76	
Intake Air DewPoint (EPA)	deg F		48	47	45	44	44	
Cyl Head (Spark Plug)	deg F		450	406	358	321	305	
PRESSURES								
Exhaust BP Before Cat	psig		------	------	------	------	------	
Barometer	"Hg		29.032	29.037	29.044	29.048	29.041	
F Factor	-----		1.025	1.023	1.019	1.016	1.016	
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		137.13	102.36	98.40	62.09	34.50	
Dilute CO conc (dry)	%		0.15	0.10	0.09	0.06	0.04	
Dilute CO_2 conc (dry)	%		0.63	0.54	0.43	0.35	0.31	
Dilute NO_x conc (dry)	ppm		11.71	6.05	2.51	0.88	0.44	
Measured A/F	-----		13.42	13.54	13.29	13.37	13.43	
Dry/Wet Correction	-----		0.98	0.98	0.99	0.99	0.99	
NO_x Humidity Correction	-----		0.90	0.89	0.88	0.87	0.87	
Raw O_2 conc $(dry)_{measured}$	%		1.31	1.57	1.77	1.93	2.10	
HC Mass	g/hr		17.61	13.10	12.68	7.86	4.14	
NO_x Mass	g/hr		4.54	2.33	0.94	0.30	0.13	
CO Mass	g/hr		399.1	253.2	236.7	155.3	101.0	
CO_2 Mass	g/hr		2444	2087	1639	1313	1150	
BSHC	g/hp-hr		5.56	5.49	8.01	10.24	13.29	
$BSNO_x$	g/hp-hr		1.43	0.98	0.59	0.39	0.41	
BSCO	g/hp-hr		126.03	106.04	149.49	202.26	323.94	
$BSCO_2$	g/hp-hr		771.57	874.16	1035.14	1710.02	3685.58	

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**7.27**	**0.85**	**8.12**	**144.0**	**1094.5**	**0.959**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: B+S#1 6.5 hp**

Date: 2/6/03

Test ID: B+S #1-125-#2

125-hr. interval emissions testing with replacement SAI check valve, fixed jet #2 (0.027in.), and catalyst C

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07	
DF Mode Interval (sec)	-----		300	300	300	300	300	
Speed Set	%Rated		85	85	85	85	85	
Load Set	%Rated		100	75	50	25	10	
ENGINE DATA								
Obs. Speed	rpm		3061	3060	3061	3077	3057	
Obs. Power	hp		3.26	2.43	1.62	0.84	0.32	
Obs. Torque	ft-lb		5.51	4.11	2.75	1.41	0.54	
Calc. Power (Obs. Torque*Speed)	hp		3.21	2.39	1.60	0.83	0.32	
Work (5 min Interval)	hp-hr		0.271	0.202	0.135	0.070	0.027	
Fuel Flow	lb/hr		2.291	1.876	1.461	1.185	0.958	
TEMPERATURES								
Catalyst Mid-bed	deg F		1325	1317	1272	1260	1251	
Oil	deg F		247	224	197	182	173	
Exhaust Gas (muffler-in/manifold)	deg F		1045	998	922	878	860	
Exhaust Gas (muffler out)	deg F		820	767	679	615	566	
Catalyst/Muffler Surface	deg F		763	726	666	634	608	
Intake Air (EPA)	deg F		78	76	75	74	73	
Intake Air DewPoint (EPA)	deg F		49	49	49	49	49	
Cyl Head (Spark Plug)	deg F		447	401	351	316	299	
PRESSURES								
Exhaust BP Before Cat	psig		------	------	------	------	------	
Barometer	"Hg		29.042	29.051	29.065	29.068	29.068	
F Factor	-----		1.021	1.018	1.016	1.014	1.013	
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		143.71	107.49	96.18	68.20	40.75	
Dilute CO conc (dry)	%		0.16	0.10	0.09	0.06	0.04	
Dilute CO_2 conc (dry)	%		0.64	0.54	0.43	0.37	0.32	
Dilute NO_x conc (dry)	ppm		13.23	6.80	2.61	0.92	0.61	
Measured A/F	-----		13.42	13.51	13.32	13.33	13.48	
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	
NO_x Humidity Correction	-----		0.91	0.91	0.90	0.90	0.91	
Raw O_2 conc $(dry)_{measured}$	%		1.19	1.42	1.61	1.85	1.96	
HC Mass	g/hr		18.94	14.51	12.58	8.86	5.17	
NO_x Mass	g/hr		5.24	2.75	1.00	0.32	0.20	
CO Mass	g/hr		412.6	277.7	244.7	163.4	99.8	
CO_2 Mass	g/hr		2502	2147	1623	1376	1169	
BSHC	g/hp-hr		5.82	5.93	7.77	10.55	15.95	
$BSNO_x$	g/hp-hr		1.61	1.12	0.62	0.38	0.61	
BSCO	g/hp-hr		126.86	113.38	151.15	194.56	308.22	
$BSCO_2$	g/hp-hr		769.26	876.68	1002.37	1638.98	3609.19	

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**7.51**	**0.94**	**8.45**	**146.2**	**1078.5**	**0.950**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: B+S#1 6.5 hp**

Date: 2/7/03

Test ID: B+S#1-125-BSLN

Fixed Jet #2 (0.027 in.) and stock muffler, tested after 125-hr. service accumulation

DESCRIPTION	UNIT		1	2	3	4	5	
Mode	-----		1	2	3	4	5	
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07	
DF Mode Interval (sec)	-----		300	300	300	300	300	
Speed Set	%Rated		85	85	85	85	85	
Load Set	%Rated		100	75	50	25	10	
ENGINE DATA								
Obs. Speed	rpm		3058	3061	3058	3062	3046	
Obs. Power	hp		3.18	2.41	1.59	0.79	0.31	
Obs. Torque	ft-lb		5.39	4.07	2.70	1.33	0.53	
Calc. Power (Obs. Torque*Speed)	hp		3.14	2.37	1.57	0.78	0.31	
Work (5 min Interval)	hp-hr		0.265	0.201	0.133	0.066	0.026	
Fuel Flow	lb/hr		2.309	1.886	1.509	1.125	1.057	
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	
Oil	deg F		244	229	201	179	173	
Exhaust Gas (muffler-in/manifold)	deg F		1287	1256	1221	1224	1234	
Exhaust Gas (muffler out)	deg F		777	683	563	467	420	
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	
Intake Air (EPA)	deg F		77	81	77	71	77	
Intake Air DewPoint (EPA)	deg F		30	30	30	30	29	
Cyl Head (Spark Plug)	deg F		440	405	355	314	302	
PRESSURES								
Exhaust BP Before Cat	psig		------	------	------	------	------	
Barometer	"Hg		29.461	29.453	29.444	29.451	29.449	
F Factor	-----		0.998	1.004	0.999	0.991	0.999	
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		244.53	228.89	198.03	126.25	104.38	
Dilute CO conc (dry)	%		0.20	0.16	0.13	0.10	0.10	
Dilute CO_2 conc (dry)	%		0.58	0.48	0.38	0.29	0.27	
Dilute NO_x conc (dry)	ppm		57.68	37.84	16.57	4.94	2.91	
Measured A/F	-----		13.20	13.17	13.00	12.92	12.82	
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	
NO_x Humidity Correction	-----		0.81	0.81	0.81	0.81	0.81	
Raw O_2 conc $(dry)_{measured}$	%		0.57	0.63	0.66	0.55	0.55	
HC Mass	g/hr		32.59	30.53	26.66	17.04	14.02	
NO_x Mass	g/hr		20.86	13.75	6.04	1.76	1.01	
CO Mass	g/hr		532.3	427.7	364.0	284.6	284.6	
CO_2 Mass	g/hr		2297	1875	1459	1076	990	
BSHC	g/hp-hr		10.25	12.72	16.70	21.52	43.29	
$BSNO_x$	g/hp-hr		6.56	5.73	3.78	2.23	3.12	
BSCO	g/hp-hr		167.32	178.19	228.02	359.36	878.58	
$BSCO_2$	g/hp-hr		722.17	781.24	913.56	1358.23	3055.16	

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**15.63**	**4.73**	**20.35**	**235.0**	**952.9**	**0.978**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: B+S#1 6.5 hp**

Date: 2/7/03

Test ID: B+S#1-125-STK-BSLN

Stock fixed jet and muffler, tested after 125-hr. service accumulation

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5		
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07		
DF Mode Interval (sec)	-----		300	300	300	300	300		
Speed Set	%Rated		85	85	85	85	85		
Load Set	%Rated		100	75	50	25	10		
ENGINE DATA									
Obs. Speed	rpm		3069	3053	3058	3058	3072		
Obs. Power	hp		3.25	2.47	1.64	0.83	0.33		
Obs. Torque	ft-lb		5.49	4.19	2.77	1.41	0.55		
Calc. Power (Obs. Torque*Speed)	hp		3.21	2.44	1.61	0.82	0.32		
Work (5 min Interval)	hp-hr		0.271	0.206	0.136	0.070	0.027		
Fuel Flow	lb/hr		2.506	2.066	1.631	1.339	1.176		
TEMPERATURES									
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA		
Oil	deg F		224	208	184	169	163		
Exhaust Gas (muffler-in/manifold)	deg F		1242	1210	1176	1180	1198		
Exhaust Gas (muffler out)	deg F		755	658	539	456	408		
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA		
Intake Air (EPA)	deg F		71	69	67	68	70		
Intake Air DewPoint (EPA)	deg F		30	29	29	30	30		
Cyl Head (Spark Plug)	deg F		411	376	332	301	286		
PRESSURES									
Exhaust BP Before Cat	psig		------	------	------	------	------		
Barometer	"Hg		29.445	29.426	29.424	29.425	29.431		
F Factor	-----		0.991	0.989	0.986	0.988	0.990		
GASEOUS EMISSIONS			EMISSIONS ARE UNWEIGHTED[1] (ETIS)						
Dilute HC conc (wet)	ppm		282.83	258.24	215.57	166.37	142.72		
Dilute CO conc (dry)	%		0.30	0.25	0.20	0.16	0.15		
Dilute CO_2 conc (dry)	%		0.53	0.44	0.35	0.29	0.25		
Dilute NO_x conc (dry)	ppm		24.49	16.91	8.30	3.43	2.12		
Measured A/F	-----		12.32	12.30	12.16	11.94	11.75		
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99		
NO_x Humidity Correction	-----		0.81	0.81	0.81	0.81	0.81		
Raw O_2 conc $(dry)_{measured}$	%		0.56	0.60	0.58	0.55	0.54		
HC Mass	g/hr		37.32	34.27	28.70	22.08	18.82		
NO_x Mass	g/hr		8.91	6.19	3.07	1.28	0.79		
CO Mass	g/hr		827.3	679.6	544.1	459.4	429.9		
CO_2 Mass	g/hr		2094	1720	1341	1085	914		
BSHC	g/hp-hr		11.31	13.94	17.37	26.29	58.09		
$BSNO_x$	g/hp-hr		2.70	2.52	1.86	1.53	2.45		
BSCO	g/hp-hr		250.77	276.33	329.24	547.04	1326.80		
$BSCO_2$	g/hp-hr		634.81	699.56	811.26	1292.21	2819.68		

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC $(^{lb}/_{hp\text{-}hr})$
Weighted Specific Emissions[3]	g/hp-hr		**17.46**	**2.21**	**19.67**	**353.1**	**863.4**	**1.051**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

APPENDIX B

BRIGGS AND STRATTON INTEK NO. 2 EMISSION DATA SHEETS

Steady-State SORE Engine Test Information **Engine: B+S#2 6.5HP**

Date: 10/21/02

Test ID: B+S #2 BSLN1

Baseline emissions test with "lighter" governor spring and stock jetting

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07	
DF Mode Interval (sec)	-----		300	300	300	300	300	
Speed Set	%Rated		85	85	85	85	85	
Load Set	%Rated		100	75	50	25	10	
ENGINE DATA								
Obs. Speed	rpm		3050	3065	3058	3053	3079	
Obs. Power	hp		4.31	3.27	2.17	1.08	0.43	
Obs. Torque	ft-lb		7.32	5.52	3.68	1.84	0.73	
Calc. Power (Obs. Torque*Speed)	hp		4.25	3.22	2.14	1.07	0.43	
Work (5 min Interval)	hp-hr		0.359	0.272	0.181	0.090	0.036	
Fuel Flow	lb/hr		2.857	2.357	1.865	1.501	1.214	
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	
Oil	deg F		245	250	231	208	190	
Exhaust Gas (muffler-in/manifold)	deg F		1320	1312	1339	1326	1344	
Exhaust Gas (muffler out)	deg F		825	722	628	486	399	
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	
Intake Air (EPA)	deg F		74	74	73	72	71	
Intake Air DewPoint (EPA)	deg F		60	60	60	60	60	
Cyl Head (Spark Plug)	deg F		431	411	372	329	303	
PRESSURES								
Exhaust BP Before Cat	psig		0.88	0.64	0.44	0.25	0.15	
Barometer	"Hg		29.048	29.036	29.038	29.040	29.035	
F Factor	-----		1.021	1.022	1.020	1.019	1.018	
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		110.67	113.92	94.84	109.35	119.43	
Dilute CO conc (dry)	%		0.41	0.32	0.24	0.21	0.16	
Dilute CO_2 conc (dry)	%		0.57	0.49	0.40	0.31	0.26	
Dilute NO_x conc (dry)	ppm		13.99	12.05	6.87	3.15	1.88	
Measured A/F	-----		12.50	12.55	12.61	12.44	12.54	
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	
NO_x Humidity Correction	-----		1.02	1.02	1.02	1.02	1.02	
Raw O_2 conc (dry)$_{measured}$	%		0.30	0.20	0.20	0.20	0.50	
HC Mass	g/hr		14.52	15.01	12.55	14.64	16.24	
NO_x Mass	g/hr		6.13	5.36	3.03	1.39	0.82	
CO Mass	g/hr		1075.6	844.2	646.2	559.7	434.4	
CO_2 Mass	g/hr		2215	1886	1524	1150	947	
BSHC	g/hp-hr		3.35	4.58	5.74	13.56	37.58	
BSNO_x	g/hp-hr		1.42	1.64	1.39	1.29	1.89	
BSCO	g/hp-hr		248.45	257.79	295.77	518.23	1005.65	
BSCO_2	g/hp-hr		511.75	575.96	697.66	1065.13	2191.40	

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**6.75**	**1.48**	**8.23**	**325.6**	**715.3**	**0.903**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: B+S#2 6.5HP**

Date: 10/22/02

Test ID: B+S #2 BSLN2

Baseline emissions testing with "lighter" governor spring and stock jetting

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5		
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07		
DF Mode Interval (sec)	-----		300	300	300	300	300		
Speed Set	%Rated		85	85	85	85	85		
Load Set	%Rated		100	75	50	25	10		
ENGINE DATA									
Obs. Speed	rpm		3055	3050	3054	3064	3042		
Obs. Power	hp		4.29	3.24	2.15	1.08	0.43		
Obs. Torque	ft-lb		7.28	5.50	3.65	1.82	0.73		
Calc. Power (Obs. Torque*Speed)	hp		4.24	3.19	2.12	1.06	0.42		
Work (5 min Interval)	hp-hr		0.358	0.270	0.179	0.090	0.036		
Fuel Flow	lb/hr		2.819	2.396	1.929	1.485	1.110		
TEMPERATURES									
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA		
Oil	deg F		260	256	228	208	193		
Exhaust Gas (muffler-in/manifold)	deg F		1333	1316	1350	1332	1341		
Exhaust Gas (muffler out)	deg F		825	727	626	488	397		
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA		
Intake Air (EPA)	deg F		78	78	72	74	74		
Intake Air DewPoint (EPA)	deg F		61	64	61	62	60		
Cyl Head (Spark Plug)	deg F		441	418	373	331	306		
PRESSURES									
Exhaust BP Before Cat	psig		0.64	0.54	0.38	0.21	0.12		
Barometer	"Hg		29.125	29.116	29.112	29.105	29.096		
F Factor	-----		1.025	1.028	1.018	1.020	1.021		
GASEOUS EMISSIONS			EMISSIONS ARE UNWEIGHTED[1] (ETIS)						
Dilute HC conc (wet)	ppm		104.37	115.08	94.23	106.69	104.15		
Dilute CO conc (dry)	%		0.40	0.33	0.24	0.20	0.15		
Dilute CO_2 conc (dry)	%		0.57	0.50	0.42	0.31	0.24		
Dilute NO_x conc (dry)	ppm		14.85	12.29	7.65	3.06	1.86		
Measured A/F	-----		12.33	12.44	12.57	12.53	12.69		
Dry/Wet Correction	-----		0.98	0.97	0.98	0.98	0.98		
NO_x Humidity Correction	-----		1.04	1.08	1.04	1.05	1.03		
Raw O_2 conc (dry)$_{measured}$	%		0.10	0.10	0.10	0.20	0.60		
HC Mass	g/hr		13.62	15.08	12.49	14.31	14.01		
NO_x Mass	g/hr		6.58	5.69	3.50	1.39	0.83		
CO Mass	g/hr		1042.2	853.7	638.8	537.0	396.8		
CO_2 Mass	g/hr		2218	1925	1624	1165	868		
BSHC	g/hp-hr		3.16	4.67	5.79	13.17	32.43		
$BSNO_x$	g/hp-hr		1.53	1.76	1.62	1.28	1.91		
BSCO	g/hp-hr		241.99	264.56	295.92	494.22	918.40		
$BSCO_2$	g/hp-hr		515.11	596.42	752.58	1072.06	2008.62		

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**6.64**	**1.62**	**8.26**	**322.1**	**740.1**	**0.916**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: B+S#2 6.5HP**

Date: 10/22/02

Test ID: B+S #2 BSLN3

Baseline emissions test with "lighter" governor spring and stock jetting (methane test)

DESCRIPTION	UNIT		1	2	3	4	5	
Mode	-----		1	2	3	4	5	
Weight Factor	-----		0.09	0.21	0.31	0.32	0.07	
DF Mode Interval (sec)	-----		300	300	300	300	300	
Speed Set	%Rated		85	85	85	85	85	
Load Set	%Rated		100	75	50	25	10	
ENGINE DATA								
Obs. Speed	rpm		3064	3051	3054	3079	3070	
Obs. Power	hp		4.35	3.24	2.18	1.09	0.45	
Obs. Torque	ft-lb		7.36	5.51	3.70	1.84	0.77	
Calc. Power (Obs. Torque*Speed)	hp		4.29	3.20	2.15	1.08	0.45	
Work (5 min Interval)	hp-hr		0.363	0.270	0.182	0.091	0.038	
Fuel Flow	lb/hr		2.850	2.430	1.863	1.438	1.121	
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	
Oil	deg F		244	246	225	201	188	
Exhaust Gas (muffler-in/manifold)	deg F		1317	1297	1325	1305	1309	
Exhaust Gas (muffler out)	deg F		830	713	626	490	403	
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	
Intake Air (EPA)	deg F		74	75	73	73	72	
Intake Air DewPoint (EPA)	deg F		62	62	62	62	62	
Cyl Head (Spark Plug)	deg F		436	413	375	331	306	
PRESSURES								
Exhaust BP Before Cat	psig		0.85	0.60	0.38	0.21	0.11	
Barometer	"Hg		29.097	29.129	29.125	29.121	29.120	
F Factor	-----		1.022	1.021	1.019	1.019	1.018	
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		103.80	104.67	84.30	97.20	105.28	
Dilute CO conc (dry)	%		0.39	0.32	0.23	0.19	0.15	
Dilute CO_2 conc (dry)	%		0.58	0.51	0.41	0.30	0.24	
Dilute NO_x conc (dry)	ppm		14.95	13.28	7.33	3.13	1.78	
Measured A/F	-----		12.38	12.29	12.49	12.57	12.69	
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	
NO_x Humidity Correction	-----		1.05	1.06	1.05	1.05	1.05	
Raw O_2 conc $(dry)_{measured}$	%		NA	NA	NA	NA	NA	
HC Mass	g/hr		13.70	13.88	11.17	13.08	14.24	
NO_x Mass	g/hr		6.88	6.23	3.40	1.45	0.81	
CO Mass	g/hr		1033.9	842.9	610.2	523.8	405.7	
CO_2 Mass	g/hr		2274	1993	1582	1125	869	
BSHC	g/hp-hr		3.14	4.27	5.11	11.97	32.09	
$BSNO_x$	g/hp-hr		1.58	1.92	1.56	1.33	1.83	
BSCO	g/hp-hr		237.13	259.29	279.03	479.63	914.30	
$BSCO_2$	g/hp-hr		521.55	612.92	723.40	1030.32	1957.83	

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC $(^{lb}/_{hp\text{-}hr})$
Weighted Specific Emissions[3]	g/hp-hr		**6.08**	**1.67**	**7.75**	**311.6**	**729.8**	**0.896**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 5-mode CARB Generator Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

APPENDIX C

TECUMSEH OVRM120 EMISSION DATA SHEETS

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 12/26/02

Test ID: TEC2 BSLN #1

Baseline testing of Tecumseh engine #2 with Carb. sent on engine from Tecumseh (w/methane analysis)

