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APPENDIX A

PARTIAL LISTING OF OHV CATEGORY ENGINE MANUFACTURERS, MODELS, AND APPLICATIONS

Engine Manufacturer	Model	Fuel	Cylinders	Stroke	Type	Cooling	Power Output	Displacement	Application
Deutz	1011 Series	Diesel	2,3,4	4	DI	Air/Oil	24–58 hp @ 30/2800 rpm	83–167 ci	Pump/Gen/Con
	FL912 Series	Diesel	3,4,5,6	4	DI	Air	41–82 hp @ 2300 rpm	173–345 ci	Mining/Ag/Con/Pump
	D916 Series	Diesel	2,3,4,6	4	IDI	Water	31–94 hp @ 2300 rpm	127–380 ci	Mining
Fuji Heavy Industries Tokyo, Japan	Various						0.6–90 hp		Ind/Con/Gen/SM/ATV
Hatz Diesel	2,3,4–M31	Diesel	2,3,4	4		Air	20–40 kw @ 3000 rpm	1470–2940 cc	Ind
Ruhstorf, W. Germany	2,3,4–M40	Diesel	2,3,4	4		Air	26–52 kw @ 3000 rpm	1716–3432 cc	Ind
Waukesha, WI.	2,3,4–L31	Diesel	2,3,4	4		Air	21–41 kw @ 3000 rpm	1416–2832 cc	Ind
	2,3,4–L40	Diesel	2,3,4	4		Air	25–50 kw @ 3000 rpm	1716–3432 cc	Ind
Hercules Canton OH	G1600	NG/LPG	4	4	SI	Water	48 hp @ 2800 rpm	163 ci	Ind
Isuzu	3KR1	Diesel	3	4	IDI	Water	29 hp @ 3600 rpm	1400 cc	Ind/Gen
Tokyo, Japan	2AB1	Diesel	2	4	IDI	Water	23 hp @ 2800 rpm	1200	Ind/Mar
Novi, MI.	3AB1	Diesel	3	4	IDI	Water	34 hp @ 2800 rpm	1800	Ind/Mar
	C240	Diesel	4	4	IDI	Water	45 hp @ 3000 rpm	2400	Ind/Gen
	4JC1	Diesel	4	4	DI	Water	47 hp @ 3000 rpm	2200	Ind
Kubota	D1402	Diesel	3	4	IDI	Water	25 hp @ 2800 rpm	1395 cc	Ind
	V1702	Diesel	4	4	IDI	Water	31 hp @ 2800 rpm	1732 cc	Ind
	V1902	Diesel	4	4	IDI	Water	33 hp @ 2800 rpm	1861 cc	Ind
	V2203	Diesel	4	4	DI	Water	40 hp @ 2800 rpm	2197 cc	Ind
	S2800	Diesel	6	4	IDI	Water	45 hp @ 2600rpm	2791 cc	Ind
Lister Petter	LPA4	Diesel	4	4	DI	Air	28 hp @ 3600 rpm	1452 cc	Ind/Con/Gen/Mar
Dursley, England	LPW3,4	Diesel	3,4	4	DI	Water	31–41 hp @ 3600 rpm	1395–1860 cc	Ind/Con/Gen/Mar
Olathe, KS	LPWS3,4	Diesel	3,4	4	IDI	Water	31–41 hp @ 3600 rpm	1395–1860 cc	Ind/Con/Gen/Mar
	T Series	Diesel		4		Air	6–43 hp		Ind/Con/Gen/Mar
	H Series	Diesel		4		Air	18–115 hp		Con/Gen/Ag
	C Series	Diesel		4		Water	31–152 hp		Mar/Gen/Ag
	HRG Series	NG		4	SI	Air	11–34 hp		Ind/Gen/Ag
Lombardini	8LD665/740	Diesel	2	4		Air	22–26 hp @ 3000 rpm	81–90 ci	Ind
Italy	11LD535/626	Diesel	3	4		Air	27–35 hp @ 3000 rpm	98–114 ci	Ind
Duluth, GA	5LD825/930	Diesel	2,3,4	4		Air	27–64 hp @ 2600 rpm	100–226 ci	Ind
Onan	J Series	G/D/NG/LPG	2,4	4		Air/Water			Gen