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3037	3055	3066	3054	3041	2499
Obs. Power	hp		3.31	2.53	1.69	0.83	0.33	0.06
Obs. Torque	ft-lb		5.64	4.29	2.85	1.41	0.57	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.26	2.50	1.66	0.82	0.33	0.06
Work (5 min Interval)	hp-hr		0.275	0.211	0.140	0.069	0.028	0.005
Fuel Flow	lb/hr		2.539	2.174	1.658	1.292	1.070	0.801
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		317	288	262	242	238	216
Exhaust Gas (muffler-in/manifold)	deg F		1251	1123	1060	1036	1054	786
Exhaust Gas (muffler out)	deg F		NA	NA	NA	NA	NA	NA
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	NA
Intake Air (EPA)	deg F		72	71	70	70	70	69
Intake Air DewPoint (EPA)	deg F		36	36	37	37	38	38
Cyl Head (Spark Plug)	deg F		522	459	417	388	385	340
PRESSURES								
Exhaust BP Before Cat	psig		1.73	1.24	0.89	0.65	0.55	0.26
Barometer	"Hg		29.425	29.417	29.418	29.414	29.406	29.398
F Factor	-----		0.995	0.994	0.993	0.994	0.994	0.993
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		80.59	83.28	68.91	54.97	35.03	52.54
Dilute CO conc (dry)	%		0.28	0.30	0.21	0.14	0.07	0.10
Dilute CO_2 conc (dry)	%		0.61	0.46	0.37	0.32	0.32	0.20
Dilute NO_x conc (dry)	ppm		26.67	8.76	5.11	3.22	2.72	1.18
Measured A/F	-----		12.71	11.86	12.10	12.58	13.52	12.10
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.83	0.83	0.83	0.84	0.84	0.84
Raw O_2 conc $(dry)_{measured}$	%		0.12	0.13	0.13	0.12	0.12	0.44
HC Mass	g/hr		10.42	10.90	9.05	7.18	4.48	6.96
NO_x Mass	g/hr		9.51	3.17	1.87	1.18	1.00	0.42
CO Mass	g/hr		733.7	792.0	568.7	379.5	182.8	274.1
CO_2 Mass	g/hr		2372	1767	1400	1192	1197	670
BSHC	g/hp-hr		3.11	4.31	5.39	8.55	13.32	-----
$BSNO_x$	g/hp-hr		2.83	1.25	1.11	1.40	2.97	-----
BSCO	g/hp-hr		218.58	312.92	338.49	451.60	543.99	-----
$BSCO_2$	g/hp-hr		706.61	698.11	833.46	1418.23	3562.51	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**5.45**	**1.58**	**7.02**	**337.1**	**921.5**	**1.048**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 12/27/02

Test ID: TEC2 BSLN #2

Baseline testing of Tecumseh engine #2 with Carb. sent on engine from Tecumseh

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3069	3071	3064	3051	3054	2409
Obs. Power	hp		3.38	2.55	1.70	0.83	0.33	0.07
Obs. Torque	ft-lb		5.70	4.31	2.87	1.41	0.56	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.33	2.52	1.68	0.82	0.33	0.07
Work (5 min Interval)	hp-hr		0.281	0.213	0.142	0.069	0.028	0.006
Fuel Flow	lb/hr		2.585	2.179	1.748	1.268	1.096	0.772
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		310	291	264	244	238	205
Exhaust Gas (muffler-in/manifold)	deg F		1257	1128	1079	1038	1064	755
Exhaust Gas (muffler out)	deg F		NA	NA	NA	NA	NA	NA
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	NA
Intake Air (EPA)	deg F		73	70	68	70	70	68
Intake Air DewPoint (EPA)	deg F		45	45	45	44	44	43
Cyl Head (Spark Plug)	deg F		512	460	414	382	381	335
PRESSURES								
Exhaust BP Before Cat	psig		1.75	1.27	0.94	0.66	0.58	0.29
Barometer	"Hg		29.511	29.509	29.508	29.505	29.502	29.497
F Factor	-----		0.996	0.993	0.990	0.993	0.993	0.989
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		89.70	84.42	87.18	57.17	35.31	64.57
Dilute CO conc (dry)	%		0.27	0.30	0.23	0.14	0.06	0.11
Dilute CO_2 conc (dry)	%		0.64	0.46	0.38	0.31	0.33	0.17
Dilute NO_x conc (dry)	ppm		28.90	8.31	4.97	2.97	2.72	0.94
Measured A/F	-----		12.78	11.83	12.00	12.55	13.59	11.25
Dry/Wet Correction	-----		0.98	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.88	0.88	0.88	0.87	0.87	0.86
Raw O_2 conc $(dry)_{measured}$	%		0.13	0.13	0.13	0.14	0.14	0.42
HC Mass	g/hr		11.54	11.01	11.49	7.46	4.45	8.61
NO_x Mass	g/hr		10.93	3.16	1.91	1.14	1.05	0.34
CO Mass	g/hr		698.6	793.4	613.6	376.8	174.7	312.4
CO_2 Mass	g/hr		2487	1772	1448	1161	1248	565
BSHC	g/hp-hr		3.41	4.33	6.79	8.89	13.26	-----
$BSNO_x$	g/hp-hr		3.23	1.24	1.13	1.36	3.13	-----
BSCO	g/hp-hr		206.45	312.06	362.64	448.69	519.86	-----
$BSCO_2$	g/hp-hr		734.86	696.91	855.84	1382.11	3712.90	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**6.05**	**1.65**	**7.70**	**342.2**	**925.7**	**1.058**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 12/30/02

Test ID: TEC2 BSLN #3

Baseline testing of Tecumseh engine #2 with Carb. sent on engine from Tecumseh

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3054	3071	3057	3064	3059	2416
Obs. Power	hp		3.04	2.29	1.52	0.76	0.30	0.01
Obs. Torque	ft-lb		5.15	3.87	2.58	1.29	0.50	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.00	2.26	1.50	0.75	0.29	0.01
Work (5 min Interval)	hp-hr		0.253	0.191	0.127	0.063	0.025	0.001
Fuel Flow	lb/hr		2.527	2.186	1.616	1.301	1.059	0.772
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		314	285	270	253	245	214
Exhaust Gas (muffler-in/manifold)	deg F		1230	1114	1060	1037	1036	780
Exhaust Gas (muffler out)	deg F		NA	NA	NA	NA	NA	NA
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	NA
Intake Air (EPA)	deg F		80	80	81	80	79	77
Intake Air DewPoint (EPA)	deg F		63	63	64	63	63	62
Cyl Head (Spark Plug)	deg F		505	450	418	392	383	345
PRESSURES								
Exhaust BP Before Cat	psig		1.73	1.28	0.95	0.73	0.64	0.37
Barometer	"Hg		28.801	28.759	28.745	28.740	28.744	28.743
F Factor	-----		1.040	1.043	1.044	1.042	1.041	1.039
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		93.31	94.06	72.44	60.62	43.87	65.80
Dilute CO conc (dry)	%		0.32	0.34	0.23	0.16	0.09	0.11
Dilute CO_2 conc (dry)	%		0.60	0.45	0.36	0.32	0.31	0.18
Dilute NO_x conc (dry)	ppm		16.01	6.05	3.97	2.82	2.24	0.94
Measured A/F	-----		12.31	11.42	11.77	12.39	13.26	11.45
Dry/Wet Correction	-----		0.97	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.08	1.08	1.09	1.07	1.07	1.07
Raw O_2 conc $(dry)_{measured}$	%		0.12	0.13	0.13	0.13	0.13	0.33
HC Mass	g/hr		11.65	11.91	9.15	7.65	5.42	8.44
NO_x Mass	g/hr		7.14	2.75	1.81	1.27	1.01	0.41
CO Mass	g/hr		810.7	870.4	593.4	413.0	228.2	302.7
CO_2 Mass	g/hr		2229	1657	1303	1149	1108	579
BSHC	g/hp-hr		3.84	5.24	6.00	10.12	18.09	-----
$BSNO_x$	g/hp-hr		2.35	1.21	1.19	1.68	3.37	-----
BSCO	g/hp-hr		267.42	382.91	389.48	546.52	760.88	-----
$BSCO_2$	g/hp-hr		735.42	729.05	855.00	1520.36	3693.65	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**6.48**	**1.54**	**8.02**	**405.2**	**960.5**	**1.155**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 1/7/03

Test ID: TEC2-C-DEV1

Testing of Tecumseh engine #2 with Carb. sent on engine from Tecumseh w/Catalyst C

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3066	3057	3070	3064	3078	2403
Obs. Power	hp		3.75	2.82	1.88	0.93	0.38	0.07
Obs. Torque	ft-lb		6.33	4.77	3.17	1.57	0.63	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.69	2.78	1.85	0.92	0.37	0.07
Work (5 min Interval)	hp-hr		0.312	0.235	0.157	0.078	0.031	0.006
Fuel Flow	lb/hr		2.554	2.165	1.758	1.331	1.056	0.799
TEMPERATURES								
Catalyst Mid-bed	deg F		1289	1119	1050	1009	1012	807
Oil	deg F		304	273	257	241	231	215
Exhaust Gas (muffler-in/manifold)	deg F		1315	1195	1193	1217	1273	1003
Exhaust Gas (muffler out)	deg F		842	686	596	515	450	410
Catalyst/Muffler Surface	deg F		765	675	647	625	591	605
Intake Air (EPA)	deg F		71	71	71	71	70	75
Intake Air DewPoint (EPA)	deg F		38	39	39	39	38	38
Cyl Head (Spark Plug)	deg F		504	445	405	375	366	328
PRESSURES								
Exhaust BP Before Cat	psig		0.84	0.59	0.45	0.35	0.31	0.22
Barometer	"Hg		29.528	29.518	29.517	29.516	29.517	29.511
F Factor	-----		0.991	0.991	0.991	0.991	0.990	0.997
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		60.62	66.61	50.09	35.10	20.07	46.36
Dilute CO conc (dry)	%		0.16	0.20	0.15	0.08	0.03	0.08
Dilute CO_2 conc (dry)	%		0.72	0.54	0.46	0.39	0.35	0.21
Dilute NO_x conc (dry)	ppm		9.73	2.68	1.75	1.12	0.86	0.68
Measured A/F	-----		13.34	12.44	12.51	12.91	13.62	11.03
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.84	0.84	0.84	0.84	0.84	0.84
Raw O_2 conc $(dry)_{measured}$	%		0.16	0.14	0.12	0.12	0.12	0.24
HC Mass	g/hr		7.79	8.72	6.52	4.47	2.39	6.10
NO_x Mass	g/hr		3.47	0.87	0.53	0.29	0.19	0.12
CO Mass	g/hr		426.5	549.5	401.4	214.3	81.2	226.7
CO_2 Mass	g/hr		2883	2142	1812	1514	1344	744
BSHC	g/hp-hr		2.08	3.09	3.46	4.78	6.43	-----
$BSNO_x$	g/hp-hr		0.93	0.31	0.28	0.31	0.52	-----
BSCO	g/hp-hr		113.90	194.85	213.04	228.99	218.19	-----
$BSCO_2$	g/hp-hr		769.96	759.63	961.83	1617.36	3612.07	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**3.51**	**0.43**	**3.93**	**197.2**	**1025.4**	**0.961**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 1/14/03

Test ID: TEC2-C-BSLN1m

LE Developed Baseline Test #1 (Stock Jetting, Catalyst C, and Modified 4-hole Venturi SAI) with methane analysis

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3065	3066	3057	3068	3066	2471
Obs. Power	hp		3.58	2.73	1.79	0.90	0.36	-0.02
Obs. Torque	ft-lb		6.06	4.62	3.04	1.52	0.62	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.53	2.70	1.77	0.89	0.36	-0.02
Work (5 min Interval)	hp-hr		0.299	0.228	0.150	0.075	0.030	-0.002
Fuel Flow	lb/hr		2.512	2.077	1.656	1.262	1.081	0.782
TEMPERATURES								
Catalyst Mid-bed	deg F		1366	1280	1242	1236	1237	1128
Oil	deg F		298	277	253	237	231	194
Exhaust Gas (muffler-in/manifold)	deg F		1215	1118	1068	1042	1048	812
Exhaust Gas (muffler out)	deg F		964	831	740	664	601	482
Catalyst/Muffler Surface	deg F		789	758	734	712	694	603
Intake Air (EPA)	deg F		65	65	65	65	65	65
Intake Air DewPoint (EPA)	deg F		42	42	42	42	42	42
Cyl Head (Spark Plug)	deg F		506	451	405	376	370	317
PRESSURES								
Exhaust BP Before Cat	psig		1.68	1.45	1.31	1.22	1.18	1.10
Barometer	"Hg		29.493	29.484	29.485	29.478	29.485	29.476
F Factor	-----		0.986	0.985	0.986	0.986	0.986	0.986
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		54.83	48.80	39.44	24.67	15.24	33.44
Dilute CO conc (dry)	%		0.21	0.18	0.13	0.06	0.02	0.05
Dilute CO_2 conc (dry)	%		0.65	0.53	0.44	0.38	0.36	0.23
Dilute NO_x conc (dry)	ppm		4.30	1.50	0.63	0.33	0.37	0.20
Measured A/F	-----		13.02	12.82	12.80	13.33	13.94	12.56
Dry/Wet Correction	-----		0.98	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.86	0.86	0.86	0.86	0.86	0.86
Raw O_2 conc $(dry)_{measured}$	%		0.52	0.67	0.81	0.94	1.00	1.70
HC Mass	g/hr		7.11	6.35	5.10	3.06	1.73	4.35
NO_x Mass	g/hr		1.62	0.55	0.22	0.10	0.12	0.05
CO Mass	g/hr		561.2	486.1	350.4	162.1	56.0	155.2
CO_2 Mass	g/hr		2615	2125	1753	1504	1421	838
BSHC	g/hp-hr		1.97	2.35	2.83	3.43	4.80	-----
$BSNO_x$	g/hp-hr		0.45	0.20	0.12	0.11	0.32	-----
BSCO	g/hp-hr		155.88	179.97	194.69	181.73	155.60	-----
$BSCO_2$	g/hp-hr		726.40	786.81	974.14	1686.45	3947.18	-----

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**2.77**	**0.21**	**2.98**	**184.4**	**1049.2**	**0.962**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 1/14/03

Test ID: TEC2-C-BSLN2m

LE Developed Baseline Test #2 (Stock Jetting, Catalyst C, and Modified 4-hole Venturi SAI)

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3093	3061	3053	3051	3041	2509
Obs. Power	hp		3.59	2.68	1.77	0.89	0.36	-0.03
Obs. Torque	ft-lb		6.00	4.53	3.00	1.51	0.61	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.54	2.64	1.75	0.88	0.35	-0.03
Work (5 min Interval)	hp-hr		0.299	0.223	0.148	0.074	0.030	-0.003
Fuel Flow	lb/hr		2.627	2.047	1.623	1.241	1.094	0.752
TEMPERATURES								
Catalyst Mid-bed	deg F		1368	1286	1253	1252	1222	1168
Oil	deg F		302	281	261	244	239	213
Exhaust Gas (muffler-in/manifold)	deg F		1223	1128	1084	1068	1095	851
Exhaust Gas (muffler out)	deg F		963	829	737	656	550	492
Catalyst/Muffler Surface	deg F		810	769	742	719	668	624
Intake Air (EPA)	deg F		71	71	72	71	72	71
Intake Air DewPoint (EPA)	deg F		42	42	41	42	41	42
Cyl Head (Spark Plug)	deg F		509	451	414	386	383	334
PRESSURES								
Exhaust BP Before Cat	psig		1.71	1.47	1.34	1.25	1.21	1.13
Barometer	"Hg		29.398	29.393	29.391	29.390	29.395	29.391
F Factor	-----		0.996	0.996	0.998	0.996	0.998	0.996
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		54.65	46.08	32.64	19.39	10.15	23.60
Dilute CO conc (dry)	%		0.22	0.17	0.10	0.03	0.01	0.03
Dilute CO_2 conc (dry)	%		0.69	0.54	0.47	0.41	0.39	0.25
Dilute NO_x conc (dry)	ppm		4.90	1.61	0.85	0.57	2.11	0.26
Measured A/F	-----		13.02	12.88	13.22	13.86	14.57	13.14
Dry/Wet Correction	-----		0.98	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.86	0.86	0.86	0.86	0.86	0.86
Raw O_2 conc $(dry)_{measured}$	%		0.50	0.71	0.83	0.97	0.95	1.76
HC Mass	g/hr		6.93	5.83	4.03	2.22	0.94	2.82
NO_x Mass	g/hr		1.82	0.59	0.31	0.20	0.80	0.08
CO Mass	g/hr		588.3	460.0	267.2	88.3	13.7	96.1
CO_2 Mass	g/hr		2734	2126	1841	1593	1508	893
BSHC	g/hp-hr		1.95	2.18	2.27	2.50	2.61	-----
$BSNO_x$	g/hp-hr		0.51	0.22	0.17	0.23	2.22	-----
BSCO	g/hp-hr		165.63	171.85	150.48	99.42	38.06	-----
$BSCO_2$	g/hp-hr		769.71	794.06	1036.84	1793.58	4187.76	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**2.31**	**0.30**	**2.60**	**153.3**	**1103.2**	**0.965**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 3/18/03

Test ID: TEC2-125-#1

125-hour interval emission test "as-received" from durability with catalyst C, and passive SAI system. Test run prior to scheduled maintenance.

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3042	3061	3055	3055	3062	2530
Obs. Power	hp		3.36	2.52	1.69	0.85	0.32	0.00
Obs. Torque	ft-lb		5.73	4.27	2.87	1.44	0.55	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.32	2.49	1.67	0.84	0.32	0.00
Work (5 min Interval)	hp-hr		0.280	0.210	0.141	0.071	0.027	0.000
Fuel Flow	lb/hr		2.489	2.134	1.742	1.377	1.222	0.833
TEMPERATURES								
Catalyst Mid-bed	deg F		1380	1314	1286	1274	1248	1174
Oil	deg F		333	303	280	260	251	220
Exhaust Gas (muffler-in/manifold)	deg F		1183	1092	1047	1021	997	845
Exhaust Gas (muffler out)	deg F		969	839	744	648	561	468
Catalyst/Muffler Surface	deg F		812	667	635	601	570	499
Intake Air (EPA)	deg F		76	71	70	69	69	68
Intake Air DewPoint (EPA)	deg F		52	51	49	49	50	51
Cyl Head (Spark Plug)	deg F		521	470	433	404	385	355
PRESSURES								
Exhaust BP Before Cat	psig		0.13	0.12	0.07	0.03	0.01	-0.02
Barometer	"Hg		28.675	28.662	28.663	28.659	28.655	28.678
F Factor	-----		1.032	1.027	1.024	1.023	1.023	1.022
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		94.71	79.86	57.72	40.65	30.44	31.31
Dilute CO conc (dry)	%		0.22	0.23	0.17	0.10	0.06	0.05
Dilute CO_2 conc (dry)	%		0.66	0.51	0.44	0.39	0.38	0.25
Dilute NO_x conc (dry)	ppm		5.84	1.24	0.65	0.38	0.49	0.20
Measured A/F	-----		13.10	12.48	12.67	13.10	13.64	13.03
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		0.94	0.93	0.91	0.91	0.92	0.92
Raw O_2 conc $(dry)_{measured}$	%		0.61	0.72	0.90	1.04	1.20	1.80
HC Mass	g/hr		11.92	10.08	7.18	4.90	3.53	3.69
NO_x Mass	g/hr		2.33	0.48	0.24	0.13	0.17	0.05
CO Mass	g/hr		565.9	623.8	454.7	266.1	151.8	144.0
CO_2 Mass	g/hr		2560	1978	1703	1496	1463	929
BSHC	g/hp-hr		3.51	3.98	4.24	5.71	10.91	-----
$BSNO_x$	g/hp-hr		0.69	0.19	0.14	0.15	0.54	-----
BSCO	g/hp-hr		166.70	246.55	268.75	310.22	468.50	-----
$BSCO_2$	g/hp-hr		754.17	781.54	1006.65	1744.00	4514.68	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC $(^{lb}/_{hp\text{-}hr})$
Weighted Specific Emissions[3]	g/hp-hr		**4.47**	**0.27**	**4.74**	**256.1**	**1085.4**	**1.072**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 3/19/03

Test ID: TEC2-125-#2

125-hour interval emission test with catalyst C, and passive SAI system. Test run after scheduled maintenance.

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3067	3056	3063	3065	3047	2478
Obs. Power	hp		3.21	2.41	1.62	0.80	0.33	0.00
Obs. Torque	ft-lb		5.43	4.08	2.73	1.36	0.56	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.17	2.37	1.59	0.79	0.33	0.00
Work (5 min Interval)	hp-hr		0.268	0.200	0.135	0.067	0.027	0.000
Fuel Flow	lb/hr		2.467	2.114	1.656	1.278	1.106	0.763
TEMPERATURES								
Catalyst Mid-bed	deg F		1410	1352	1327	1273	1273	1237
Oil	deg F		337	329	315	292	273	250
Exhaust Gas (muffler-in/manifold)	deg F		1195	1116	1084	1005	999	868
Exhaust Gas (muffler out)	deg F		980	884	790	690	628	536
Catalyst/Muffler Surface	deg F		840	790	765	727	708	666
Intake Air (EPA)	deg F		88	89	88	84	83	81
Intake Air DewPoint (EPA)	deg F		36	34	35	33	33	33
Cyl Head (Spark Plug)	deg F		548	508	477	427	407	371
PRESSURES								
Exhaust BP Before Cat	psig		0.15	0.10	0.06	0.03	0.02	-0.01
Barometer	"Hg		28.679	28.673	28.677	28.678	28.678	28.678
F Factor	-----		1.042	1.044	1.042	1.036	1.034	1.033
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		101.76	95.44	52.60	38.05	25.06	23.36
Dilute CO conc (dry)	%		0.22	0.23	0.13	0.10	0.05	0.05
Dilute CO_2 conc (dry)	%		0.65	0.51	0.45	0.35	0.34	0.23
Dilute NO_x conc (dry)	ppm		10.53	2.65	1.17	0.41	0.50	0.18
Measured A/F	-----		13.24	12.72	13.25	12.95	13.52	12.92
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.83	0.83	0.83	0.82	0.82	0.82
Raw O_2 conc $(dry)_{measured}$	%		0.63	0.83	0.90	1.16	1.27	1.83
HC Mass	g/hr		12.77	12.10	6.55	4.68	2.96	2.77
NO_x Mass	g/hr		3.78	0.95	0.42	0.14	0.17	0.06
CO Mass	g/hr		559.5	596.1	349.4	277.2	148.3	137.8
CO_2 Mass	g/hr		2537	1987	1750	1340	1307	844
BSHC	g/hp-hr		3.98	5.02	4.04	5.82	9.15	-----
$BSNO_x$	g/hp-hr		1.18	0.39	0.26	0.17	0.54	-----
BSCO	g/hp-hr		174.54	247.13	215.52	344.92	457.94	-----
$BSCO_2$	g/hp-hr		791.40	823.75	1079.31	1667.13	4036.05	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**4.80**	**0.47**	**5.27**	**246.8**	**1108.9**	**1.079**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 3/20/03

Test ID: TEC2-125-#3

125-hour interval emission test with catalyst C, and passive SAI system. Test run after scheduled maintenance.

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3059	3058	3073	3081	3050	2486
Obs. Power	hp		3.18	2.40	1.61	0.80	0.33	0.00
Obs. Torque	ft-lb		5.39	4.06	2.71	1.35	0.56	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.14	2.37	1.58	0.79	0.32	0.00
Work (5 min Interval)	hp-hr		0.265	0.200	0.134	0.067	0.027	0.000
Fuel Flow	lb/hr		2.412	2.136	1.719	1.248	1.040	0.788
TEMPERATURES								
Catalyst Mid-bed	deg F		1421	1337	1314	1270	1277	1242
Oil	deg F		326	331	312	287	270	251
Exhaust Gas (muffler-in/manifold)	deg F		1202	1101	1065	1003	1010	869
Exhaust Gas (muffler out)	deg F		985	868	779	687	622	529
Catalyst/Muffler Surface	deg F		844	776	754	721	705	675
Intake Air (EPA)	deg F		87	95	92	87	81	77
Intake Air DewPoint (EPA)	deg F		43	43	44	44	45	43
Cyl Head (Spark Plug)	deg F		543	501	469	426	410	376
PRESSURES								
Exhaust BP Before Cat	psig		0.10	0.04	0.01	-0.02	-0.03	-0.06
Barometer	"Hg		28.977	28.987	28.990	28.993	28.993	28.996
F Factor	-----		1.033	1.043	1.039	1.032	1.025	1.019
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		83.49	90.71	61.63	35.78	18.34	25.85
Dilute CO conc (dry)	%		0.19	0.24	0.15	0.09	0.04	0.06
Dilute CO_2 conc (dry)	%		0.66	0.50	0.45	0.35	0.34	0.24
Dilute NO_x conc (dry)	ppm		9.38	1.82	1.02	0.33	0.32	0.24
Measured A/F	-----		13.36	12.49	13.02	12.97	13.77	12.78
Dry/Wet Correction	-----		0.98	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.87	0.87	0.87	0.87	0.88	0.87
Raw O_2 conc $(dry)_{measured}$	%		0.65	0.83	0.95	1.13	1.26	1.85
HC Mass	g/hr		10.52	11.71	7.92	4.49	2.12	3.18
NO_x Mass	g/hr		3.51	0.69	0.39	0.12	0.12	0.09
CO Mass	g/hr		492.2	647.3	406.1	256.0	100.9	153.4
CO_2 Mass	g/hr		2572	1939	1745	1332	1292	853
BSHC	g/hp-hr		3.28	4.88	4.93	5.59	6.80	-----
$BSNO_x$	g/hp-hr		1.10	0.29	0.24	0.15	0.38	-----
BSCO	g/hp-hr		153.68	269.73	252.58	318.35	323.35	-----
$BSCO_2$	g/hp-hr		802.96	807.76	1084.94	1657.21	4142.14	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**4.84**	**0.41**	**5.25**	**255.8**	**1107.0**	**1.088**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 3/19/03

Test ID: TEC2-125-STK-#1

125-hour interval emission test "as-received" from durability with stock muffler. Test run prior to scheduled maintenance.

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3051	3064	3057	3066	3062	2468
Obs. Power	hp		3.15	2.41	1.57	0.80	0.32	0.00
Obs. Torque	ft-lb		5.35	4.07	2.67	1.35	0.54	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.11	2.38	1.55	0.79	0.32	0.00
Work (5 min Interval)	hp-hr		0.263	0.201	0.131	0.067	0.027	0.000
Fuel Flow	lb/hr		2.515	2.166	1.697	1.205	1.010	0.757
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		347	342	327	311	299	277
Exhaust Gas (muffler-in/manifold)	deg F		1207	1138	1090	1048	1044	829
Exhaust Gas (muffler out)	deg F		NA	NA	NA	NA	NA	NA
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	NA
Intake Air (EPA)	deg F		83	83	84	83	84	83
Intake Air DewPoint (EPA)	deg F		38	37	39	38	38	37
Cyl Head (Spark Plug)	deg F		523	487	455	429	416	373
PRESSURES								
Exhaust BP Before Cat	psig		0.49	0.33	0.22	0.13	0.10	0.02
Barometer	"Hg		28.761	28.762	28.761	28.765	28.762	28.763
F Factor	-----		1.033	1.033	1.035	1.033	1.035	1.033
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		129.31	125.15	105.05	63.54	53.77	68.28
Dilute CO conc (dry)	%		0.31	0.33	0.23	0.13	0.07	0.11
Dilute CO_2 conc (dry)	%		0.57	0.43	0.36	0.30	0.29	0.17
Dilute NO_x conc (dry)	ppm		19.55	7.18	4.90	3.23	2.55	1.04
Measured A/F	-----		12.79	11.60	11.92	12.72	13.46	11.89
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.84	0.84	0.85	0.84	0.84	0.84
Raw O_2 conc $(dry)_{measured}$	%		0.24	0.30	0.30	0.30	0.43	0.79
HC Mass	g/hr		16.52	16.07	13.58	8.15	6.88	8.95
NO_x Mass	g/hr		6.99	2.44	1.66	1.04	0.80	0.22
CO Mass	g/hr		804.0	859.9	620.5	349.6	199.6	292.4
CO_2 Mass	g/hr		2208	1633	1360	1113	1080	573
BSHC	g/hp-hr		5.16	6.73	8.57	10.14	21.24	-----
$BSNO_x$	g/hp-hr		2.18	1.02	1.05	1.29	2.47	-----
BSCO	g/hp-hr		250.97	360.23	391.74	435.03	616.16	-----
$BSCO_2$	g/hp-hr		689.11	683.97	858.54	1384.28	3334.21	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**8.07**	**1.33**	**9.40**	**374.6**	**911.9**	**1.089**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 3/19/03

Test ID: TEC2-125-STK-#2

125-hour interval emission test with stock muffler. Test run after scheduled maintenance.

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3059	3042	3066	3076	3060	2542
Obs. Power	hp		2.96	2.22	1.48	0.75	0.29	0.00
Obs. Torque	ft-lb		5.01	3.78	2.50	1.27	0.49	0.00
Calc. Power (Obs. Torque*Speed)	hp		2.92	2.19	1.46	0.74	0.28	0.00
Work (5 min Interval)	hp-hr		0.247	0.185	0.123	0.063	0.024	0.000
Fuel Flow	lb/hr		2.366	2.060	1.656	1.280	1.052	0.796
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		347	333	310	294	269	248
Exhaust Gas (muffler-in/manifold)	deg F		1209	1111	1062	1035	978	845
Exhaust Gas (muffler out)	deg F		NA	NA	NA	NA	NA	NA
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	NA
Intake Air (EPA)	deg F		88	84	81	81	80	80
Intake Air DewPoint (EPA)	deg F		33	33	34	33	32	33
Cyl Head (Spark Plug)	deg F		535	486	454	426	396	375
PRESSURES								
Exhaust BP Before Cat	psig		0.48	0.31	0.23	0.16	0.10	0.03
Barometer	"Hg		28.734	28.729	28.732	28.719	28.713	28.712
F Factor	-----		1.040	1.034	1.031	1.030	1.029	1.029
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		142.87	139.09	99.34	77.41	60.87	57.83
Dilute CO conc (dry)	%		0.30	0.32	0.22	0.15	0.11	0.11
Dilute CO_2 conc (dry)	%		0.53	0.39	0.35	0.30	0.26	0.18
Dilute NO_x conc (dry)	ppm		20.26	6.62	5.00	3.15	2.10	1.14
Measured A/F	-----		12.39	11.50	11.97	12.46	12.68	11.92
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.82	0.82	0.82	0.82	0.82	0.82
Raw O_2 conc (dry)$_{measured}$	%		0.33	0.43	0.23	0.22	0.24	0.45
HC Mass	g/hr		18.17	18.01	12.85	10.00	7.87	7.52
NO_x Mass	g/hr		7.18	2.38	1.83	1.16	0.78	0.42
CO Mass	g/hr		771.0	850.8	602.6	403.7	307.2	296.6
CO_2 Mass	g/hr		2046	1493	1333	1128	967	626
BSHC	g/hp-hr		6.06	8.07	8.63	13.45	27.31	-----
BSNO_x	g/hp-hr		2.39	1.07	1.23	1.55	2.69	-----
BSCO	g/hp-hr		256.99	381.17	404.99	542.76	1066.59	-----
BSCO_2	g/hp-hr		682.08	668.77	895.76	1516.53	3355.97	-----

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**9.27**	**1.49**	**10.76**	**411.0**	**939.2**	**1.152**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 4/21/03

Test ID: TEC2-250-#1

250-hour interval emission test with catalyst C, and passive SAI system. Test run before scheduled maintenance.

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3085	3062	3058	3053	3073	2558
Obs. Power	hp		3.32	2.46	1.66	0.81	0.32	0.00
Obs. Torque	ft-lb		5.57	4.17	2.81	1.37	0.54	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.27	2.43	1.64	0.80	0.32	0.00
Work (5 min Interval)	hp-hr		0.276	0.205	0.138	0.067	0.027	0.000
Fuel Flow	lb/hr		2.368	2.030	1.676	1.331	1.075	0.778
TEMPERATURES								
Catalyst Mid-bed	deg F		1423	1335	1317	1303	1293	1211
Oil	deg F		303	272	252	239	230	214
Exhaust Gas (muffler-in/manifold)	deg F		1208	1111	1074	1048	1041	903
Exhaust Gas (muffler out)	deg F		954	827	748	694	627	520
Catalyst/Muffler Surface	deg F		882	812	787	776	752	685
Intake Air (EPA)	deg F		79	79	79	79	78	77
Intake Air DewPoint (EPA)	deg F		50	50	50	50	50	50
Cyl Head (Spark Plug)	deg F		539	476	442	415	398	364
PRESSURES								
Exhaust BP Before Cat	psig		0.48	0.33	0.23	0.16	0.12	0.05
Barometer	"Hg		29.230	29.197	29.181	29.169	29.165	29.168
F Factor	-----		1.016	1.017	1.018	1.018	1.017	1.016
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		65.47	61.58	42.03	28.69	16.85	19.02
Dilute CO conc (dry)	%		0.16	0.21	0.15	0.09	0.04	0.04
Dilute CO_2 conc (dry)	%		0.65	0.49	0.43	0.37	0.34	0.25
Dilute NO_x conc (dry)	ppm		8.10	1.16	0.69	0.40	0.30	0.24
Measured A/F	-----		13.50	12.68	12.88	13.04	13.61	13.27
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.99
NO_x Humidity Correction	-----		0.91	0.91	0.92	0.92	0.91	0.92
Raw O_2 conc $(dry)_{measured}$	%		0.67	0.81	0.92	1.00	1.07	1.51
HC Mass	g/hr		8.35	7.89	5.27	3.44	1.81	2.12
NO_x Mass	g/hr		3.26	0.45	0.26	0.14	0.10	0.07
CO Mass	g/hr		435.2	556.1	399.3	255.6	110.4	96.0
CO_2 Mass	g/hr		2607	1946	1703	1451	1327	932
BSHC	g/hp-hr		2.52	3.19	3.18	4.16	5.58	-----
$BSNO_x$	g/hp-hr		0.98	0.18	0.16	0.17	0.30	-----
BSCO	g/hp-hr		131.45	224.87	241.30	308.74	340.96	-----
$BSCO_2$	g/hp-hr		787.36	786.86	1029.27	1753.50	4096.04	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**3.32**	**0.33**	**3.65**	**230.3**	**1096.7**	**1.049**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 4/21/03

Test ID: TEC2-250-#2

250-hour interval emission test with catalyst C, and passive SAI system. Test run before scheduled maintenance.

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3070	3067	3065	3054	3046	2535
Obs. Power	hp		3.30	2.46	1.62	0.81	0.30	0.00
Obs. Torque	ft-lb		5.57	4.15	2.74	1.37	0.51	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.26	2.42	1.60	0.80	0.30	0.00
Work (5 min Interval)	hp-hr		0.275	0.205	0.135	0.067	0.025	0.000
Fuel Flow	lb/hr		2.327	2.092	1.721	1.378	1.018	0.774
TEMPERATURES								
Catalyst Mid-bed	deg F		1426	1338	1318	1300	1287	1212
Oil	deg F		307	279	255	239	231	215
Exhaust Gas (muffler-in/manifold)	deg F		1208	1111	1073	1041	1030	897
Exhaust Gas (muffler out)	deg F		957	833	753	701	623	520
Catalyst/Muffler Surface	deg F		885	812	785	776	748	681
Intake Air (EPA)	deg F		82	82	81	80	80	80
Intake Air DewPoint (EPA)	deg F		52	52	52	52	52	52
Cyl Head (Spark Plug)	deg F		543	482	444	414	398	364
PRESSURES								
Exhaust BP Before Cat	psig		0.47	0.32	0.23	0.16	0.11	0.04
Barometer	"Hg		29.161	29.161	29.145	29.139	29.133	29.100
F Factor	-----		1.024	1.023	1.023	1.022	1.022	1.023
GASEOUS EMISSIONS			EMISSIONS ARE UNWEIGHTED[1] (ETIS)					
Dilute HC conc (wet)	ppm		59.48	64.77	45.29	33.96	16.11	18.44
Dilute CO conc (dry)	%		0.16	0.21	0.16	0.11	0.04	0.04
Dilute CO_2 conc (dry)	%		0.65	0.51	0.44	0.37	0.33	0.25
Dilute NO_x conc (dry)	ppm		7.36	1.42	0.71	0.41	0.29	0.21
Measured A/F	-----		13.50	12.69	12.78	12.76	13.60	13.20
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		0.93	0.93	0.93	0.93	0.93	0.94
Raw O_2 conc $(dry)_{measured}$	%		0.68	0.80	0.90	0.98	1.05	1.51
HC Mass	g/hr		7.45	8.27	5.66	4.13	1.67	2.01
NO_x Mass	g/hr		2.97	0.53	0.23	0.11	0.06	0.02
CO Mass	g/hr		425.2	570.6	426.4	311.3	101.8	99.5
CO_2 Mass	g/hr		2568	2007	1724	1428	1261	921
BSHC	g/hp-hr		2.28	3.38	3.45	5.06	5.56	-----
$BSNO_x$	g/hp-hr		0.91	0.21	0.14	0.13	0.19	-----
BSCO	g/hp-hr		129.80	233.09	259.45	381.63	339.28	-----
$BSCO_2$	g/hp-hr		783.84	819.99	1048.78	1750.62	4201.72	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**3.55**	**0.31**	**3.86**	**249.9**	**1110.3**	**1.081**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 4/22/03

Test ID: TEC2-250-STK-#1

250-hour interval emission test with stock muffler and stock jetting. Test run before scheduled maintenance.

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3063	3059	3061	3055	3058	2517
Obs. Power	hp		3.01	2.23	1.50	0.75	0.32	0.00
Obs. Torque	ft-lb		5.10	3.78	2.54	1.27	0.55	0.00
Calc. Power (Obs. Torque*Speed)	hp		2.97	2.20	1.48	0.74	0.32	0.00
Work (5 min Interval)	hp-hr		0.251	0.186	0.125	0.063	0.027	0.000
Fuel Flow	lb/hr		2.448	2.196	1.722	1.496	1.201	0.779
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		300	275	257	242	231	216
Exhaust Gas (muffler-in/manifold)	deg F		1246	1166	1144	1090	1063	895
Exhaust Gas (muffler out)	deg F		916	759	655	556	490	351
Catalyst/Muffler Surface	deg F		871	793	738	657	607	478
Intake Air (EPA)	deg F		79	79	78	76	76	75
Intake Air DewPoint (EPA)	deg F		62	62	63	62	62	61
Cyl Head (Spark Plug)	deg F		518	472	446	411	393	361
PRESSURES								
Exhaust BP Before Cat	psig		1.40	1.06	0.82	0.63	0.49	0.24
Barometer	"Hg		29.072	29.070	29.074	29.074	29.079	29.080
F Factor	-----		1.029	1.029	1.027	1.026	1.024	1.022
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		126.57	120.97	85.87	81.28	58.51	45.29
Dilute CO conc (dry)	%		0.27	0.30	0.19	0.20	0.13	0.08
Dilute CO_2 conc (dry)	%		0.59	0.47	0.42	0.33	0.30	0.21
Dilute NO_x conc (dry)	ppm		16.39	6.25	4.88	2.74	1.92	1.07
Measured A/F	-----		12.58	11.89	12.58	11.96	12.56	12.59
Dry/Wet Correction	-----		0.97	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.06	1.06	1.06	1.06	1.06	1.04
Raw O_2 conc (dry)$_{measured}$	%		0.26	0.21	0.19	0.17	0.16	0.38
HC Mass	g/hr		16.38	15.79	11.18	10.64	7.57	5.80
NO_x Mass	g/hr		7.21	2.60	1.99	1.00	0.62	0.21
CO Mass	g/hr		705.0	785.3	495.3	529.7	350.2	226.7
CO_2 Mass	g/hr		2271	1794	1599	1230	1109	716
BSHC	g/hp-hr		5.44	7.00	7.39	14.07	24.27	-----
BSNO_x	g/hp-hr		2.40	1.15	1.32	1.33	1.98	-----
BSCO	g/hp-hr		234.16	348.19	327.56	700.61	1122.93	-----
BSCO_2	g/hp-hr		754.19	795.34	1057.59	1626.81	3555.65	-----

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**8.43**	**1.49**	**9.93**	**396.6**	**1071.0**	**1.228**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 4/22/03

Test ID: TEC2-250-STK-#2

250-hour interval emission test with stock muffler and stock jetting. Test run after scheduled maintenance.

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3072	3071	3061	3067	3050	2526
Obs. Power	hp		2.89	2.20	1.44	0.72	0.30	0.00
Obs. Torque	ft-lb		4.88	3.71	2.44	1.21	0.51	0.00
Calc. Power (Obs. Torque*Speed)	hp		2.85	2.17	1.42	0.71	0.30	0.00
Work (5 min Interval)	hp-hr		0.241	0.183	0.120	0.060	0.025	0.000
Fuel Flow	lb/hr		2.447	2.195	1.846	1.487	1.265	0.830
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		305	280	257	243	235	217
Exhaust Gas (muffler-in/manifold)	deg F		1254	1167	1123	1083	1058	936
Exhaust Gas (muffler out)	deg F		923	774	658	556	498	374
Catalyst/Muffler Surface	deg F		879	799	733	654	615	504
Intake Air (EPA)	deg F		80	79	79	78	77	76
Intake Air DewPoint (EPA)	deg F		63	63	62	62	61	61
Cyl Head (Spark Plug)	deg F		528	479	445	416	399	377
PRESSURES								
Exhaust BP Before Cat	psig		1.34	1.05	0.81	0.63	0.49	0.26
Barometer	"Hg		29.057	29.043	29.041	29.034	29.027	29.017
F Factor	-----		1.032	1.031	1.030	1.028	1.027	1.026
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		130.40	126.03	101.58	89.34	64.22	40.44
Dilute CO conc (dry)	%		0.26	0.32	0.25	0.19	0.16	0.08
Dilute CO_2 conc (dry)	%		0.60	0.45	0.39	0.33	0.29	0.22
Dilute NO_x conc (dry)	ppm		18.39	5.96	4.09	2.67	2.01	1.12
Measured A/F	-----		12.70	11.70	11.80	12.00	12.08	12.82
Dry/Wet Correction	-----		0.97	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.07	1.06	1.06	1.05	1.04	1.04
Raw O_2 conc $(dry)_{measured}$	%		0.24	0.21	0.19	0.14	0.10	0.30
HC Mass	g/hr		16.81	16.42	13.27	11.67	8.28	5.07
NO_x Mass	g/hr		8.42	2.74	1.89	1.22	0.92	0.50
CO Mass	g/hr		678.7	830.8	676.1	516.4	429.6	222.6
CO_2 Mass	g/hr		2310	1718	1482	1236	1072	797
BSHC	g/hp-hr		5.79	7.48	9.21	16.21	27.37	-----
$BSNO_x$	g/hp-hr		2.90	1.25	1.32	1.69	3.03	-----
BSCO	g/hp-hr		234.03	378.33	469.52	717.49	1420.21	-----
$BSCO_2$	g/hp-hr		796.38	782.14	1029.02	1717.01	3542.04	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**9.58**	**1.70**	**11.28**	**457.2**	**1082.5**	**1.307**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 4/23/03

Test ID: TEC2-250-#3

250-hour interval emission test with catalyst C, and passive SAI system. Test run after scheduled maintenance.

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3070	3055	3054	3047	3077	2604
Obs. Power	hp		3.19	2.38	1.58	0.80	0.32	0.00
Obs. Torque	ft-lb		5.38	4.04	2.67	1.36	0.53	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.14	2.35	1.56	0.79	0.31	0.00
Work (5 min Interval)	hp-hr		0.266	0.199	0.131	0.067	0.026	0.000
Fuel Flow	lb/hr		2.335	2.091	1.692	1.401	1.172	0.789
TEMPERATURES								
Catalyst Mid-bed	deg F		1440	1368	1349	1339	1333	1298
Oil	deg F		303	276	257	242	231	215
Exhaust Gas (muffler-in/manifold)	deg F		1196	1108	1071	1040	1019	930
Exhaust Gas (muffler out)	deg F		953	850	774	712	651	545
Catalyst/Muffler Surface	deg F		827	795	791	782	770	708
Intake Air (EPA)	deg F		82	81	80	80	79	78
Intake Air DewPoint (EPA)	deg F		63	62	62	62	61	61
Cyl Head (Spark Plug)	deg F		544	486	450	419	395	372
PRESSURES								
Exhaust BP Before Cat	psig		0.45	0.31	0.22	0.15	0.11	0.04
Barometer	"Hg		28.932	28.929	28.928	28.925	28.924	28.918
F Factor	-----		1.038	1.037	1.036	1.035	1.034	1.033
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		64.04	63.88	44.32	33.64	27.70	18.29
Dilute CO conc (dry)	%		0.18	0.24	0.17	0.13	0.10	0.03
Dilute CO_2 conc (dry)	%		0.65	0.50	0.43	0.37	0.33	0.27
Dilute NO_x conc (dry)	ppm		7.39	1.21	0.61	0.31	0.26	0.21
Measured A/F	-----		13.46	12.57	12.68	12.61	12.75	13.46
Dry/Wet Correction	-----		0.97	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.07	1.06	1.06	1.05	1.05	1.04
Raw O_2 conc (dry)$_{measured}$	%		0.85	0.99	1.11	1.27	1.40	1.89
HC Mass	g/hr		8.14	8.21	5.61	4.21	3.41	2.14
NO_x Mass	g/hr		3.39	0.54	0.26	0.12	0.09	0.07
CO Mass	g/hr		460.6	624.2	453.0	349.9	251.9	74.4
CO_2 Mass	g/hr		2522	1923	1640	1400	1235	982
BSHC	g/hp-hr		2.55	3.46	3.54	5.31	10.98	-----
BSNO_x	g/hp-hr		1.06	0.23	0.16	0.15	0.30	-----
BSCO	g/hp-hr		144.34	262.80	285.98	441.83	810.49	-----
BSCO_2	g/hp-hr		790.21	809.41	1035.55	1767.32	3974.60	-----

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**3.79**	**0.36**	**4.15**	**286.3**	**1109.2**	**1.121**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Tecumseh OVRM120 #2**

Date: 4/23/03

Test ID: TEC2-250-#4

250-hour interval emission test with catalyst C, and passive SAI system. Test run after scheduled maintenance.