Engine Manufacturer	Model	Fuel	Cylinders	Stroke	Type	Cooling	Power Output	Displacement	Application
Perkins	103 Series	Diesel	3	4	IDI-NA	Water	17-32 hp@ 36-2800 rpm	0.6-1.5 L	Ind/Con/Ag/Gen/Pump
	104-19	Diesel	4	4	IDI/DI-NA	Water	42-44 hp @ 2800 rpm	1.9 L	"
	504-2/2LR	Diesel	4	4	DI-NA	Water	48-50 hp @ 3000 rpm	2.0 L	"
	504-2T	Diesel	4	4	DI-TC	Water	57 hp @ 3100 rpm	2.0 L	"
	3.152 Series	Diesel	3	4	DI-NA	Water	47-52 hp@ 25-2250 rpm	2.5 L	"
	T3.1524	Diesel	3	4	DI-TC	Water	55 hp @ 2250 rpm	2.5 L	"
	4. Series	Diesel	4	4	DI-NA	Water	60-78 hp@26-4000 rpm	2.2-3.34 L	"
Teledyne Total Power	TRD Series	Diesel	2,3	4		Air	25-36 hp @ 3600 rpm		Ind/Con/Gen/Pump
Memphis TN	W2,4	Gaso/propane	2,4	4	SI	Air	30-35 hp @ 3000 rpm	1.2-1.7 L	"
	VH/VG	Gaso/propane	4	4	SI	Air	30-37 hp @ 2400 rpm	1.7-2.5 L	"
	TRDL	Diesel	2,3	4		Water	12-35 hp @ 3600 rpm		"
	TMD	Diesel	2,3,4	4	IDI-NA/TC	Water	29-80 hp @ 3000 rpm	1.35-2.7 L	"
	TM	Gaso/LPG/NG	2,3,4	4	SI	Water	34-72 hp @ 3000 rpm	1.35-2.7 L	"
	R11,14	Gasoline	4	4	SI	Water	35-47 hp @3600 rpm	1.1-1.3 L	"
	Y	Gaso/LPG/NG	4	4	SI	Water	38 hp @ 2800 rpm	1.2 L	"
	RD	Diesel	4	4	IDI	Water	45 hp @ 3600 rpm	2.1 L	"
Toyota Industrial		Gas/LPG	4	4	Carb/OHV	Water	42-53 hp @21/2500 rpm	2.2 L	Forklift
		Diesel		4	IDI	Water	50 hp @ 2400 rpm	2.5 L	Forklift
		Diesel		4	DI	Water	58 hp @ 2300 rpm	3.0 L	Forklift
		Gasoline		4	3X/CLC	Water			European forklift
Waukesha	VRG330	NG	6	4	SI	Water	80 hp @ 2200 rpm	5.4 L	Ind/Cog
Waukesha, WI.	VRG220	NG	4	4	SI	Water	53 hp @ 2200 rpm	3.6 L	Ind/Cog
	VRG155	NG	4	4	SI	Water	27 hp @ 2000 rpm	2.5 L	Ind/Cog
Yanmar	D Series	Diesel	2,3	4		Water	18-36 hp @4500 rpm		Marine Main
Osaka, Japan	GM Series	Diesel	1,2,3	4		Water	9-27 hp @ 3600 rpm		Marine Main
	HM Series	Diesel	3	4		Water	34 hp @ 3400 rpm		Marine Main
	TD Series	Diesel	2,3,4	4		Water	26-60hp @ 2100		Marine Main
	JH2 Series	Diesel	4	4		Water	50-88 hp @ 3600 rpm		Marine Main
	CHL Series	Diesel	4	4		Water	50 hp @ 1800 rpm		Marine Auxillary
	GN Series	NG	1	4	SI	Water	10-30 hp @ 900 rpm		Ind
	NP Series	Diesel	1	4		Water	13-30 hp @ 900 rpm		Ind
	TN Series	Diesel	2,3,4	4	IDI/DI	Water	11-96 hp @ 3600rpm		Ind
	YEG Series	Diesel		4		Water	Various		Generators
	SC/VC/VKC	Diesel		4		Water	Various		Compressors
	V/B/YB	Diesel		4		Water	8-37 hp		Construction
	CA Series	Diesel		4		Water	9-60 hp		Combine Harvestor
	YSR Series	Diesel		4		Water	13-30 hp @ 3000 rpm		Snow Thrower
	YM Series	Diesel		4		Water	14-33 hp @ 2600 rpm		Tractors