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3056	3051	3065	3053	3038	2521
Obs. Power	hp		3.15	2.36	1.59	0.79	0.29	0.00
Obs. Torque	ft-lb		5.34	4.00	2.69	1.33	0.50	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.11	2.33	1.57	0.77	0.29	0.00
Work (5 min Interval)	hp-hr		0.262	0.197	0.133	0.065	0.024	0.000
Fuel Flow	lb/hr		2.216	2.033	1.720	1.300	1.087	0.770
TEMPERATURES								
Catalyst Mid-bed	deg F		1432	1370	1351	1331	1343	1326
Oil	deg F		301	281	261	240	231	214
Exhaust Gas (muffler-in/manifold)	deg F		1194	1121	1084	1032	1042	916
Exhaust Gas (muffler out)	deg F		941	852	782	679	630	539
Catalyst/Muffler Surface	deg F		822	801	796	773	764	710
Intake Air (EPA)	deg F		84	83	82	81	80	79
Intake Air DewPoint (EPA)	deg F		63	63	63	62	62	61
Cyl Head (Spark Plug)	deg F		539	491	456	413	401	365
PRESSURES								
Exhaust BP Before Cat	psig		0.43	0.31	0.22	0.13	0.10	0.03
Barometer	"Hg		28.895	28.893	28.887	28.886	28.879	28.874
F Factor	-----		1.042	1.041	1.040	1.039	1.037	1.036
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		53.96	55.28	43.81	26.04	18.12	22.87
Dilute CO conc (dry)	%		0.17	0.22	0.16	0.10	0.05	0.03
Dilute CO_2 conc (dry)	%		0.62	0.50	0.45	0.37	0.35	0.26
Dilute NO_x conc (dry)	ppm		6.32	1.40	0.65	0.64	0.51	0.34
Measured A/F	-----		13.44	12.68	12.83	13.00	13.58	13.44
Dry/Wet Correction	-----		0.97	0.97	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.08	1.08	1.07	1.06	1.05	1.05
Raw O_2 conc $(dry)_{measured}$	%		0.82	0.99	1.12	1.28	1.33	1.95
HC Mass	g/hr		6.68	6.92	5.45	3.08	2.01	2.67
NO_x Mass	g/hr		2.94	0.64	0.29	0.29	0.22	0.15
CO Mass	g/hr		444.3	581.7	425.0	260.7	123.9	74.9
CO_2 Mass	g/hr		2384	1912	1724	1402	1322	952
BSHC	g/hp-hr		2.12	2.93	3.44	3.95	6.69	-----
$BSNO_x$	g/hp-hr		0.93	0.27	0.18	0.37	0.75	-----
BSCO	g/hp-hr		140.74	245.99	268.29	334.32	412.86	-----
$BSCO_2$	g/hp-hr		755.27	808.73	1088.43	1797.76	4407.43	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC $(^{lb}/_{hp\text{-}hr})$
Weighted Specific Emissions[3]	g/hp-hr		**3.24**	**0.40**	**3.64**	**251.6**	**1126.7**	**1.094**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

APPENDIX D

HONDA GCV160 EMISSION DATA SHEETS

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 3/25/03

Test ID: HON-160-BSLN#1

Baseline test with stock jetting and stock muffler after 1 hour break-in (methane test)

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3045	3062	3063	3070	3060	1852
Obs. Power	hp		3.41	2.56	1.73	0.86	0.34	0.00
Obs. Torque	ft-lb		5.80	4.34	2.93	1.45	0.57	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.37	2.53	1.71	0.85	0.33	0.00
Work (5 min Interval)	hp-hr		0.284	0.214	0.144	0.072	0.028	0.000
Fuel Flow	lb/hr		2.352	1.809	1.509	1.084	0.910	0.438
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		236	214	194	179	164	136
Exhaust Gas (muffler-in/manifold)	deg F		1260	1195	1108	1079	1043	816
Exhaust Gas (muffler out)	deg F		845	700	590	494	418	261
Catalyst/Muffler Surface	deg F		571	508	441	393	350	245
Intake Air (EPA)	deg F		95	92	88	86	84	79
Intake Air DewPoint (EPA)	deg F		64	63	63	64	63	63
Cyl Head (Spark Plug)	deg F		440	402	356	322	295	246
PRESSURES								
Exhaust BP Before Cat	psig		0.29	0.20	0.14	0.10	0.08	0.04
Barometer	"Hg		29.000	29.000	29.003	28.997	28.997	28.998
F Factor	-----		1.054	1.049	1.044	1.041	1.039	1.033
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		113.03	80.67	82.30	70.85	75.18	66.72
Dilute CO conc (dry)	%		0.29	0.21	0.21	0.13	0.12	0.06
Dilute CO_2 conc (dry)	%		0.55	0.44	0.33	0.26	0.21	0.12
Dilute NO_x conc (dry)	ppm		30.08	19.28	5.26	2.37	1.55	0.47
Measured A/F	-----		12.22	12.52	11.83	12.24	11.84	11.94
Dry/Wet Correction	-----		0.97	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.08	1.07	1.07	1.08	1.08	1.08
Raw O_2 conc $(dry)_{measured}$	%		0.16	0.19	0.27	0.41	0.73	2.47
HC Mass	g/hr		14.41	10.32	10.69	9.23	9.89	8.82
NO_x Mass	g/hr		13.26	8.38	1.96	0.60	0.21	0.00
CO Mass	g/hr		750.0	542.5	552.9	358.7	334.8	156.8
CO_2 Mass	g/hr		2071	1650	1212	926	718	340
BSHC	g/hp-hr		4.17	4.00	6.23	10.68	29.50	-----
$BSNO_x$	g/hp-hr		3.84	3.25	1.14	0.70	0.63	-----
BSCO	g/hp-hr		217.15	210.29	322.18	415.06	998.67	-----
$BSCO_2$	g/hp-hr		599.79	639.43	706.32	1071.27	2142.61	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**6.45**	**2.26**	**8.71**	**295.7**	**754.7**	**0.885**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 3/25/03

Test ID: HON-160-BSLN#2

Baseline test with stock jetting and stock muffler after 1 hour break-in

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3065	3064	3060	3053	3048	1807
Obs. Power	hp		3.37	2.54	1.67	0.83	0.33	0.00
Obs. Torque	ft-lb		5.69	4.30	2.83	1.41	0.55	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.32	2.51	1.65	0.82	0.32	0.00
Work (5 min Interval)	hp-hr		0.281	0.212	0.140	0.069	0.027	0.000
Fuel Flow	lb/hr		2.292	1.848	1.502	1.124	0.923	0.432
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		231	211	191	176	166	138
Exhaust Gas (muffler-in/manifold)	deg F		1258	1192	1106	1072	1057	792
Exhaust Gas (muffler out)	deg F		840	696	576	484	434	250
Catalyst/Muffler Surface	deg F		570	508	440	391	361	237
Intake Air (EPA)	deg F		97	93	90	87	85	80
Intake Air DewPoint (EPA)	deg F		63	63	62	63	63	62
Cyl Head (Spark Plug)	deg F		440	403	356	321	301	244
PRESSURES								
Exhaust BP Before Cat	psig		0.31	0.22	0.15	0.12	0.10	0.06
Barometer	"Hg		28.984	28.967	28.965	28.964	28.959	28.960
F Factor	-----		1.057	1.053	1.048	1.045	1.042	1.034
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		101.49	85.02	88.86	74.32	73.38	65.81
Dilute CO conc (dry)	%		0.29	0.21	0.21	0.14	0.12	0.05
Dilute CO_2 conc (dry)	%		0.53	0.45	0.33	0.27	0.22	0.12
Dilute NO_x conc (dry)	ppm		26.12	18.38	5.28	2.57	1.62	0.61
Measured A/F	-----		12.14	12.51	11.93	12.18	12.02	12.12
Dry/Wet Correction	-----		0.97	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.08	1.08	1.06	1.07	1.07	1.05
Raw O_2 conc $(dry)_{measured}$	%		0.18	0.19	0.25	0.43	0.65	2.95
HC Mass	g/hr		12.86	10.86	11.54	9.68	9.61	8.70
NO_x Mass	g/hr		11.41	7.98	1.94	0.68	0.24	0.00
CO Mass	g/hr		754.5	553.1	546.6	367.1	320.0	145.7
CO_2 Mass	g/hr		1985	1686	1209	968	760	350
BSHC	g/hp-hr		3.83	4.29	6.87	11.53	27.62	-----
$BSNO_x$	g/hp-hr		3.40	3.15	1.15	0.81	0.69	-----
BSCO	g/hp-hr		224.63	218.45	325.23	437.12	919.63	-----
$BSCO_2$	g/hp-hr		591.09	665.99	719.56	1152.87	2183.34	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**6.80**	**2.17**	**8.97**	**303.3**	**780.8**	**0.913**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 3/26/03

Test ID: HON-160-BSLN#3

Baseline test with stock jetting and stock muffler after 1 hour break-in

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3084	3064	3060	3077	3064	1828
Obs. Power	hp		3.54	2.65	1.74	0.90	0.34	0.00
Obs. Torque	ft-lb		5.95	4.48	2.95	1.51	0.58	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.50	2.61	1.72	0.89	0.34	0.00
Work (5 min Interval)	hp-hr		0.295	0.221	0.145	0.075	0.029	0.000
Fuel Flow	lb/hr		2.445	1.883	1.528	1.129	0.876	0.434
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		235	216	196	179	167	147
Exhaust Gas (muffler-in/manifold)	deg F		1264	1200	1112	1079	1027	794
Exhaust Gas (muffler out)	deg F		863	722	595	501	420	251
Catalyst/Muffler Surface	deg F		569	507	438	390	339	234
Intake Air (EPA)	deg F		87	86	83	79	81	78
Intake Air DewPoint (EPA)	deg F		44	43	42	43	39	39
Cyl Head (Spark Plug)	deg F		444	406	358	322	292	243
PRESSURES								
Exhaust BP Before Cat	psig		0.23	0.15	0.09	0.06	0.02	-0.02
Barometer	"Hg		29.182	29.182	29.178	29.175	29.171	29.171
F Factor	-----		1.025	1.024	1.020	1.015	1.016	1.012
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		98.52	80.52	82.06	71.37	65.00	58.68
Dilute CO conc (dry)	%		0.29	0.20	0.19	0.13	0.12	0.05
Dilute CO_2 conc (dry)	%		0.56	0.45	0.34	0.27	0.20	0.13
Dilute NO_x conc (dry)	ppm		35.41	23.61	6.85	3.02	1.49	0.72
Measured A/F	-----		12.35	12.64	12.17	12.41	11.83	12.59
Dry/Wet Correction	-----		0.98	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.87	0.87	0.86	0.86	0.85	0.84
Raw O_2 conc (dry)$_{measured}$	%		0.15	0.18	0.23	0.31	0.50	1.70
HC Mass	g/hr		12.74	10.48	10.85	9.49	8.60	7.87
NO_x Mass	g/hr		13.39	8.96	2.55	1.06	0.45	0.15
CO Mass	g/hr		764.3	548.8	516.1	350.0	320.2	127.9
CO_2 Mass	g/hr		2184	1743	1296	1002	698	383
BSHC	g/hp-hr		3.62	3.95	6.15	10.69	23.90	-----
BSNO_x	g/hp-hr		3.81	3.38	1.45	1.19	1.25	-----
BSCO	g/hp-hr		217.31	207.17	292.66	394.59	889.86	-----
BSCO_2	g/hp-hr		620.83	657.93	734.89	1129.54	1938.85	-----

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**6.20**	**2.48**	**8.69**	**280.2**	**782.0**	**0.886**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 3/27/03

Test ID: HON-160-J-#1

Development using catalyst J in place of stock muffler

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3075	3058	3062	3058	3057	1869
Obs. Power	hp		3.62	2.69	1.80	0.90	0.37	0.00
Obs. Torque	ft-lb		6.09	4.56	3.04	1.53	0.62	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.57	2.66	1.78	0.89	0.36	0.00
Work (5 min Interval)	hp-hr		0.301	0.225	0.150	0.075	0.031	0.000
Fuel Flow	lb/hr		2.419	1.835	1.537	1.129	0.927	0.501
TEMPERATURES								
Catalyst Mid-bed	deg F		1211	1110	969	869	808	619
Oil	deg F		230	210	188	170	162	144
Exhaust Gas (muffler-in/manifold)	deg F		1192	1148	1088	1104	1096	897
Exhaust Gas (muffler out)	deg F		NA	NA	NA	NA	NA	NA
Catalyst/Muffler Surface	deg F		504	453	391	335	304	246
Intake Air (EPA)	deg F		94	92	90	86	83	79
Intake Air DewPoint (EPA)	deg F		54	52	53	54	54	54
Cyl Head (Spark Plug)	deg F		440	404	357	319	296	252
PRESSURES								
Exhaust BP Before Cat	psig		0.25	0.23	0.22	0.21	0.20	0.19
Barometer	"Hg		28.838	28.812	28.807	28.799	28.792	28.784
F Factor	-----		1.052	1.050	1.047	1.043	1.039	1.035
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		86.10	67.47	78.61	65.07	61.92	54.19
Dilute CO conc (dry)	%		0.21	0.14	0.16	0.11	0.10	0.04
Dilute CO_2 conc (dry)	%		0.63	0.50	0.37	0.29	0.23	0.15
Dilute NO_x conc (dry)	ppm		6.72	3.95	1.17	0.42	0.15	0.11
Measured A/F	-----		12.54	12.84	12.10	12.35	11.86	12.27
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		0.95	0.94	0.94	0.95	0.95	0.95
Raw O_2 conc $(dry)_{measured}$	%		0.13	0.14	0.14	0.14	0.16	0.33
HC Mass	g/hr		11.07	8.73	10.31	8.57	8.17	7.19
NO_x Mass	g/hr		2.74	1.59	0.45	0.15	0.03	0.01
CO Mass	g/hr		554.4	365.0	437.8	289.3	273.0	101.9
CO_2 Mass	g/hr		2483	1970	1432	1100	844	519
BSHC	g/hp-hr		3.06	3.24	5.69	9.52	21.97	-----
$BSNO_x$	g/hp-hr		0.76	0.59	0.25	0.16	0.08	-----
BSCO	g/hp-hr		153.43	135.26	241.67	321.48	733.88	-----
$BSCO_2$	g/hp-hr		687.26	730.17	790.80	1222.77	2268.96	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**5.48**	**0.44**	**5.92**	**214.0**	**858.8**	**0.865**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 4/8/03

Test ID: HON-160-J-BSLN#1

Final 0-hr development tests with catalyst J, stock jetting, and passive SAI system (methane analysis)

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3071	3062	3069	3070	3058	1847
Obs. Power	hp		3.73	2.69	1.78	0.89	0.34	0.00
Obs. Torque	ft-lb		6.30	4.55	3.01	1.51	0.58	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.68	2.65	1.76	0.88	0.34	0.00
Work (5 min Interval)	hp-hr		0.311	0.224	0.149	0.074	0.028	0.000
Fuel Flow	lb/hr		2.347	1.762	1.416	1.042	0.877	0.403
TEMPERATURES								
Catalyst Mid-bed	deg F		1441	1361	1251	1200	1134	762
Oil	deg F		240	216	200	181	167	161
Exhaust Gas (muffler-in/manifold)	deg F		1277	1196	1121	1089	991	815
Exhaust Gas (muffler out)	deg F		766	655	552	479	413	242
Catalyst/Muffler Surface	deg F		698	631	556	505	449	314
Intake Air (EPA)	deg F		90	86	84	81	78	76
Intake Air DewPoint (EPA)	deg F		34	36	35	37	36	34
Cyl Head (Spark Plug)	deg F		428	382	342	308	275	250
PRESSURES								
Exhaust BP Before Cat	psig		0.17	0.12	0.07	0.04	0.02	-0.02
Barometer	"Hg		29.416	29.415	29.414	29.410	29.406	29.400
F Factor	-----		1.018	1.013	1.010	1.007	1.003	1.001
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		38.97	33.52	29.74	24.62	36.19	16.93
Dilute CO conc (dry)	%		0.14	0.07	0.08	0.04	0.06	0.00
Dilute CO_2 conc (dry)	%		0.68	0.54	0.42	0.33	0.26	0.17
Dilute NO_x conc (dry)	ppm		4.27	2.28	0.74	0.23	0.11	0.83
Measured A/F	-----		13.10	13.46	13.17	13.40	12.76	16.37
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.82	0.83	0.83	0.84	0.83	0.82
Raw O_2 conc $(dry)_{measured}$	%		0.85	1.06	1.20	1.40	1.63	5.00
HC Mass	g/hr		4.87	4.23	3.76	3.10	4.74	2.06
NO_x Mass	g/hr		1.54	0.85	0.27	0.08	0.03	0.31
CO Mass	g/hr		367.4	197.6	204.0	112.3	154.1	0.0
CO_2 Mass	g/hr		2696	2145	1651	1274	971	559
BSHC	g/hp-hr		1.32	1.58	2.10	3.51	13.17	-----
$BSNO_x$	g/hp-hr		0.42	0.32	0.15	0.09	0.09	-----
BSCO	g/hp-hr		99.72	73.88	114.11	127.16	428.23	-----
$BSCO_2$	g/hp-hr		731.68	801.77	923.56	1442.73	2698.57	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**2.23**	**0.25**	**2.49**	**105.2**	**972.1**	**0.817**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 4/8/03

Test ID: HON-160-J-BSLN#2

Final 0-hr development tests with catalyst J, stock jetting, and passive SAI system (methane analysis)

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3061	3056	3049	3056	3056	1834
Obs. Power	hp		3.58	2.68	1.78	0.89	0.35	0.00
Obs. Torque	ft-lb		6.05	4.54	3.02	1.51	0.60	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.53	2.64	1.75	0.88	0.35	0.00
Work (5 min Interval)	hp-hr		0.298	0.223	0.148	0.074	0.029	0.000
Fuel Flow	lb/hr		2.375	1.770	1.446	1.047	0.870	0.352
TEMPERATURES								
Catalyst Mid-bed	deg F		1432	1356	1248	1205	1159	773
Oil	deg F		247	218	195	180	168	149
Exhaust Gas (muffler-in/manifold)	deg F		1271	1192	1113	1085	1015	814
Exhaust Gas (muffler out)	deg F		760	650	555	484	422	238
Catalyst/Muffler Surface	deg F		672	623	563	528	480	363
Intake Air (EPA)	deg F		89	86	83	81	79	74
Intake Air DewPoint (EPA)	deg F		36	35	37	34	37	37
Cyl Head (Spark Plug)	deg F		431	387	342	309	281	248
PRESSURES								
Exhaust BP Before Cat	psig		0.16	0.11	0.07	0.04	0.02	-0.02
Barometer	"Hg		29.388	29.382	29.385	29.390	29.385	29.383
F Factor	-----		1.018	1.014	1.011	1.007	1.005	0.999
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		41.13	29.58	34.22	25.83	26.62	9.87
Dilute CO conc (dry)	%		0.15	0.08	0.08	0.05	0.04	0.00
Dilute CO_2 conc (dry)	%		0.68	0.54	0.42	0.34	0.28	0.15
Dilute NO_x conc (dry)	ppm		5.92	2.93	0.88	0.39	0.21	0.72
Measured A/F	-----		13.13	13.48	13.07	13.39	13.24	16.34
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.83	0.83	0.83	0.82	0.84	0.84
Raw O_2 conc $(dry)_{measured}$	%		0.80	1.00	1.13	1.31	1.52	5.00
HC Mass	g/hr		5.12	3.63	4.32	3.08	3.33	0.98
NO_x Mass	g/hr		2.16	1.08	0.32	0.13	0.06	0.27
CO Mass	g/hr		383.6	203.8	227.4	118.3	93.7	0.0
CO_2 Mass	g/hr		2708	2148	1654	1271	1061	491
BSHC	g/hp-hr		1.43	1.36	2.43	3.46	9.25	-----
$BSNO_x$	g/hp-hr		0.60	0.40	0.18	0.14	0.18	-----
BSCO	g/hp-hr		107.34	76.50	128.00	133.27	260.21	-----
$BSCO_2$	g/hp-hr		757.68	806.42	931.11	1430.77	2947.06	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**2.19**	**0.34**	**2.53**	**110.3**	**983.0**	**0.830**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 4/25/03

Test ID: HON-160-J-125-#1

125-hour interval testing with catalyst J, stock jetting, and passive SAI system (methane test)