Lift Truck Manufacturer	Models	Engine Manufacturer	Engine Model	Fuel	Cylinders	Power, hp	@ Speed, rpm	Displacement, cu. in.	Load Capacity, lb
Baker	(30PL)	VW	–	LPG	4	30	2300	99	3000
	(B40PL, B50PL, B60PL)	VW	035.5	LPG	5	45	2650	131	4000–6000
	(B40PL, B50PL, B60PL)	Deutz	F3L913–G	Diesel	3	50	2100	187	4000–6000
Caterpillar	T25D, T30D, T35D, TC40D	Peugot	XN1P	Gasoline	4	37	2100	120	2500–4000
	(V25D, V30D, V35D, VC40D)	Peugot	XD3P	Gasoline	4	39	2200	152	2500–4000
	T40D, T50D, TC60D	Cat	2.0 L	Gasoline	4	40	2100	121	4000–6000
	T40D, T50D, TC60D	Cat	2.5	Diesel	4	44	2300	153	4000–6000
	T40DSA, T50DSA, TC60DSA	Cat	1404	Gasoline	4	49	2100	163	4000–6000
	(V40DSA, V50DSA, VC60DSA)	Cat	3.3	Gasoline	4	55	2250	203	4000–6000
	(V60E)	Perkins	4.236	Gasoline	4	70	2000	236	6000
	(V60E)	Perkins	4.2482	Diesel	4	63	2250	248	6000
Clark	GCS–12, GCS–15, GCS–17S	Mitsubishi	4G32	Gasoline	4	37	2100	97	2500–3500
	GCS–17, GCS–20, GCX–20	Mitsubishi	4G54	Gasoline	4	47	2250	156	3500–6000
	GCS–22, GCX–22, GCS–25	"	"						
	GCX–25, GCS–27, GCX–27	"	"						
	GCX–30	"	"						
	GCS–17, GCS–20, GCX–20	Continental	TMD27	Diesel	4	52	2360	164	3500–6000
	GCS–22, GCX–22, GCS–25	"	"						
	GCX–25, GCS–27, GCX–27	"	"						
	GCS–30, GCX–30	"	"						
	C500 60	Perkins	4.236	Gasoline	4	76	2545	236	6000
	C500 60	Perkins	4.2482	Diesel	4	78	2545	248	6000
	GCS–30	Continental	TM27	Gasoline	4	59	2360	164	6000
Hyster	S25XL, S20XL, S35XL	Mazda	M4–121G	Gasoline	4	46	2600	121	2500–3500
	S40XL, S50XL, S60XL	Mazda	M4–121G	Gasoline	4	48	2800	121	4000–6000
	S40XL, S50XL, S60XL	Isuzu	C240	Diesel	4	48	2600	145	4000–6000
	S40XL, S50XL, S60XL	GM	4–181	?	4	?	?	?	4000–6000
Kalmar A.C.	C30, C40, C50	Nissan	H–20	Gasoline	4	46	2300	121	3000–5000
	C50, C60	Komatsu	4D95S	Diesel	4	50	2450	164	5000–6000
	C60	Hercules	G1600	Gasoline	4	61	2400	163	6000
	ASS60	Perkins	4.236	Gasoline	4	78	2400	220	6000
	ASS60	Perkins	4.2482	?	4	?	?	?	6000

() Models in parentheses have pneumatic tires, all others have cushion tires which are solid. Pneumatic tired truck models using the same engines as their cushion tired counterparts are not listed.