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3074	3058	3074	3041	3073	1828
Obs. Power	hp		3.40	2.55	1.72	0.83	0.35	0.00
Obs. Torque	ft-lb		5.73	4.33	2.90	1.42	0.59	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.35	2.52	1.70	0.82	0.34	0.00
Work (5 min Interval)	hp-hr		0.283	0.213	0.143	0.070	0.029	0.000
Fuel Flow	lb/hr		2.081	1.661	1.373	1.036	0.834	0.424
TEMPERATURES								
Catalyst Mid-bed	deg F		1427	1359	1261	1217	1145	831
Oil	deg F		234	208	188	178	167	144
Exhaust Gas (muffler-in/manifold)	deg F		1268	1196	1152	1127	1054	861
Exhaust Gas (muffler out)	deg F		694	589	491	430	378	243
Catalyst/Muffler Surface	deg F		610	556	497	465	423	320
Intake Air (EPA)	deg F		90	89	84	83	83	77
Intake Air DewPoint (EPA)	deg F		45	46	46	45	46	46
Cyl Head (Spark Plug)	deg F		430	385	343	318	292	250
PRESSURES								
Exhaust BP Before Cat	psig		0.17	0.11	0.07	0.04	0.02	-0.01
Barometer	"Hg		28.880	28.893	28.896	28.898	28.904	28.899
F Factor	-----		1.041	1.039	1.033	1.031	1.030	1.023
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		28.81	23.77	22.32	13.19	13.90	25.09
Dilute CO conc (dry)	%		0.07	0.05	0.05	0.01	0.02	0.00
Dilute CO_2 conc (dry)	%		0.66	0.53	0.43	0.36	0.29	0.17
Dilute NO_x conc (dry)	ppm		7.40	3.01	1.57	0.68	0.30	0.73
Measured A/F	-----		13.86	13.81	13.71	14.02	13.77	16.89
Dry/Wet Correction	-----		0.98	0.98	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.88	0.89	0.88	0.88	0.89	0.89
Raw O_2 conc (dry)$_{measured}$	%		0.82	0.96	1.15	1.24	1.38	5.50
HC Mass	g/hr		3.56	2.90	2.74	1.49	1.59	3.19
NO_x Mass	g/hr		2.86	1.15	0.58	0.23	0.07	0.25
CO Mass	g/hr		175.5	147.9	149.1	39.8	51.7	6.6
CO_2 Mass	g/hr		2628	2085	1680	1384	1082	573
BSHC	g/hp-hr		1.05	1.14	1.60	1.77	4.66	-----
BSNO_x	g/hp-hr		0.84	0.45	0.34	0.27	0.22	-----
BSCO	g/hp-hr		51.49	58.11	86.90	47.33	151.38	-----
BSCO_2	g/hp-hr		771.26	819.44	979.29	1648.16	3165.85	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**1.52**	**0.47**	**1.99**	**65.8**	**1044.9**	**0.823**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 4/25/03

Test ID: HON-160-J-125-#2

125-hour interval testing with catalyst J, stock jetting, and passive SAI system (methane test)

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3071	3056	3060	3044	3064	1850
Obs. Power	hp		3.35	2.53	1.68	0.84	0.33	0.00
Obs. Torque	ft-lb		5.66	4.29	2.85	1.44	0.57	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.31	2.50	1.66	0.83	0.33	0.00
Work (5 min Interval)	hp-hr		0.279	0.211	0.140	0.070	0.028	0.000
Fuel Flow	lb/hr		1.943	1.691	1.319	1.052	0.867	0.423
TEMPERATURES								
Catalyst Mid-bed	deg F		1427	1353	1259	1218	1135	835
Oil	deg F		230	209	191	177	167	147
Exhaust Gas (muffler-in/manifold)	deg F		1268	1192	1149	1127	1036	875
Exhaust Gas (muffler out)	deg F		686	585	490	432	378	243
Catalyst/Muffler Surface	deg F		609	557	496	465	421	321
Intake Air (EPA)	deg F		91	88	86	83	82	79
Intake Air DewPoint (EPA)	deg F		46	46	45	45	45	45
Cyl Head (Spark Plug)	deg F		432	384	346	320	290	254
PRESSURES								
Exhaust BP Before Cat	psig		0.17	0.11	0.07	0.04	0.02	-0.01
Barometer	"Hg		28.904	28.904	28.903	28.901	28.894	28.887
F Factor	-----		1.041	1.038	1.034	1.031	1.030	1.026
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		19.12	24.23	24.36	17.95	19.78	18.56
Dilute CO conc (dry)	%		0.04	0.06	0.05	0.02	0.03	0.00
Dilute CO_2 conc (dry)	%		0.65	0.54	0.42	0.36	0.29	0.18
Dilute NO_x conc (dry)	ppm		9.80	4.63	1.40	0.53	0.32	0.77
Measured A/F	-----		14.06	13.78	13.69	13.96	13.55	16.80
Dry/Wet Correction	-----		0.98	0.98	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.89	0.89	0.88	0.88	0.88	0.88
Raw O_2 conc $(dry)_{measured}$	%		0.87	1.10	1.13	1.23	1.45	5.50
HC Mass	g/hr		2.05	2.76	2.81	1.95	2.21	2.06
NO_x Mass	g/hr		3.77	1.79	0.51	0.17	0.08	0.27
CO Mass	g/hr		100.1	149.3	132.4	50.4	77.6	0.8
CO_2 Mass	g/hr		2558	2126	1631	1388	1085	585
BSHC	g/hp-hr		0.61	1.09	1.67	2.32	6.57	-----
$BSNO_x$	g/hp-hr		1.12	0.70	0.30	0.20	0.24	-----
BSCO	g/hp-hr		29.69	58.71	78.79	59.99	230.96	-----
$BSCO_2$	g/hp-hr		758.75	835.92	971.04	1652.29	3228.41	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**1.52**	**0.58**	**2.10**	**62.1**	**1047.8**	**0.821**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 4/28/03

Test ID: HON-160-STK-125-#1

125-hour interval testing with stock jetting and stock muffler (methane test)

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3077	3061	3050	3057	3069	1904
Obs. Power	hp		3.18	2.38	1.57	0.79	0.32	0.00
Obs. Torque	ft-lb		5.35	4.03	2.66	1.34	0.55	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.14	2.35	1.55	0.78	0.32	0.00
Work (5 min Interval)	hp-hr		0.265	0.198	0.131	0.066	0.027	0.000
Fuel Flow	lb/hr		2.004	1.697	1.280	1.041	0.846	0.444
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		225	207	191	181	169	148
Exhaust Gas (muffler-in/manifold)	deg F		1281	1212	1170	1170	1127	971
Exhaust Gas (muffler out)	deg F		833	713	611	547	466	355
Catalyst/Muffler Surface	deg F		560	504	464	439	387	319
Intake Air (EPA)	deg F		90	88	86	84	83	79
Intake Air DewPoint (EPA)	deg F		60	60	60	59	59	58
Cyl Head (Spark Plug)	deg F		426	387	350	327	301	262
PRESSURES								
Exhaust BP Before Cat	psig		0.60	0.43	0.30	0.22	0.16	0.05
Barometer	"Hg		29.063	29.061	29.056	29.058	29.056	29.056
F Factor	-----		1.043	1.040	1.038	1.035	1.033	1.027
GASEOUS EMISSIONS			EMISSIONS ARE UNWEIGHTED[1] (ETIS)					
Dilute HC conc (wet)	ppm		82.44	72.62	59.71	45.71	37.84	70.98
Dilute CO conc (dry)	%		0.13	0.13	0.10	0.06	0.05	0.00
Dilute CO_2 conc (dry)	%		0.58	0.47	0.36	0.32	0.26	0.17
Dilute NO_x conc (dry)	ppm		67.32	34.16	11.87	4.91	2.35	1.10
Measured A/F	-----		13.57	13.33	13.27	13.67	13.57	15.91
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.02	1.02	1.02	1.02	1.01	1.00
Raw O_2 conc $(dry)_{measured}$	%		0.20	0.33	0.24	0.30	0.43	5.00
HC Mass	g/hr		10.57	9.39	7.69	5.81	4.77	9.46
NO_x Mass	g/hr		29.74	15.35	5.37	2.20	1.04	0.46
CO Mass	g/hr		338.2	340.4	263.0	156.4	143.0	9.9
CO_2 Mass	g/hr		2243	1812	1356	1195	945	577
BSHC	g/hp-hr		3.35	3.95	4.89	7.33	15.29	-----
$BSNO_x$	g/hp-hr		9.43	6.46	3.41	2.78	3.34	-----
BSCO	g/hp-hr		107.18	143.27	167.22	197.00	458.40	-----
$BSCO_2$	g/hp-hr		711.07	762.78	862.26	1505.63	3028.44	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**5.16**	**5.46**	**10.62**	**157.4**	**956.6**	**0.871**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 4/29/03

Test ID: HON-160-STK-125-#2

125-hour interval testing with stock jetting and stock muffler (methane test)

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3072	3060	3068	3058	3080	1818
Obs. Power	hp		3.13	2.34	1.57	0.79	0.32	0.00
Obs. Torque	ft-lb		5.28	3.97	2.66	1.33	0.53	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.09	2.31	1.55	0.77	0.31	0.00
Work (5 min Interval)	hp-hr		0.261	0.195	0.131	0.065	0.026	0.000
Fuel Flow	lb/hr		2.014	1.654	1.359	1.044	0.865	0.442
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		228	209	192	180	171	150
Exhaust Gas (muffler-in/manifold)	deg F		1277	1216	1171	1168	1139	937
Exhaust Gas (muffler out)	deg F		828	707	608	540	468	335
Catalyst/Muffler Surface	deg F		554	501	460	435	389	307
Intake Air (EPA)	deg F		92	91	88	86	85	80
Intake Air DewPoint (EPA)	deg F		64	64	64	64	64	64
Cyl Head (Spark Plug)	deg F		430	389	351	328	305	260
PRESSURES								
Exhaust BP Before Cat	psig		0.59	0.41	0.32	0.23	0.16	0.04
Barometer	"Hg		29.027	29.024	29.026	29.027	29.031	29.029
F Factor	-----		1.050	1.047	1.043	1.041	1.039	1.033
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		81.22	71.77	63.85	47.48	39.43	86.29
Dilute CO conc (dry)	%		0.14	0.12	0.11	0.06	0.05	0.01
Dilute CO_2 conc (dry)	%		0.58	0.47	0.38	0.32	0.27	0.17
Dilute NO_x conc (dry)	ppm		61.33	33.76	11.36	4.75	2.61	0.98
Measured A/F	-----		13.51	13.42	13.22	13.64	13.61	16.11
Dry/Wet Correction	-----		0.97	0.97	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.09	1.08	1.08	1.09	1.09	1.08
Raw O_2 conc $(dry)_{measured}$	%		0.22	0.32	0.25	0.30	0.41	4.50
HC Mass	g/hr		10.42	9.26	8.27	6.08	5.01	11.62
NO_x Mass	g/hr		28.58	15.72	5.18	2.04	1.01	0.21
CO Mass	g/hr		355.9	313.6	282.9	163.2	138.5	15.0
CO_2 Mass	g/hr		2229	1796	1433	1187	979	559
BSHC	g/hp-hr		3.32	3.94	5.26	7.80	16.05	-----
$BSNO_x$	g/hp-hr		9.09	6.69	3.30	2.61	3.23	-----
BSCO	g/hp-hr		113.24	133.44	179.93	209.23	444.08	-----
$BSCO_2$	g/hp-hr		709.24	764.09	911.62	1521.99	3139.42	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**5.43**	**5.40**	**10.83**	**161.3**	**975.0**	**0.889**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 5/16/03

Test ID: HON-160-J-250-#1

250-hour interval testing with catalyst J, stock jetting, and passive SAI system (methane test)

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3054	3062	3069	3053	3076	1775
Obs. Power	hp		3.55	2.69	1.79	0.90	0.35	0.00
Obs. Torque	ft-lb		6.02	4.55	3.02	1.52	0.59	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.50	2.65	1.76	0.88	0.35	0.00
Work (5 min Interval)	hp-hr		0.296	0.224	0.149	0.075	0.029	0.000
Fuel Flow	lb/hr		2.141	1.693	1.331	1.052	0.783	0.398
TEMPERATURES								
Catalyst Mid-bed	deg F		1440	1408	1303	1266	1183	821
Oil	deg F		235	216	199	187	174	155
Exhaust Gas (muffler-in/manifold)	deg F		1249	1207	1148	1125	1016	850
Exhaust Gas (muffler out)	deg F		693	603	503	438	377	241
Catalyst/Muffler Surface	deg F		661	624	553	519	466	299
Intake Air (EPA)	deg F		97	96	94	92	90	86
Intake Air DewPoint (EPA)	deg F		64	64	63	63	62	62
Cyl Head (Spark Plug)	deg F		441	400	357	329	294	265
PRESSURES								
Exhaust BP Before Cat	psig		0.16	0.11	0.07	0.04	0.02	-0.02
Barometer	"Hg		28.847	28.843	28.844	28.842	28.843	28.838
F Factor	-----		1.063	1.061	1.058	1.056	1.052	1.047
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		56.54	36.34	28.09	34.45	30.37	17.21
Dilute CO conc (dry)	%		0.10	0.05	0.06	0.02	0.03	0.00
Dilute CO_2 conc (dry)	%		0.67	0.56	0.42	0.36	0.26	0.16
Dilute NO_x conc (dry)	ppm		6.23	2.84	0.48	0.25	0.05	0.56
Measured A/F	-----		13.58	13.80	13.46	13.82	13.33	16.84
Dry/Wet Correction	-----		0.97	0.97	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.09	1.09	1.08	1.08	1.06	1.06
Raw O_2 conc $(dry)_{measured}$	%		0.87	1.15	1.24	1.31	1.51	5.50
HC Mass	g/hr		7.15	4.52	3.47	4.36	3.84	2.06
NO_x Mass	g/hr		2.85	1.27	0.18	0.08	0.00	0.22
CO Mass	g/hr		247.3	127.8	161.8	63.2	89.0	11.3
CO_2 Mass	g/hr		2589	2156	1599	1361	945	534
BSHC	g/hp-hr		2.00	1.69	1.94	4.91	11.03	-----
$BSNO_x$	g/hp-hr		0.80	0.48	0.10	0.09	0.00	-----
BSCO	g/hp-hr		69.15	47.78	90.50	71.20	255.84	-----
$BSCO_2$	g/hp-hr		723.92	806.08	894.45	1531.64	2716.27	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**2.54**	**0.36**	**2.90**	**72.3**	**977.7**	**0.785**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 5/16/03

Test ID: HON-160-J-250-#2

250-hour interval testing with catalyst J, stock jetting, and passive SAI system

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3047	3049	3063	3063	3072	1797
Obs. Power	hp		3.47	2.62	1.74	0.87	0.35	0.00
Obs. Torque	ft-lb		5.90	4.44	2.95	1.48	0.59	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.42	2.58	1.72	0.86	0.34	0.00
Work (5 min Interval)	hp-hr		0.289	0.218	0.145	0.073	0.029	0.000
Fuel Flow	lb/hr		2.115	1.705	1.359	1.034	0.829	0.414
TEMPERATURES								
Catalyst Mid-bed	deg F		1434	1398	1302	1259	1189	821
Oil	deg F		241	221	202	187	175	158
Exhaust Gas (muffler-in/manifold)	deg F		1244	1201	1147	1124	1021	861
Exhaust Gas (muffler out)	deg F		690	594	501	436	378	246
Catalyst/Muffler Surface	deg F		660	620	554	514	469	312
Intake Air (EPA)	deg F		100	98	95	94	92	88
Intake Air DewPoint (EPA)	deg F		63	62	62	62	61	61
Cyl Head (Spark Plug)	deg F		444	400	358	329	296	269
PRESSURES								
Exhaust BP Before Cat	psig		0.15	0.11	0.07	0.04	0.02	-0.02
Barometer	"Hg		28.827	28.824	28.821	28.818	28.816	28.809
F Factor	-----		1.066	1.063	1.060	1.058	1.054	1.050
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		37.13	29.61	29.91	20.33	21.43	21.79
Dilute CO conc (dry)	%		0.10	0.06	0.06	0.02	0.03	0.00
Dilute CO_2 conc (dry)	%		0.66	0.56	0.43	0.36	0.28	0.17
Dilute NO_x conc (dry)	ppm		6.63	3.94	1.03	0.30	0.16	0.64
Measured A/F	-----		13.56	13.73	13.46	13.80	13.38	16.78
Dry/Wet Correction	-----		0.97	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.07	1.06	1.05	1.05	1.04	1.04
Raw O_2 conc (dry)$_{measured}$	%		0.88	1.15	1.24	1.37	1.56	5.50
HC Mass	g/hr		4.52	3.57	3.64	2.39	2.55	2.63
NO_x Mass	g/hr		2.92	1.67	0.37	0.04	0.00	0.19
CO Mass	g/hr		266.2	149.1	169.5	58.5	85.2	9.5
CO_2 Mass	g/hr		2530	2144	1625	1349	1019	557
BSHC	g/hp-hr		1.30	1.37	2.09	2.72	7.33	-----
BSNO_x	g/hp-hr		0.84	0.64	0.21	0.04	0.00	-----
BSCO	g/hp-hr		76.48	57.27	97.41	66.62	244.72	-----
BSCO_2	g/hp-hr		727.01	823.43	934.11	1535.95	2927.67	-----

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**1.97**	**0.44**	**2.41**	**78.0**	**1003.3**	**0.808**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 5/14/03

Test ID: HON-160-STK-250-#1

250-hour interval testing with stock muffler and stock jetting (methane test)

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3049	3062	3053	3062	3065	1856
Obs. Power	hp		3.28	2.47	1.65	0.82	0.33	0.00
Obs. Torque	ft-lb		5.57	4.18	2.81	1.39	0.55	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.24	2.44	1.63	0.81	0.32	0.00
Work (5 min Interval)	hp-hr		0.273	0.206	0.138	0.069	0.027	0.000
Fuel Flow	lb/hr		2.083	1.695	1.325	1.008	0.845	0.416
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		228	213	190	177	168	145
Exhaust Gas (muffler-in/manifold)	deg F		1289	1281	1144	1116	1081	922
Exhaust Gas (muffler out)	deg F		914	827	619	526	451	364
Catalyst/Muffler Surface	deg F		489	464	383	369	356	292
Intake Air (EPA)	deg F		91	89	86	84	83	79
Intake Air DewPoint (EPA)	deg F		62	62	62	62	62	61
Cyl Head (Spark Plug)	deg F		434	408	353	322	297	262
PRESSURES								
Exhaust BP Before Cat	psig		0.70	0.54	0.29	0.20	0.15	0.04
Barometer	"Hg		28.976	28.966	28.969	28.964	28.959	28.962
F Factor	-----		1.048	1.046	1.042	1.040	1.038	1.032
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		90.89	68.24	68.42	56.99	50.38	76.18
Dilute CO conc (dry)	%		0.14	0.07	0.11	0.07	0.07	0.00
Dilute CO_2 conc (dry)	%		0.60	0.53	0.36	0.29	0.24	0.16
Dilute NO_x conc (dry)	ppm		68.27	51.65	11.04	3.61	1.96	0.90
Measured A/F	-----		13.57	14.12	13.11	13.32	13.17	15.99
Dry/Wet Correction	-----		0.97	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.06	1.06	1.05	1.05	1.05	1.04
Raw O_2 conc $(dry)_{measured}$	%		0.30	0.30	0.26	0.30	0.48	3.80
HC Mass	g/hr		11.64	8.73	8.89	7.41	6.54	10.19
NO_x Mass	g/hr		30.86	23.43	5.00	1.54	0.77	0.27
CO Mass	g/hr		361.9	191.8	297.4	199.7	188.6	8.9
CO_2 Mass	g/hr		2312	2045	1361	1075	867	538
BSHC	g/hp-hr		3.51	3.53	5.41	9.08	20.20	-----
$BSNO_x$	g/hp-hr		9.31	9.48	3.04	1.89	2.38	-----
BSCO	g/hp-hr		109.22	77.57	180.89	244.80	582.44	-----
$BSCO_2$	g/hp-hr		697.96	827.45	828.05	1317.38	2675.39	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**5.57**	**6.14**	**11.72**	**150.1**	**925.3**	**0.841**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 5/14/03

Test ID: HON-160-STK-250-#2

250-hour interval testing with stock muffler and stock jetting (methane test)

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3049	3052	3053	3049	3069	1874
Obs. Power	hp		3.40	2.55	1.70	0.86	0.35	0.00
Obs. Torque	ft-lb		5.78	4.33	2.89	1.45	0.58	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.36	2.52	1.68	0.84	0.34	0.00
Work (5 min Interval)	hp-hr		0.284	0.213	0.142	0.071	0.029	0.000
Fuel Flow	lb/hr		2.146	1.669	1.327	0.989	0.760	0.419
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		235	220	194	182	173	149
Exhaust Gas (muffler-in/manifold)	deg F		1245	1284	1151	1120	1089	921
Exhaust Gas (muffler out)	deg F		877	833	626	532	456	365
Catalyst/Muffler Surface	deg F		489	474	404	421	381	310
Intake Air (EPA)	deg F		94	93	90	89	88	83
Intake Air DewPoint (EPA)	deg F		61	61	61	62	62	61
Cyl Head (Spark Plug)	deg F		446	414	359	329	303	265
PRESSURES								
Exhaust BP Before Cat	psig		0.64	0.52	0.29	0.20	0.15	0.04
Barometer	"Hg		28.933	28.914	28.907	28.901	28.897	28.890
F Factor	-----		1.053	1.052	1.049	1.049	1.047	1.041
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		97.54	60.79	66.58	50.81	40.28	73.10
Dilute CO conc (dry)	%		0.19	0.06	0.11	0.07	0.05	0.00
Dilute CO_2 conc (dry)	%		0.57	0.54	0.36	0.29	0.23	0.16
Dilute NO_x conc (dry)	ppm		55.65	59.42	11.70	3.91	1.77	0.89
Measured A/F	-----		13.14	14.37	13.14	13.44	13.34	16.04
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.04	1.04	1.04	1.06	1.06	1.05
Raw O_2 conc $(dry)_{measured}$	%		0.19	0.30	0.22	0.32	0.50	4.00
HC Mass	g/hr		12.47	7.60	8.53	6.45	5.04	9.61
NO_x Mass	g/hr		24.67	26.38	5.19	1.70	0.70	0.28
CO Mass	g/hr		488.1	149.2	296.3	182.7	140.4	10.2
CO_2 Mass	g/hr		2200	2080	1367	1079	828	541
BSHC	g/hp-hr		3.66	2.97	5.01	7.57	14.99	-----
$BSNO_x$	g/hp-hr		7.24	10.30	3.04	2.00	2.07	-----
BSCO	g/hp-hr		143.18	58.25	173.84	214.46	417.92	-----
$BSCO_2$	g/hp-hr		645.36	812.19	802.04	1266.42	2464.10	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**4.95**	**6.01**	**10.96**	**141.2**	**891.2**	**0.806**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 5/20/03

Test ID: HON-160-J-250-#3

250-hour interval testing with catalyst J, stock jetting, and passive SAI system after carburetor maintenance

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3062	3062	3052	3066	3065	1835
Obs. Power	hp		3.67	2.76	1.83	0.91	0.37	0.01
Obs. Torque	ft-lb		6.21	4.67	3.11	1.55	0.63	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.62	2.72	1.81	0.90	0.37	0.01
Work (5 min Interval)	hp-hr		0.306	0.230	0.153	0.076	0.031	0.001
Fuel Flow	lb/hr		2.079	1.771	1.491	1.105	0.941	0.498
TEMPERATURES								
Catalyst Mid-bed	deg F		1450	1412	1278	1203	1136	1069
Oil	deg F		228	213	193	178	165	146
Exhaust Gas (muffler-in/manifold)	deg F		1276	1241	1146	1091	988	723
Exhaust Gas (muffler out)	deg F		712	622	512	439	381	255
Catalyst/Muffler Surface	deg F		656	614	530	477	430	352
Intake Air (EPA)	deg F		92	90	88	87	86	82
Intake Air DewPoint (EPA)	deg F		58	58	58	58	58	58
Cyl Head (Spark Plug)	deg F		440	404	359	322	287	253
PRESSURES								
Exhaust BP Before Cat	psig		0.18	0.13	0.09	0.05	0.03	-0.01
Barometer	"Hg		29.246	29.243	29.239	29.236	29.232	29.231
F Factor	-----		1.037	1.035	1.032	1.031	1.029	1.025
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		35.31	32.54	37.53	31.83	41.31	22.70
Dilute CO conc (dry)	%		0.09	0.05	0.10	0.07	0.08	0.01
Dilute CO_2 conc (dry)	%		0.65	0.58	0.43	0.33	0.26	0.19
Dilute NO_x conc (dry)	ppm		5.45	6.06	1.36	0.66	0.61	0.59
Measured A/F	-----		13.69	13.88	13.16	13.21	12.58	14.13
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.00	0.99	0.99	0.99	1.00	0.99
Raw O_2 conc $(dry)_{measured}$	%		0.84	0.92	1.05	1.18	1.42	3.05
HC Mass	g/hr		4.27	3.94	4.68	3.94	5.27	2.71
NO_x Mass	g/hr		2.36	2.65	0.60	0.29	0.27	0.26
CO Mass	g/hr		229.3	125.3	260.1	181.2	221.6	31.0
CO_2 Mass	g/hr		2538	2272	1666	1252	953	641
BSHC	g/hp-hr		1.16	1.43	2.56	4.26	14.18	-----
$BSNO_x$	g/hp-hr		0.64	0.96	0.33	0.32	0.73	-----
BSCO	g/hp-hr		62.46	45.41	142.59	196.12	595.77	-----
$BSCO_2$	g/hp-hr		691.41	823.83	913.11	1354.93	2562.49	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**2.46**	**0.60**	**3.06**	**112.3**	**956.8**	**0.815**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/22/2003

Steady-State SORE Engine Test Information **Engine: Honda GCV160**

Date: 5/20/03

Test ID: HON-160-STK-250-#3

250-hour interval testing with stock muffler and stock jetting after carburetor maintenance

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3046	3064	3064	3059	3070	1847
Obs. Power	hp		3.39	2.58	1.72	0.87	0.35	0.01
Obs. Torque	ft-lb		5.77	4.36	2.91	1.47	0.59	0.00
Calc. Power (Obs. Torque*Speed)	hp		3.35	2.54	1.70	0.85	0.34	0.01
Work (5 min Interval)	hp-hr		0.283	0.215	0.143	0.072	0.029	0.000
Fuel Flow	lb/hr		2.126	1.789	1.546	1.100	1.020	0.484
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		235	215	198	176	166	144
Exhaust Gas (muffler-in/manifold)	deg F		1301	1283	1198	1100	1087	823
Exhaust Gas (muffler out)	deg F		874	776	636	489	440	275
Catalyst/Muffler Surface	deg F		573	538	479	400	371	214
Intake Air (EPA)	deg F		93	91	89	86	85	81
Intake Air DewPoint (EPA)	deg F		61	61	60	59	59	58
Cyl Head (Spark Plug)	deg F		447	413	369	318	298	252
PRESSURES								
Exhaust BP Before Cat	psig		0.67	0.51	0.34	0.20	0.16	0.03
Barometer	"Hg		29.197	29.220	29.223	29.231	29.236	29.241
F Factor	-----		1.042	1.038	1.035	1.031	1.028	1.023
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		96.56	81.63	83.48	72.79	78.35	61.87
Dilute CO conc (dry)	%		0.16	0.11	0.14	0.11	0.11	0.04
Dilute CO_2 conc (dry)	%		0.59	0.52	0.40	0.28	0.25	0.15
Dilute NO_x conc (dry)	ppm		59.69	43.63	11.05	3.39	2.08	0.88
Measured A/F	-----		13.36	13.58	12.90	12.67	12.44	13.25
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.03	1.03	1.02	1.01	1.01	1.00
Raw O_2 conc $(dry)_{measured}$	%		0.14	0.16	0.17	0.26	0.35	1.22
HC Mass	g/hr		12.38	10.50	10.86	9.54	10.39	8.17
NO_x Mass	g/hr		26.54	19.63	4.83	1.39	0.81	0.26
CO Mass	g/hr		425.2	295.9	386.8	307.6	312.0	102.8
CO_2 Mass	g/hr		2272	2009	1524	1029	906	491
BSHC	g/hp-hr		3.61	4.07	6.33	11.06	29.88	-----
$BSNO_x$	g/hp-hr		7.74	7.61	2.82	1.61	2.33	-----
BSCO	g/hp-hr		123.95	114.75	225.33	356.35	897.02	-----
$BSCO_2$	g/hp-hr		662.24	779.16	887.70	1191.73	2605.00	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**6.46**	**5.11**	**11.57**	**204.8**	**899.9**	**0.886**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/22/2003

APPENDIX E

KAWASAKI FH601V EMISSION DATA SHEETS

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 2/14/03

Test ID: KAW2-BSLN#1

Baseline Test #1 of replacement Kawasaki engine after break-in (methane test)

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3056	3057	3045	3089	3045	1556
Obs. Power	hp		15.38	11.56	7.68	3.86	1.51	0.00
Obs. Torque	ft-lb		26.08	19.59	13.06	6.46	2.56	0.00
Calc. Power (Obs. Torque*Speed)	hp		15.17	11.40	7.57	3.80	1.48	0.00
Work (5 min Interval)	hp-hr		1.282	0.964	0.640	0.321	0.125	0.000
Fuel Flow	lb/hr		9.660	8.101	6.849	5.943	3.992	1.613
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		259	251	232	215	206	185
Exhaust Gas (muffler-in/manifold)	deg F		1275	1258	1222	1194	1154	775
Exhaust Gas (muffler out)	deg F		828	737	641	534	423	180
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	NA
Intake Air (EPA)	deg F		95	88	85	84	83	84
Intake Air DewPoint (EPA)	deg F		65	65	66	65	65	64
Cyl Head (Spark Plug)	deg F		421	384	338	309	297	243
PRESSURES								
Exhaust BP Before Cat	psig		0.25	0.16	0.10	0.05	0.02	0.00
Barometer	"Hg		28.907	28.893	28.881	28.880	28.868	28.865
F Factor	-----		1.059	1.050	1.047	1.045	1.044	1.044
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		97.64	88.79	104.77	161.32	83.37	82.08
Dilute CO conc (dry)	%		0.48	0.39	0.38	0.38	0.21	0.08
Dilute CO_2 conc (dry)	%		0.64	0.53	0.39	0.28	0.24	0.12
Dilute NO_x conc (dry)	ppm		20.45	12.40	4.73	1.38	1.41	0.23
Measured A/F	-----		11.26	11.16	10.57	9.91	10.64	10.85
Dry/Wet Correction	-----		0.97	0.97	0.97	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.12	1.11	1.12	1.11	1.11	1.08
Raw O_2 conc (dry)$_{measured}$	%		0.07	0.09	0.11	0.19	0.22	0.93
HC Mass	g/hr		38.47	35.61	42.88	67.69	34.97	35.12
NO_x Mass	g/hr		29.66	18.17	7.07	2.00	2.08	0.23
CO Mass	g/hr		3771.2	3180.7	3142.7	3162.4	1804.5	664.3
CO_2 Mass	g/hr		7485	6239	4522	3146	2647	1107
BSHC	g/hp-hr		2.52	3.08	5.59	17.63	23.12	-----
BSNO_x	g/hp-hr		1.94	1.57	0.92	0.52	1.38	-----
BSCO	g/hp-hr		246.68	274.85	409.85	823.53	1193.05	-----
BSCO_2	g/hp-hr		489.63	539.15	589.69	819.38	1750.32	-----

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**6.63**	**1.27**	**7.90**	**417.6**	**615.9**	**0.923**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V**

Date: 2/14/03

Test ID: KAW2-BSLN#2

Baseline Test #2 of replacement Kawasaki engine after break-in (TEST VOID-Idle emissions invalid)

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	~~6~~
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	~~0.05~~
DF Mode Interval (sec)	-----		300	300	300	300	300	~~300~~
Speed Set	%Rated		85	85	85	85	85	~~Idle~~
Load Set	%Rated		100	75	50	25	10	~~0~~
ENGINE DATA								
Obs. Speed	rpm							
Obs. Power	hp							
Obs. Torque	ft-lb							
Calc. Power (Obs. Torque*Speed)	hp							
Work (5 min Interval)	hp-hr							
Fuel Flow	lb/hr							
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	~~NA~~
Oil	deg F		270	256	236	217	207	~~191~~
Exhaust Gas (muffler-in/manifold)	deg F		1294	1248	1225	1191	1147	~~798~~
Exhaust Gas (muffler out)	deg F		848	736	642	531	420	~~190~~
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	~~NA~~
Intake Air (EPA)	deg F		93	89	87	85	84	~~84~~
Intake Air DewPoint (EPA)	deg F		64	64	64	63	63	~~62~~
Cyl Head (Spark Plug)	deg F		430	383	341	309	296	~~248~~
PRESSURES								
Exhaust BP Before Cat	psig		0.23	0.14	0.08	0.03	0.00	~~0.00~~
Barometer	"Hg		28.948	28.937	28.939	28.929	28.928	~~28.919~~
F Factor	-----		1.053	1.048	1.045	1.043	1.042	~~1.042~~
GASEOUS EMISSIONS								
Dilute HC conc (wet)	ppm							
Dilute CO conc (dry)	%							
Dilute CO_2 conc (dry)	%							
Dilute NO_x conc (dry)	ppm							
Measured A/F	-----							
Dry/Wet Correction	-----							
NO_x Humidity Correction	-----							
	%		0.08	0.09	0.11	0.19	0.26	~~0.86~~
Weighted Specific Emissions[3]	g/hp-hr		**6.41**	**1.32**	**7.73**	**423.7**	**618.0**	**0.931**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V**

Date: 2/17/03

Test ID: KAW2-BSLN #3

Baseline Test #3 of replacement Kawasaki engine after break-in

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3068	3086	3055	3053	3078	1544
Obs. Power	hp		16.12	12.13	8.05	4.02	1.61	0.00
Obs. Torque	ft-lb		27.22	20.36	13.65	6.82	2.72	0.00
Calc. Power (Obs. Torque*Speed)	hp		15.90	11.96	7.94	3.96	1.59	0.04
Work (5 min Interval)	hp-hr		1.344	1.011	0.671	0.335	0.135	0.000
Fuel Flow	lb/hr		8.747	8.624	7.232	5.831	4.172	1.666
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		276	242	224	206	197	180
Exhaust Gas (muffler-in/manifold)	deg F		1381	1246	1225	1173	1143	758
Exhaust Gas (muffler out)	deg F		872	720	614	484	402	159
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	NA
Intake Air (EPA)	deg F		103	106	94	90	88	83
Intake Air DewPoint (EPA)	deg F		36	38	37	37	38	39
Cyl Head (Spark Plug)	deg F		452	380	331	297	288	238
PRESSURES								
Exhaust BP Before Cat	psig		0.18	0.09	0.03	0.00	0.00	0.00
Barometer	"Hg		29.328	29.319	29.318	29.319	29.310	29.305
F Factor	-----		1.039	1.043	1.028	1.022	1.021	1.014
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		68.42	89.06	90.00	107.83	81.55	85.60
Dilute CO conc (dry)	%		0.20	0.44	0.37	0.33	0.22	0.08
Dilute CO_2 conc (dry)	%		0.77	0.49	0.40	0.28	0.23	0.12
Dilute NO_x conc (dry)	ppm		96.81	11.47	6.24	2.05	1.36	0.20
Measured A/F	-----		12.68	10.88	10.64	10.15	10.45	10.74
Dry/Wet Correction	-----		0.99	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.83	0.84	0.84	0.83	0.84	0.84
Raw O_2 conc (dry)$_{measured}$	%		0.07	0.08	0.10	0.18	0.19	0.94
HC Mass	g/hr		27.35	37.05	38.07	46.70	35.43	37.85
NO_x Mass	g/hr		110.37	13.51	7.51	2.49	1.67	0.23
CO Mass	g/hr		1661.6	3760.7	3243.6	2988.6	1966.2	705.7
CO_2 Mass	g/hr		9556	6056	4916	3327	2645	1108
BSHC	g/hp-hr		1.69	3.05	4.72	11.59	22.03	-----
BSNO_x	g/hp-hr		6.84	1.11	0.93	0.62	1.04	-----
BSCO	g/hp-hr		102.91	309.88	402.23	741.47	1222.76	-----
BSCO_2	g/hp-hr		591.82	498.99	609.57	825.51	1644.80	-----

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**5.21**	**2.08**	**7.29**	**386.1**	**628.0**	**0.893**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: FH601V 19 Hp**

Date: 2/17/03

Test ID: KAW2-BSLN#4

Baseline Test #4 of replacement Kawasaki engine after break-in (methane analysis)

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3035	3084	3067	3063	3042	1533
Obs. Power	hp		15.60	11.95	7.93	3.97	1.57	0.00
Obs. Torque	ft-lb		26.63	20.07	13.39	6.71	2.68	0.00
Calc. Power (Obs. Torque*Speed)	hp		15.39	11.78	7.82	3.91	1.55	0.04
Work (5 min Interval)	hp-hr		1.300	0.996	0.660	0.331	0.131	0.000
Fuel Flow	lb/hr		8.405	7.836	6.624	5.506	3.920	1.620
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		286	251	226	208	201	182
Exhaust Gas (muffler-in/manifold)	deg F		1378	1288	1236	1174	1142	770
Exhaust Gas (muffler out)	deg F		846	731	621	491	400	171
Catalyst/Muffler Surface	deg F		NA	NA	NA	NA	NA	NA
Intake Air (EPA)	deg F		112	88	85	82	81	88
Intake Air DewPoint (EPA)	deg F		40	38	39	38	40	38
Cyl Head (Spark Plug)	deg F		462	390	337	302	291	236
PRESSURES								
Exhaust BP Before Cat	psig		0.27	0.14	0.08	0.04	0.01	0.00
Barometer	"Hg		29.182	29.229	29.222	29.210	29.200	29.197
F Factor	-----		1.056	1.024	1.020	1.015	1.015	1.024
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		61.36	71.13	79.30	104.97	70.21	79.35
Dilute CO conc (dry)	%		0.20	0.32	0.32	0.32	0.20	0.08
Dilute CO_2 conc (dry)	%		0.75	0.54	0.39	0.27	0.23	0.12
Dilute NO_x conc (dry)	ppm		96.82	20.88	6.92	1.87	1.61	0.16
Measured A/F	-----		12.60	11.40	10.95	10.10	10.74	10.73
Dry/Wet Correction	-----		0.98	0.99	0.99	0.99	0.99	0.99
NO_x Humidity Correction	-----		0.85	0.84	0.84	0.84	0.85	0.84
Raw O_2 conc $(dry)_{measured}$	%		0.08	0.09	0.10	0.16	0.19	0.94
HC Mass	g/hr		23.89	28.78	32.88	44.75	29.80	34.48
NO_x Mass	g/hr		111.41	24.52	8.29	2.25	1.94	0.15
CO Mass	g/hr		1607.1	2684.7	2812.0	2801.4	1759.3	705.7
CO_2 Mass	g/hr		9173	6668	4758	3172	2634	1054
BSHC	g/hp-hr		1.52	2.41	4.15	11.29	18.81	-----
$BSNO_x$	g/hp-hr		7.11	2.06	1.05	0.57	1.23	-----
BSCO	g/hp-hr		102.55	225.15	355.05	706.97	1110.31	-----
$BSCO_2$	g/hp-hr		585.30	559.22	600.75	800.54	1662.62	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**4.69**	**2.46**	**7.15**	**337.7**	**639.6**	**0.846**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information Engine: Kawasaki FH601V #2

Test ID: KAW2-E-BSLN#1

Development testing with catalyst E, stock carburetion, and no SAI

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3071	3073	3041	3098	3047	1541
Obs. Power	hp		15.90	11.92	7.89	3.98	1.56	0.00
Obs. Torque	ft-lb		26.82	20.09	13.44	6.66	2.65	0.00
Calc. Power (Obs. Torque*Speed)	hp		15.68	11.76	7.78	3.93	1.54	0.00
Work (5 min Interval)	hp-hr		1.325	0.993	0.657	0.332	0.130	0.000
Fuel Flow	lb/hr		9.735	8.554	7.279	6.163	3.940	1.713
TEMPERATURES								
Catalyst Mid-bed	deg F		1329	1247	1169	1107	1009	633
Oil	deg F		277	264	244	224	215	192
Exhaust Gas (muffler-in/manifold)	deg F		1281	1230	1200	1184	1145	747
Exhaust Gas (muffler out)	deg F		1040	940	838	737	560	297
Catalyst/Muffler Surface	deg F		649	598	550	512	427	267
Intake Air (EPA)	deg F		93	91	89	87	85	75
Intake Air DewPoint (EPA)	deg F		60	60	60	61	60	60
Cyl Head (Spark Plug)	deg F		424	385	335	305	292	238
PRESSURES								
Exhaust BP Before Cat	psig		0.26	0.19	0.14	0.10	0.07	0.02
Barometer	"Hg		29.182	29.184	29.188	29.195	29.193	29.183
F Factor	-----		1.042	1.039	1.036	1.033	1.031	1.018
GASEOUS EMISSIONS			EMISSIONS ARE UNWEIGHTED[1] (ETIS)					
Dilute HC conc (wet)	ppm		52.17	81.83	79.52	105.04	64.65	85.81
Dilute CO conc (dry)	%		0.28	0.27	0.26	0.24	0.11	0.06
Dilute CO_2 conc (dry)	%		0.85	0.70	0.56	0.44	0.34	0.15
Dilute NO_x conc (dry)	ppm		1.08	0.55	0.34	0.19	0.25	0.22
Measured A/F	-----		11.81	10.83	10.17	9.15	11.00	10.71
Dry/Wet Correction	-----		0.97	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.02	1.02	1.02	1.03	1.02	1.02
Raw O_2 conc (dry)$_{measured}$	%		0.08	0.09	0.10	0.13	0.12	0.31
HC Mass	g/hr		20.82	33.41	33.13	44.67	27.84	37.91
NO_x Mass	g/hr		1.26	0.56	0.28	0.07	0.15	0.11
CO Mass	g/hr		2185.3	2204.3	2123.9	2051.6	914.1	498.3
CO_2 Mass	g/hr		10138	8414	6756	5270	3996	1499
BSHC	g/hp-hr		1.31	2.81	4.18	11.19	17.58	-----
$BSNO_x$	g/hp-hr		0.08	0.05	0.03	0.02	0.10	-----
BSCO	g/hp-hr		137.48	185.17	267.86	513.94	577.29	-----
$BSCO_2$	g/hp-hr		637.80	706.81	852.02	1320.08	2523.39	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**4.77**	**0.05**	**4.82**	**263.9**	**874.7**	**0.931**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 3/14/03

Test ID: KAW2-EO3-#1

Development "engine-out" testing with stock muffler, SAI venturi pipe, and Tier 3 jetting (116/120)

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3041	3059	3050	3053	3050	1527
Obs. Power	hp		15.23	11.50	7.64	3.80	1.52	0.00
Obs. Torque	ft-lb		25.95	19.47	12.98	6.45	2.57	0.00
Calc. Power (Obs. Torque*Speed)	hp		15.03	11.34	7.54	3.75	1.50	0.00
Work (5 min Interval)	hp-hr		1.269	0.958	0.637	0.317	0.126	0.000
Fuel Flow	lb/hr		8.898	6.732	5.906	4.535	3.616	1.192
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		289	281	261	239	222	199
Exhaust Gas (muffler-in/manifold)	deg F		1288	1317	1217	1145	1091	769
Exhaust Gas (muffler out)	deg F		NA	NA	NA	NA	NA	NA
Catalyst/Muffler Surface	deg F		524	507	435	364	330	195
Intake Air (EPA)	deg F		101	101	99	97	95	83
Intake Air DewPoint (EPA)	deg F		53	53	52	52	52	52
Cyl Head (Spark Plug)	deg F		459	428	368	329	307	249
PRESSURES								
Exhaust BP Before Cat	psig		0.71	0.58	0.47	0.36	0.07	0.00
Barometer	"Hg		29.030	29.023	29.018	29.016	29.013	29.010
F Factor	-----		1.054	1.053	1.052	1.048	1.046	1.030
GASEOUS EMISSIONS			EMISSIONS ARE UNWEIGHTED[1] (ETIS)					
Dilute HC conc (wet)	ppm		81.27	58.83	63.03	60.22	53.18	71.90
Dilute CO conc (dry)	%		0.34	0.15	0.22	0.19	0.14	0.02
Dilute CO_2 conc (dry)	%		0.67	0.61	0.43	0.31	0.26	0.13
Dilute NO_x conc (dry)	ppm		44.79	63.69	12.68	3.63	2.19	0.40
Measured A/F	-----		12.09	13.68	12.64	12.33	12.59	15.03
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.99
NO_x Humidity Correction	-----		0.95	0.94	0.94	0.93	0.94	0.93
Raw O_2 conc $(dry)_{measured}$	%		0.30	0.35	0.52	0.82	1.27	5.00
HC Mass	g/hr		31.82	23.16	25.44	24.72	21.93	30.51
NO_x Mass	g/hr		56.64	81.16	16.47	4.79	2.93	0.54
CO Mass	g/hr		2722.2	1215.7	1881.2	1605.0	1231.3	212.1
CO_2 Mass	g/hr		8087	7448	5237	3753	3062	1243
BSHC	g/hp-hr		2.08	2.01	3.32	6.48	14.28	-----
$BSNO_x$	g/hp-hr		3.71	7.06	2.15	1.25	1.91	-----
BSCO	g/hp-hr		178.26	105.75	245.72	420.61	801.86	-----
$BSCO_2$	g/hp-hr		529.55	647.86	684.06	983.58	1994.34	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**3.55**	**3.89**	**7.43**	**225.6**	**719.1**	**0.774**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 3/14/03

Test ID: KAW2-E-DEV-FNL#1

Final development testing with catalyst E muffler, SAI venturi pipe, and Tier 3 jetting (116/120) w/methane

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3064	3059	3061	3078	3070	1532
Obs. Power	hp		15.56	11.60	7.78	3.89	1.53	0.00
Obs. Torque	ft-lb		26.31	19.65	13.16	6.55	2.57	0.00
Calc. Power (Obs. Torque*Speed)	hp		15.35	11.44	7.67	3.84	1.50	0.00
Work (5 min Interval)	hp-hr		1.297	0.967	0.648	0.324	0.127	0.000
Fuel Flow	lb/hr		8.953	6.567	5.689	4.664	3.430	1.407
TEMPERATURES								
Catalyst Mid-bed	deg F		1359	1390	1247	1175	1136	1067
Oil	deg F		283	269	251	227	214	190
Exhaust Gas (muffler-in/manifold)	deg F		1300	1344	1236	1154	1105	805
Exhaust Gas (muffler out)	deg F		1101	1016	884	743	627	398
Catalyst/Muffler Surface	deg F		474	460	440	403	395	311
Intake Air (EPA)	deg F		90	90	89	88	86	77
Intake Air DewPoint (EPA)	deg F		57	57	56	56	55	55
Cyl Head (Spark Plug)	deg F		453	419	359	317	298	247
PRESSURES								
Exhaust BP Before Cat	psig		0.66	0.54	0.43	0.11	0.07	0.02
Barometer	"Hg		29.179	29.180	29.177	29.172	29.171	29.166
F Factor	-----		1.037	1.037	1.035	1.033	1.030	1.018
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		46.68	16.15	26.97	33.62	25.85	16.22
Dilute CO conc (dry)	%		0.19	0.04	0.11	0.11	0.07	0.00
Dilute CO_2 conc (dry)	%		0.84	0.71	0.53	0.41	0.32	0.18
Dilute NO_x conc (dry)	ppm		0.71	1.17	0.06	0.15	0.00	0.38
Measured A/F	-----		12.88	13.95	12.67	12.07	12.24	14.61
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		0.98	0.98	0.98	0.97	0.96	0.96
Raw O_2 conc (dry)$_{measured}$	%		0.46	0.54	0.57	0.82	1.05	3.00
HC Mass	g/hr		17.66	5.44	10.10	13.14	9.91	5.83
NO_x Mass	g/hr		0.92	1.54	0.08	0.20	0.00	0.53
CO Mass	g/hr		1519.7	350.8	921.6	950.1	599.9	27.3
CO_2 Mass	g/hr		10098	8631	6489	4999	3832	1909
BSHC	g/hp-hr		1.13	0.47	1.30	3.38	6.45	-----
BSNO_x	g/hp-hr		0.06	0.13	0.01	0.05	0.00	-----
BSCO	g/hp-hr		97.68	30.20	118.89	244.44	390.68	-----
BSCO_2	g/hp-hr		649.01	742.86	837.06	1286.28	2495.45	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**1.45**	**0.07**	**1.52**	**110.8**	**880.6**	**0.756**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 3/14/03

Test ID: KAW2-E-DEV-FNL#2

Final development testing with catalyst E muffler, SAI venturi pipe, and Tier 3 jetting (116/120) w/methane

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3059	3073	3065	3063	3053	1537
Obs. Power	hp		15.35	11.59	7.72	3.85	1.53	0.00
Obs. Torque	ft-lb		26.00	19.54	13.05	6.51	2.59	0.00
Calc. Power (Obs. Torque*Speed)	hp		15.14	11.43	7.62	3.80	1.51	0.00
Work (5 min Interval)	hp-hr		1.279	0.966	0.644	0.321	0.127	0.000
Fuel Flow	lb/hr		8.807	6.338	5.704	4.299	3.434	1.296
TEMPERATURES								
Catalyst Mid-bed	deg F		1368	1411	1237	1161	1121	1079
Oil	deg F		287	279	257	238	222	202
Exhaust Gas (muffler-in/manifold)	deg F		1301	1348	1226	1146	1096	795
Exhaust Gas (muffler out)	deg F		1118	1037	882	736	619	417
Catalyst/Muffler Surface	deg F		462	485	456	423	399	351
Intake Air (EPA)	deg F		96	96	95	94	92	83
Intake Air DewPoint (EPA)	deg F		53	54	54	53	53	53
Cyl Head (Spark Plug)	deg F		462	429	366	328	306	256
PRESSURES								
Exhaust BP Before Cat	psig		0.68	0.58	0.44	0.14	0.07	0.02
Barometer	"Hg		29.103	29.091	29.083	29.078	29.071	29.066
F Factor	-----		1.045	1.046	1.044	1.042	1.041	1.029
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		33.78	10.65	29.11	28.71	30.24	16.57
Dilute CO conc (dry)	%		0.19	0.03	0.11	0.09	0.07	0.00
Dilute CO_2 conc (dry)	%		0.83	0.70	0.53	0.39	0.32	0.17
Dilute NO_x conc (dry)	ppm		1.11	0.14	0.33	0.15	0.07	0.30
Measured A/F	-----		12.93	14.12	12.69	12.23	12.42	14.51
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		0.95	0.95	0.95	0.94	0.94	0.95
Raw O_2 conc $(dry)_{measured}$	%		0.44	0.59	0.60	0.75	1.01	3.00
HC Mass	g/hr		12.53	3.35	11.12	11.14	11.92	6.15
NO_x Mass	g/hr		1.38	0.18	0.43	0.20	0.09	0.41
CO Mass	g/hr		1469.4	224.8	925.6	790.3	587.3	14.5
CO_2 Mass	g/hr		9988	8514	6500	4745	3850	1773
BSHC	g/hp-hr		0.81	0.29	1.44	2.90	7.71	-----
$BSNO_x$	g/hp-hr		0.09	0.02	0.06	0.05	0.06	-----
BSCO	g/hp-hr		95.52	19.45	119.85	205.74	379.51	-----
$BSCO_2$	g/hp-hr		649.27	736.79	841.69	1235.33	2488.07	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**1.32**	**0.05**	**1.37**	**100.7**	**871.1**	**0.738**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 4/14/03

Test ID: KAW2-125-E-#1

125-hour interval emission test "as-received" from durability with catalyst E, Tier 3 jetting (116/120), and passive SAI system. (methane test)

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3057	3052	3069	3068	3046	1533
Obs. Power	hp		15.39	11.50	7.69	3.86	1.53	0.00
Obs. Torque	ft-lb		26.07	19.52	12.98	6.51	2.61	0.00
Calc. Power (Obs. Torque*Speed)	hp		15.18	11.34	7.59	3.80	1.51	0.00
Work (5 min Interval)	hp-hr		1.282	0.959	0.641	0.321	0.128	0.000
Fuel Flow	lb/hr		8.877	6.653	5.801	4.477	3.459	1.263
TEMPERATURES								
Catalyst Mid-bed	deg F		1207	1187	1076	978	929	661
Oil	deg F		274	266	243	224	214	187
Exhaust Gas (muffler-in/manifold)	deg F		1317	1359	1259	1182	1137	796
Exhaust Gas (muffler out)	deg F		1075	993	841	694	600	337
Catalyst/Muffler Surface	deg F		707	694	614	545	510	347
Intake Air (EPA)	deg F		87	88	88	86	85	75
Intake Air DewPoint (EPA)	deg F		58	58	58	58	57	57
Cyl Head (Spark Plug)	deg F		432	407	350	312	296	248
PRESSURES								
Exhaust BP Before Cat	psig		1.17	0.72	0.43	0.20	0.11	-0.09
Barometer	"Hg		29.264	29.270	29.273	29.278	29.277	29.276
F Factor	-----		1.030	1.031	1.030	1.027	1.026	1.013
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		38.56	24.27	33.97	37.84	30.16	12.17
Dilute CO conc (dry)	%		0.23	0.07	0.13	0.12	0.08	0.00
Dilute CO_2 conc (dry)	%		0.81	0.70	0.53	0.39	0.32	0.17
Dilute NO_x conc (dry)	ppm		0.30	1.49	0.44	0.29	0.22	0.45
Measured A/F	-----		12.69	13.75	12.69	12.27	12.58	15.01
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.00	0.99	0.99	0.99	0.98	0.98
Raw O_2 conc $(dry)_{measured}$	%		0.35	0.47	0.55	0.71	0.88	2.70
HC Mass	g/hr		14.02	8.45	12.71	14.57	11.42	3.74
NO_x Mass	g/hr		0.34	1.93	0.56	0.36	0.26	0.59
CO Mass	g/hr		1763.8	547.1	1057.0	984.5	650.5	3.1
CO_2 Mass	g/hr		9618	8433	6425	4678	3788	1753
BSHC	g/hp-hr		0.91	0.73	1.65	3.78	7.38	-----
$BSNO_x$	g/hp-hr		0.02	0.17	0.07	0.09	0.17	-----
BSCO	g/hp-hr		114.96	47.49	137.36	255.67	420.34	-----
$BSCO_2$	g/hp-hr		626.90	732.01	834.93	1214.90	2447.63	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**1.67**	**0.10**	**1.77**	**127.5**	**859.6**	**0.760**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 4/14/03

Test ID: KAW2-125-E-#2

125-hour interval emission test "as-received" from durability with catalyst E, Tier 3 jetting (116/120), and passive SAI system. (methane test)

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3057	3055	3049	3049	3074	1529
Obs. Power	hp		15.34	11.52	7.65	3.82	1.52	0.00
Obs. Torque	ft-lb		25.99	19.53	12.99	6.49	2.57	0.00
Calc. Power (Obs. Torque*Speed)	hp		15.13	11.36	7.54	3.77	1.50	0.00
Work (5 min Interval)	hp-hr		1.278	0.960	0.637	0.319	0.127	0.000
Fuel Flow	lb/hr		9.074	6.797	5.656	4.366	3.490	1.221
TEMPERATURES								
Catalyst Mid-bed	deg F		1369	1385	1283	1229	1217	803
Oil	deg F		280	269	244	229	218	193
Exhaust Gas (muffler-in/manifold)	deg F		1315	1342	1252	1179	1143	808
Exhaust Gas (muffler out)	deg F		1085	1064	958	852	765	370
Catalyst/Muffler Surface	deg F		725	705	628	565	538	345
Intake Air (EPA)	deg F		91	92	91	90	89	80
Intake Air DewPoint (EPA)	deg F		57	57	57	57	56	55
Cyl Head (Spark Plug)	deg F		438	410	353	316	301	253
PRESSURES								
Exhaust BP Before Cat	psig		1.10	0.65	0.33	0.12	0.04	-0.17
Barometer	"Hg		29.269	29.233	29.223	29.214	29.215	29.212
F Factor	-----		1.034	1.037	1.036	1.035	1.033	1.021
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		43.77	30.74	30.02	29.59	23.85	14.89
Dilute CO conc (dry)	%		0.23	0.08	0.12	0.10	0.06	0.00
Dilute CO_2 conc (dry)	%		0.83	0.71	0.53	0.40	0.34	0.16
Dilute NO_x conc (dry)	ppm		1.12	1.04	0.27	0.24	0.26	0.56
Measured A/F	-----		12.74	13.65	12.82	12.46	12.80	15.96
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		0.98	0.98	0.98	0.98	0.97	0.97
Raw O_2 conc $(dry)_{measured}$	%		0.55	0.66	0.80	1.04	1.25	4.43
HC Mass	g/hr		16.02	10.98	10.91	10.92	8.59	4.88
NO_x Mass	g/hr		1.27	1.18	0.19	0.15	0.18	0.60
CO Mass	g/hr		1779.1	629.4	961.5	828.3	531.1	9.1
CO_2 Mass	g/hr		9865	8498	6377	4780	4028	1681
BSHC	g/hp-hr		1.04	0.95	1.43	2.85	5.59	-----
$BSNO_x$	g/hp-hr		0.08	0.10	0.03	0.04	0.12	-----
BSCO	g/hp-hr		115.74	54.48	125.78	216.31	345.99	-----
$BSCO_2$	g/hp-hr		641.74	735.64	834.26	1248.17	2623.82	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**1.52**	**0.07**	**1.59**	**118.7**	**870.2**	**0.758**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 4/15/03

Test ID: KAW2-125-STK-#1

125-hr. testing of Kawasaki with stock muffler, no SAI system, and stock jetting (136/140)

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3068	3063	3074	3052	3056	1533
Obs. Power	hp		15.22	11.39	7.64	3.76	1.51	0.00
Obs. Torque	ft-lb		25.70	19.26	12.88	6.39	2.56	0.00
Calc. Power (Obs. Torque*Speed)	hp		15.02	11.23	7.54	3.71	1.49	0.00
Work (5 min Interval)	hp-hr		1.269	0.949	0.637	0.314	0.126	0.000
Fuel Flow	lb/hr		10.742	8.044	6.686	5.039	3.478	1.141
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		260	249	237	222	215	187
Exhaust Gas (muffler-in/manifold)	deg F		1211	1228	1203	1165	1167	787
Exhaust Gas (muffler out)	deg F		182	657	570	461	380	157
Catalyst/Muffler Surface	deg F		478	437	397	339	305	166
Intake Air (EPA)	deg F		90	89	89	88	87	78
Intake Air DewPoint (EPA)	deg F		59	59	59	58	58	58
Cyl Head (Spark Plug)	deg F		404	378	336	305	298	238
PRESSURES								
Exhaust BP Before Cat	psig		0.54	0.30	0.16	0.04	-0.03	-0.13
Barometer	"Hg		29.130	29.126	29.123	29.110	29.107	29.099
F Factor	-----		1.039	1.039	1.038	1.036	1.035	1.024
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		144.34	105.78	103.37	95.40	50.16	94.62
Dilute CO conc (dry)	%		0.68	0.43	0.37	0.29	0.14	0.01
Dilute CO_2 conc (dry)	%		0.54	0.47	0.37	0.27	0.26	0.13
Dilute NO_x conc (dry)	ppm		8.02	8.51	4.87	2.47	2.31	0.76
Measured A/F	-----		10.15	11.13	10.72	10.41	12.28	14.70
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.00	1.01	1.00	1.00	0.99	1.00
Raw O_2 conc $(dry)_{measured}$	%		0.12	0.13	0.12	0.16	0.17	3.00
HC Mass	g/hr		56.47	41.80	41.45	38.65	19.60	39.58
NO_x Mass	g/hr		10.21	11.10	6.27	3.00	2.76	0.61
CO Mass	g/hr		5413.3	3525.7	3094.8	2441.3	1151.9	107.7
CO_2 Mass	g/hr		6365	5597	4373	3103	3000	1306
BSHC	g/hp-hr		3.71	3.68	5.44	10.23	12.96	-----
$BSNO_x$	g/hp-hr		0.67	0.98	0.82	0.79	1.83	-----
BSCO	g/hp-hr		355.77	310.15	406.15	645.84	761.81	-----
$BSCO_2$	g/hp-hr		418.31	492.37	573.91	820.81	1984.35	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**5.70**	**0.86**	**6.55**	**410.0**	**587.5**	**0.892**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 4/15/03

Test ID: KAW2-125-STK-#2

125-hr. testing of Kawasaki with stock muffler, no SAI system, and stock jetting (136/140)

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3055	3066	3071	3062	3062	1545
Obs. Power	hp		15.16	11.40	7.61	3.79	1.51	0.00
Obs. Torque	ft-lb		25.70	19.26	12.84	6.40	2.56	0.00
Calc. Power (Obs. Torque*Speed)	hp		14.95	11.24	7.51	3.73	1.49	0.00
Work (5 min Interval)	hp-hr		1.263	0.950	0.634	0.315	0.126	0.000
Fuel Flow	lb/hr		10.817	8.683	6.626	5.074	3.440	1.253
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		268	257	241	226	218	193
Exhaust Gas (muffler-in/manifold)	deg F		1203	1211	1200	1166	1167	826
Exhaust Gas (muffler out)	deg F		749	661	569	462	381	164
Catalyst/Muffler Surface	deg F		481	449	398	343	309	174
Intake Air (EPA)	deg F		93	92	91	89	89	80
Intake Air DewPoint (EPA)	deg F		58	58	58	57	58	57
Cyl Head (Spark Plug)	deg F		407	382	338	307	300	249
PRESSURES								
Exhaust BP Before Cat	psig		0.59	0.36	0.18	0.05	-0.02	-0.13
Barometer	"Hg		29.084	29.073	29.070	29.061	29.062	29.050
F Factor	-----		1.045	1.043	1.042	1.039	1.039	1.027
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		151.56	131.35	103.33	98.03	50.47	83.94
Dilute CO conc (dry)	%		0.70	0.52	0.38	0.29	0.13	0.01
Dilute CO_2 conc (dry)	%		0.53	0.45	0.36	0.27	0.26	0.15
Dilute NO_x conc (dry)	ppm		7.59	6.55	4.71	2.49	2.49	0.86
Measured A/F	-----		9.99	9.80	10.77	10.45	12.26	14.16
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.00	1.00	1.00	0.99	0.99	0.99
Raw O_2 conc $(dry)_{measured}$	%		0.10	0.12	0.12	0.16	0.17	2.80
HC Mass	g/hr		59.55	52.29	41.63	40.11	20.07	35.15
NO_x Mass	g/hr		9.59	8.35	5.99	2.97	3.02	0.76
CO Mass	g/hr		5565.3	4254.0	3127.1	2464.3	1118.8	106.8
CO_2 Mass	g/hr		6222	5316	4238	3111	2998	1479
BSHC	g/hp-hr		3.92	4.60	5.47	10.58	13.17	-----
$BSNO_x$	g/hp-hr		0.63	0.73	0.79	0.78	1.98	-----
BSCO	g/hp-hr		366.79	374.01	410.89	650.09	734.13	-----
$BSCO_2$	g/hp-hr		410.04	467.41	556.84	820.69	1967.29	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**6.08**	**0.76**	**6.84**	**434.5**	**573.8**	**0.911**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 4/16/03

Test ID: KAW2-125-EO3-#3

125-hr. testing with stock muffler, passive SAI, and Tier 3 jetting (116/120)

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3060	3058	3074	3069	3049	1516
Obs. Power	hp		15.16	11.37	7.64	3.79	1.51	0.00
Obs. Torque	ft-lb		25.66	19.26	12.88	6.40	2.57	0.00
Calc. Power (Obs. Torque*Speed)	hp		14.95	11.21	7.54	3.74	1.49	0.00
Work (5 min Interval)	hp-hr		1.263	0.948	0.637	0.316	0.126	0.000
Fuel Flow	lb/hr		8.747	6.504	5.542	4.324	3.259	1.167
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		279	272	253	235	221	194
Exhaust Gas (muffler-in/manifold)	deg F		1312	1347	1250	1178	1136	742
Exhaust Gas (muffler out)	deg F		808	719	582	444	364	171
Catalyst/Muffler Surface	deg F		553	532	463	390	362	195
Intake Air (EPA)	deg F		98	99	97	94	93	82
Intake Air DewPoint (EPA)	deg F		57	57	56	55	56	56
Cyl Head (Spark Plug)	deg F		444	417	360	321	304	236
PRESSURES								
Exhaust BP Before Cat	psig		1.23	0.77	0.43	0.19	0.09	-0.11
Barometer	"Hg		28.989	28.984	28.980	28.977	28.973	28.964
F Factor	-----		1.054	1.055	1.052	1.048	1.047	1.032
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		87.04	62.66	65.00	56.91	46.86	136.01
Dilute CO conc (dry)	%		0.32	0.13	0.20	0.17	0.12	0.01
Dilute CO_2 conc (dry)	%		0.69	0.62	0.43	0.32	0.26	0.14
Dilute NO_x conc (dry)	ppm		46.31	63.66	13.48	4.30	2.65	0.99
Measured A/F	-----		12.88	13.84	12.83	12.56	12.96	17.09
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		0.99	0.99	0.98	0.97	0.98	0.97
Raw O_2 conc (dry)$_{measured}$	%		0.29	0.41	0.53	0.80	1.11	5.80
HC Mass	g/hr		33.99	24.61	26.06	23.12	19.04	58.21
NO_x Mass	g/hr		60.06	83.63	18.04	5.77	3.63	1.39
CO Mass	g/hr		2519.6	1027.0	1643.1	1433.4	987.4	33.3
CO_2 Mass	g/hr		8187	7420	5100	3733	2955	1402
BSHC	g/hp-hr		2.24	2.17	3.43	6.10	12.49	-----
BSNO_x	g/hp-hr		3.96	7.37	2.38	1.52	2.38	-----
BSCO	g/hp-hr		166.11	90.57	216.38	378.00	647.90	-----
BSCO_2	g/hp-hr		539.74	654.28	671.66	984.44	1938.91	-----

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**3.77**	**4.16**	**7.93**	**199.1**	**719.9**	**0.746**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

4/22/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 5/6/03

Test ID: KAW2-250-E-#1

250-hour interval emission test "as-received" from durability with catalyst E, Tier 3 jetting (116/120), and passive SAI system. (methane test)

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3054	3048	3073	3063	3079	1556
Obs. Power	hp		14.97	11.23	7.52	3.77	1.52	0.00
Obs. Torque	ft-lb		25.39	19.08	12.67	6.38	2.56	0.00
Calc. Power (Obs. Torque*Speed)	hp		14.76	11.08	7.41	3.72	1.50	0.00
Work (5 min Interval)	hp-hr		1.247	0.936	0.626	0.314	0.127	0.000
Fuel Flow	lb/hr		8.593	6.794	6.000	4.511	3.687	1.590
TEMPERATURES								
Catalyst Mid-bed	deg F		1381	1378	1249	1169	1150	904
Oil	deg F		283	274	249	229	221	196
Exhaust Gas (muffler-in/manifold)	deg F		1357	1372	1263	1190	1165	783
Exhaust Gas (muffler out)	deg F		1103	1020	852	701	616	342
Catalyst/Muffler Surface	deg F		717	730	664	598	570	410
Intake Air (EPA)	deg F		101	100	96	94	93	87
Intake Air DewPoint (EPA)	deg F		62	62	63	65	67	66
Cyl Head (Spark Plug)	deg F		443	415	358	321	308	244
PRESSURES								
Exhaust BP Before Cat	psig		1.20	0.78	0.45	0.23	0.13	-0.07
Barometer	"Hg		28.816	28.831	28.838	28.846	28.860	28.854
F Factor	-----		1.068	1.066	1.062	1.060	1.059	1.050
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		41.80	27.70	38.60	33.00	30.00	17.40
Dilute CO conc (dry)	%		0.17	0.06	0.14	0.12	0.08	0.00
Dilute CO_2 conc (dry)	%		0.81	0.70	0.52	0.37	0.32	0.17
Dilute NO_x conc (dry)	ppm		1.10	1.20	0.39	0.24	0.34	0.69
Measured A/F	-----		13.17	13.84	12.67	12.32	12.73	15.96
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.06	1.06	1.08	1.11	1.15	1.13
Raw O_2 conc $(dry)_{measured}$	%		0.45	0.55	0.60	0.76	0.88	4.50
HC Mass	g/hr		15.67	10.27	15.00	12.95	11.77	6.58
NO_x Mass	g/hr		1.48	1.62	0.53	0.33	0.50	1.07
CO Mass	g/hr		1330.5	507.0	1122.0	963.2	634.2	25.7
CO_2 Mass	g/hr		9897	8688	6595	4765	4131	2166
BSHC	g/hp-hr		1.04	0.91	2.01	3.45	7.72	-----
$BSNO_x$	g/hp-hr		0.10	0.14	0.07	0.09	0.33	-----
BSCO	g/hp-hr		88.63	44.96	150.27	256.52	416.01	-----
$BSCO_2$	g/hp-hr		659.24	770.48	883.22	1269.07	2709.64	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**1.83**	**0.11**	**1.95**	**125.8**	**909.1**	**0.794**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 5/6/03

Test ID: KAW2-250-E-#2

250-hour interval emission test "as-received" from durability with catalyst E, Tier 3 jetting (116/120), and passive SAI system. (methane test)

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3060	3073	3054	3054	3079	1577
Obs. Power	hp		14.79	11.16	7.35	3.66	1.48	0.00
Obs. Torque	ft-lb		25.03	18.82	12.47	6.20	2.48	0.00
Calc. Power (Obs. Torque*Speed)	hp		14.59	11.01	7.25	3.61	1.46	0.00
Work (5 min Interval)	hp-hr		1.232	0.930	0.613	0.305	0.123	0.000
Fuel Flow	lb/hr		8.402	6.829	5.818	4.531	3.712	1.522
TEMPERATURES								
Catalyst Mid-bed	deg F		1394	1367	1246	1170	1154	862
Oil	deg F		287	275	252	232	224	198
Exhaust Gas (muffler-in/manifold)	deg F		1372	1368	1261	1193	1173	807
Exhaust Gas (muffler out)	deg F		1105	1006	845	700	620	332
Catalyst/Muffler Surface	deg F		723	721	658	597	567	378
Intake Air (EPA)	deg F		102	101	98	96	96	90
Intake Air DewPoint (EPA)	deg F		67	66	66	66	65	64
Cyl Head (Spark Plug)	deg F		447	416	359	324	313	250
PRESSURES								
Exhaust BP Before Cat	psig		1.19	0.79	0.42	0.20	0.13	-0.07
Barometer	"Hg		28.834	28.809	28.798	28.795	28.791	28.784
F Factor	-----		1.073	1.071	1.067	1.065	1.064	1.055
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		37.40	25.50	37.10	34.60	26.50	13.30
Dilute CO conc (dry)	%		0.15	0.08	0.14	0.12	0.07	0.00
Dilute CO_2 conc (dry)	%		0.83	0.70	0.51	0.38	0.33	0.16
Dilute NO_x conc (dry)	ppm		1.13	0.99	0.28	0.14	0.37	0.59
Measured A/F	-----		13.35	13.70	12.66	12.39	12.81	15.94
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.16	1.13	1.13	1.13	1.12	1.10
Raw O_2 conc $(dry)_{measured}$	%		0.44	0.50	0.60	0.73	0.87	4.50
HC Mass	g/hr		13.75	9.27	14.23	13.45	10.18	4.73
NO_x Mass	g/hr		1.62	1.41	0.39	0.18	0.53	0.87
CO Mass	g/hr		1133.8	619.4	1096.6	945.3	606.4	17.1
CO_2 Mass	g/hr		9945	8564	6382	4819	4215	2091
BSHC	g/hp-hr		0.93	0.84	1.94	3.65	6.84	-----
$BSNO_x$	g/hp-hr		0.11	0.13	0.05	0.05	0.36	-----
BSCO	g/hp-hr		76.69	55.78	149.32	256.61	407.41	-----
$BSCO_2$	g/hp-hr		672.65	771.20	869.05	1308.12	2831.90	-----

Emission Test Results	-----		HC	NO_x	HC+NO_x	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**1.77**	**0.10**	**1.87**	**126.4**	**914.9**	**0.799**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 5/7/03

Test ID: KAW2-250-E-#3

250-hour interval emission test "as-received" from durability with catalyst E, Tier 3 jetting (116/120), and passive SAI system. (methane test)

DESCRIPTION	UNIT		1	2	3	4	5	6
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3054	3040	3068	3053	3062	1546
Obs. Power	hp		14.94	11.15	7.51	3.73	1.49	0.00
Obs. Torque	ft-lb		25.35	19.01	12.67	6.33	2.53	0.00
Calc. Power (Obs. Torque*Speed)	hp		14.74	11.00	7.40	3.68	1.47	0.00
Work (5 min Interval)	hp-hr		1.245	0.929	0.625	0.311	0.125	0.000
Fuel Flow	lb/hr		8.531	6.612	5.862	4.649	3.898	1.633
TEMPERATURES								
Catalyst Mid-bed	deg F		1383	1379	1254	1169	1153	1053
Oil	deg F		285	270	252	232	221	196
Exhaust Gas (muffler-in/manifold)	deg F		1361	1377	1270	1195	1176	717
Exhaust Gas (muffler out)	deg F		1101	1010	855	700	618	377
Catalyst/Muffler Surface	deg F		721	723	652	582	556	460
Intake Air (EPA)	deg F		99	97	96	94	93	86
Intake Air DewPoint (EPA)	deg F		68	68	67	67	67	66
Cyl Head (Spark Plug)	deg F		441	413	360	323	311	228
PRESSURES								
Exhaust BP Before Cat	psig		1.18	0.74	0.43	0.20	0.12	-0.07
Barometer	"Hg		28.925	28.933	28.932	28.929	28.929	28.929
F Factor	-----		1.067	1.063	1.060	1.058	1.056	1.047
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		40.20	23.50	35.70	35.30	27.20	24.10
Dilute CO conc (dry)	%		0.17	0.05	0.13	0.12	0.08	0.00
Dilute CO_2 conc (dry)	%		0.82	0.70	0.52	0.39	0.34	0.17
Dilute NO_x conc (dry)	ppm		0.98	1.39	0.28	0.14	0.16	0.72
Measured A/F	-----		13.20	13.96	12.76	12.41	12.84	16.28
Dry/Wet Correction	-----		0.98	0.98	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.18	1.18	1.15	1.15	1.15	1.14
Raw O_2 conc $(dry)_{measured}$	%		0.44	0.55	0.61	0.74	0.93	5.00
HC Mass	g/hr		15.00	8.61	13.80	13.91	10.63	9.51
NO_x Mass	g/hr		1.40	2.07	0.37	0.16	0.19	1.08
CO Mass	g/hr		1293.9	410.0	1051.4	958.6	677.3	34.2
CO_2 Mass	g/hr		9869	8591	6516	4962	4362	2204
BSHC	g/hp-hr		1.00	0.77	1.84	3.72	7.22	-----
$BSNO_x$	g/hp-hr		0.09	0.18	0.05	0.04	0.13	-----
BSCO	g/hp-hr		86.43	36.61	140.41	256.11	460.19	-----
$BSCO_2$	g/hp-hr		659.23	767.02	870.21	1325.81	2963.68	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**1.78**	**0.11**	**1.89**	**120.3**	**916.3**	**0.793**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 5/7/03

Test ID: KAW2-250-EO3-#1

250-hour interval engine-out emission test with stock muffler, Tier 3 jetting (116/120), and passive SAI system. (methane test)

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3062	3063	3070	3069	3057	1580
Obs. Power	hp		14.93	11.20	7.49	3.73	1.48	0.00
Obs. Torque	ft-lb		25.26	18.93	12.64	6.29	2.51	0.00
Calc. Power (Obs. Torque*Speed)	hp		14.73	11.04	7.39	3.68	1.46	0.00
Work (5 min Interval)	hp-hr		1.244	0.933	0.624	0.311	0.123	0.000
Fuel Flow	lb/hr		8.837	6.573	5.744	4.560	3.699	1.530
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		284	271	256	237	226	194
Exhaust Gas (muffler-in/manifold)	deg F		1349	1383	1274	1200	1192	635
Exhaust Gas (muffler out)	deg F		814	715	576	440	375	158
Catalyst/Muffler Surface	deg F		820	772	643	528	495	229
Intake Air (EPA)	deg F		102	100	99	97	96	89
Intake Air DewPoint (EPA)	deg F		65	64	64	64	64	63
Cyl Head (Spark Plug)	deg F		440	415	363	327	317	209
PRESSURES								
Exhaust BP Before Cat	psig		1.28	0.80	0.45	0.20	0.12	-0.08
Barometer	"Hg		28.905	28.899	28.882	28.876	28.868	28.857
F Factor	-----		1.068	1.065	1.065	1.062	1.061	1.051
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		90.50	55.90	65.60	57.20	43.60	248.00
Dilute CO conc (dry)	%		0.30	0.10	0.19	0.17	0.11	0.01
Dilute CO_2 conc (dry)	%		0.70	0.63	0.43	0.32	0.28	0.12
Dilute NO_x conc (dry)	ppm		45.30	65.40	12.20	3.90	2.40	1.00
Measured A/F	-----		12.96	14.03	12.82	12.59	13.10	17.38
Dry/Wet Correction	-----		0.97	0.97	0.98	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.11	1.09	1.10	1.10	1.09	1.08
Raw O_2 conc $(dry)_{measured}$	%		0.30	0.46	0.51	0.76	1.03	8.00
HC Mass	g/hr		35.20	21.82	26.21	23.15	17.59	105.90
NO_x Mass	g/hr		64.06	94.14	17.65	5.83	3.62	1.52
CO Mass	g/hr		2320.3	783.1	1574.8	1373.2	931.3	111.4
CO_2 Mass	g/hr		8623	7908	5491	4158	3663	1641
BSHC	g/hp-hr		2.36	1.95	3.49	6.18	11.83	-----
$BSNO_x$	g/hp-hr		4.30	8.43	2.35	1.56	2.43	-----
BSCO	g/hp-hr		155.61	70.12	209.56	366.78	626.06	-----
$BSCO_2$	g/hp-hr		578.32	708.12	730.67	1110.45	2462.65	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**4.10**	**4.55**	**8.65**	**186.9**	**792.8**	**0.785**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 5/8/03

Test ID: KAW2-250-EO3-#2

250-hour interval engine-out emission test with stock muffler, Tier 3 jetting (116/120), and passive SAI system. (methane test)

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3058	3080	3073	3056	3090	1530
Obs. Power	hp		14.91	11.27	7.52	3.72	1.49	0.00
Obs. Torque	ft-lb		25.27	18.95	12.67	6.31	2.50	0.00
Calc. Power (Obs. Torque*Speed)	hp		14.71	11.11	7.42	3.67	1.47	0.00
Work (5 min Interval)	hp-hr		1.243	0.939	0.627	0.310	0.124	0.000
Fuel Flow	lb/hr		8.586	6.287	5.504	4.231	3.380	1.218
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		283	271	250	230	221	188
Exhaust Gas (muffler-in/manifold)	deg F		1344	1385	1279	1204	1195	632
Exhaust Gas (muffler out)	deg F		819	725	577	442	377	153
Catalyst/Muffler Surface	deg F		816	772	644	526	494	225
Intake Air (EPA)	deg F		99	98	95	94	93	85
Intake Air DewPoint (EPA)	deg F		67	67	67	67	67	66
Cyl Head (Spark Plug)	deg F		437	414	359	323	313	203
PRESSURES								
Exhaust BP Before Cat	psig		1.26	0.79	0.45	0.20	0.11	-0.11
Barometer	"Hg		28.880	28.894	28.888	28.891	28.889	28.884
F Factor	-----		1.067	1.064	1.061	1.059	1.058	1.047
GASEOUS EMISSIONS			EMISSIONS ARE UNWEIGHTED[1] (ETIS)					
Dilute HC conc (wet)	ppm		96.75	59.47	70.07	60.45	47.06	264.32
Dilute CO conc (dry)	%		0.31	0.10	0.19	0.17	0.12	0.01
Dilute CO_2 conc (dry)	%		0.70	0.64	0.44	0.32	0.28	0.13
Dilute NO_x conc (dry)	ppm		42.81	64.64	12.12	3.88	2.48	1.12
Measured A/F	-----		12.92	14.06	12.88	12.58	13.08	17.65
Dry/Wet Correction	-----		0.97	0.97	0.97	0.97	0.97	0.98
NO_x Humidity Correction	-----		1.14	1.15	1.15	1.16	1.16	1.13
Raw O_2 conc $(dry)_{measured}$	%		0.32	0.50	0.56	0.86	1.13	8.00
HC Mass	g/hr		37.03	22.62	27.48	23.93	18.42	112.85
NO_x Mass	g/hr		61.80	96.51	17.84	5.40	3.24	1.04
CO Mass	g/hr		2404.6	770.8	1590.0	1403.5	974.4	88.5
CO_2 Mass	g/hr		8133	7525	5126	3647	3147	1218
BSHC	g/hp-hr		2.48	2.01	3.66	6.41	12.38	-----
$BSNO_x$	g/hp-hr		4.14	8.59	2.38	1.45	2.18	-----
BSCO	g/hp-hr		161.03	68.59	211.80	376.18	654.81	-----
$BSCO_2$	g/hp-hr		544.66	669.66	682.87	977.58	2114.75	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**4.28**	**4.57**	**8.85**	**189.6**	**729.3**	**0.743**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 5/8/03

Test ID: KAW2-250-STK-#1

250-hour interval stock engine-out emission test with stock muffler, and stock jetting (136/140).

DESCRIPTION	UNIT								
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3088	3048	3052	3053	3083	1534
Obs. Power	hp		15.00	11.10	7.41	3.71	1.48	0.00
Obs. Torque	ft-lb		25.16	18.86	12.58	6.30	2.48	0.00
Calc. Power (Obs. Torque*Speed)	hp		14.80	10.94	7.31	3.66	1.46	0.00
Work (5 min Interval)	hp-hr		1.250	0.925	0.617	0.309	0.123	0.000
Fuel Flow	lb/hr		10.378	7.987	6.724	5.270	3.357	1.201
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		268	260	245	229	224	197
Exhaust Gas (muffler-in/manifold)	deg F		1238	1244	1212	1188	1224	653
Exhaust Gas (muffler out)	deg F		789	693	592	490	389	165
Catalyst/Muffler Surface	deg F		656	593	526	450	406	207
Intake Air (EPA)	deg F		95	96	95	94	93	85
Intake Air DewPoint (EPA)	deg F		66	65	65	65	65	65
Cyl Head (Spark Plug)	deg F		407	385	342	314	314	215
PRESSURES								
Exhaust BP Before Cat	psig		0.48	0.27	0.14	0.02	-0.04	-0.17
Barometer	"Hg		28.865	28.859	28.854	28.852	28.848	28.839
F Factor	-----		1.061	1.062	1.061	1.059	1.059	1.048
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		160.98	124.36	121.67	132.04	49.19	264.78
Dilute CO conc (dry)	%		0.66	0.45	0.41	0.33	0.11	0.01
Dilute CO_2 conc (dry)	%		0.55	0.47	0.36	0.27	0.28	0.13
Dilute NO_x conc (dry)	ppm		8.29	7.58	3.99	2.08	2.66	1.16
Measured A/F	-----		10.34	11.01	10.32	9.97	12.72	16.62
Dry/Wet Correction	-----		0.97	0.97	0.97	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.12	1.12	1.12	1.11	1.11	1.12
Raw O_2 conc $(dry)_{measured}$	%		0.13	0.13	0.14	0.19	0.19	6.00
HC Mass	g/hr		61.94	48.52	48.19	53.24	19.05	111.68
NO_x Mass	g/hr		11.51	10.65	5.47	2.68	3.58	1.33
CO Mass	g/hr		5131.1	3581.8	3292.6	2686.5	952.3	65.7
CO_2 Mass	g/hr		6282	5409	4095	2996	3146	1235
BSHC	g/hp-hr		4.17	4.37	6.51	14.36	13.02	-----
$BSNO_x$	g/hp-hr		0.77	0.96	0.74	0.72	2.44	-----
BSCO	g/hp-hr		345.22	322.33	445.00	724.76	650.89	-----
$BSCO_2$	g/hp-hr		422.65	486.81	553.48	808.26	2150.49	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**7.54**	**0.85**	**8.38**	**434.8**	**580.3**	**0.919**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

SwRI Proj: 08-05734

CCL

5/20/2003

Steady-State SORE Engine Test Information **Engine: Kawasaki FH601V #2**

Date: 5/8/03

Test ID: KAW2-250-STK-#2

250-hour interval stock engine-out emission test with stock muffler, and stock jetting (136/140). (methane test)

DESCRIPTION	UNIT							
Mode	-----		1	2	3	4	5	6
Weight Factor	-----		0.09	0.20	0.29	0.30	0.07	0.05
DF Mode Interval (sec)	-----		300	300	300	300	300	300
Speed Set	%Rated		85	85	85	85	85	Idle
Load Set	%Rated		100	75	50	25	10	0
ENGINE DATA								
Obs. Speed	rpm		3069	3054	3058	3065	3058	1542
Obs. Power	hp		14.96	11.17	7.42	3.71	1.45	0.00
Obs. Torque	ft-lb		25.25	18.94	12.57	6.27	2.45	0.00
Calc. Power (Obs. Torque*Speed)	hp		14.76	11.02	7.32	3.66	1.43	0.00
Work (5 min Interval)	hp-hr		1.247	0.931	0.618	0.309	0.121	0.000
Fuel Flow	lb/hr		10.395	8.124	6.697	5.212	3.235	1.229
TEMPERATURES								
Catalyst Mid-bed	deg F		NA	NA	NA	NA	NA	NA
Oil	deg F		268	261	247	232	226	194
Exhaust Gas (muffler-in/manifold)	deg F		1235	1244	1215	1191	1231	527
Exhaust Gas (muffler out)	deg F		792	690	594	491	414	150
Catalyst/Muffler Surface	deg F		656	593	529	452	406	187
Intake Air (EPA)	deg F		98	98	97	96	95	87
Intake Air DewPoint (EPA)	deg F		65	65	65	64	64	65
Cyl Head (Spark Plug)	deg F		407	386	344	316	316	184
PRESSURES								
Exhaust BP Before Cat	psig		0.47	0.26	0.14	0.02	-0.05	-0.17
Barometer	"Hg		28.835	28.828	28.821	28.816	28.811	28.806
F Factor	-----		1.065	1.066	1.064	1.063	1.062	1.052
GASEOUS EMISSIONS			**EMISSIONS ARE UNWEIGHTED[1] (ETIS)**					
Dilute HC conc (wet)	ppm		163.46	127.01	121.21	128.57	47.31	379.68
Dilute CO conc (dry)	%		0.66	0.46	0.41	0.32	0.10	0.01
Dilute CO_2 conc (dry)	%		0.55	0.48	0.36	0.27	0.28	0.12
Dilute NO_x conc (dry)	ppm		8.28	7.61	4.04	2.08	2.61	1.25
Measured A/F	-----		10.29	10.97	10.35	10.02	12.89	17.60
Dry/Wet Correction	-----		0.97	0.97	0.97	0.98	0.98	0.98
NO_x Humidity Correction	-----		1.11	1.12	1.11	1.10	1.10	1.11
Raw O_2 conc $(dry)_{measured}$	%		0.13	0.12	0.14	0.19	0.19	8.00
HC Mass	g/hr		62.25	48.80	47.28	51.02	17.68	159.78
NO_x Mass	g/hr		11.33	10.54	5.48	2.61	3.41	1.43
CO Mass	g/hr		5160.7	3643.3	3280.5	2647.2	854.8	99.5
CO_2 Mass	g/hr		6258	5503	4079	2983	3133	1072
BSHC	g/hp-hr		4.17	4.36	6.35	13.68	12.09	-----
$BSNO_x$	g/hp-hr		0.76	0.94	0.74	0.70	2.33	-----
BSCO	g/hp-hr		345.87	325.52	440.36	709.56	584.27	-----
$BSCO_2$	g/hp-hr		419.44	491.66	547.61	799.58	2141.64	-----

Emission Test Results	-----		HC	NO_x	$HC+NO_x$	CO	CO_2	BSFC ($^{lb}/_{hp\text{-}hr}$)
Weighted Specific Emissions[3]	g/hp-hr		**7.70**	**0.83**	**8.53**	**431.3**	**576.5**	**0.912**

1 Emissions results are based on bag sample emissions through ETIS

2 Raw emissions are calculated using the dilution factor and dilute concentrations

3 Based on the 6-mode CARB-SORE Test Cycle

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5/20/2003

APPENDIX F

HONDA GX340 EMISSION DATA SHEETS