Lift Truck Manufacturer	Models	Engine Manufacturer	Engine Model	Fuel	Cylinders	Power, hp	@ Speed, rpm	Displacement, cu. in.	Load Capacity, lb
Komatsu	FG10ST, FG15ST, FG18ST	Nissan	H–20	Gasoline	4	46	2300	121	2000–6000
	FG20ST, FG25ST, FG30ST	"	"						
	FG25ST	Komatsu	4D95S	Diesel	4	54	2450	164	5000
Mitsubishi	FGC10, FGC15	Mitsubishi	4G33	Gasoline	4	29	2400	88	2000–3000
	(FG10, FG15, FG18)	Mitsubishi	4G33	Gasoline	4	36	2400	88	2000–3500
	FGC20, FGC25	Mitsubishi	4G52	Gasoline	4	38	2400	122	4000–5000
	FGC20, FGC25	Mitsubishi	S4E	Diesel	4	48	2400	159	4000–5000
	FGC30	Mitsubishi	4G54	Gasoline	4	48	2400	156	6000
Nissan	C20, C30, C35, C40	Nissan	H–20	Gasoline	4	42	2300	121	2000–4000
	C40, C50	Nissan	SD25	Diesel	4	48	2400	152	4000–5000
	C50	Nissan	H–20	Gasoline	4	42	2300	121	5000
	C60	Nissan	Z24	Gasoline	4	49	2400	146	6000
TCM	FCG10T, FCG15T, FCG18T	Nissan	A15	Gasoline	4	40	2700	91	2000–3500
	FCG20T, FCG25T, FCG28T	Nissan	H–20	Gasoline	4	45	2250	121	4000–5500
	FCG25T	Isuzu	C240	Diesel	4	45	2300	145	5000
	FCG30T	Nissan	H30	Gasoline	6	64	2400	182	6000
	FCG30T	Isuzu	4BC2	Diesel	4	65	2550	199	6000
Toyota	5FGC10, 5FGC13, 5FGC15	Toyota	4Y	Gasoline	4	43	2100	136	2000–3000
	5FGC10, 5FGC15	Toyota	4P	LPG	4	?	?	?	2000–3000
	5FGC18, 5FGC20, 5FGC23	Toyota	4Y	Gasoline	4	52	2400	136	3500–6000
	5FGC25, 5FGC28, 5FGC30	"	"						
	5FGC20, 5FGC25, 5FGC30	Toyota	2J	Diesel	4	47	2500	151	4000–6000
Yale	GC030AE, GC040AE, GC040DE	Yale	FE	Gasoline	4	42	2400	122	3000–5000
	GC050DE	"	"						
	GC030CE	Yale	D5	Gasoline	4	30	2400	91	3000
	GC040DE, GC050DE	Yale	XA	Diesel	4	44	2300	154	4000–5000
	GC050TE, GC060TE	Yale	F2	Gasoline	4	46	2400	133	5000–6000
	GC050TE, GC060TE, GC060LC	Yale	HA	Diesel	4	58	2250	182	5000–6000
	GC060LC	Chrysler	H225	Gasoline	6	?	?	225	6000
	(GP060LC)	Yale	ZB	Diesel	6	?	?	247	6000

() Models in parentheses have pneumatic tires, all others have cushion tires which are solid. Pneumatic tired truck models using the same engines as their cushion tired counterparts are not listed.

Golf Car Manufacturers	Engine Manufacturer	Fuel	Cylinders	Stroke	Type	Cooling	Power Output	Displacement
Club Car, Inc. Augusta, GA.	Kawasaki FE290	Gasoline	1	4	OHV	Air	9 hp @ 3600 rpm	
EZ Go/Textron, Inc.	Fuji	Gasoline	1	2		Air	8 hp @ 3600 rpm	
Augusta, GA.	Fuji	Gasoline	2	4	OHV	Air	8.5 hp @ 3600 rpm	295 cc
Yamaha Motor Corp. Cypress, CA	Yamaha	Gasoline	1	4	OHV	Air	8.6 hp @ 3600 rpm	286 cc
Shuttlecraft Inc. Minnesota	Honda GX240	Gasoline	1	4	OHV	Air	8 hp @ 3600 rpm	238 cc
Columbia Par Car Corp. Deerfield, WI	Columbia	Gasoline	1	2		Air	7 hp @ 3600 rpm	250 cc
Melex USA, Inc. Raleigh, NC								
Sioux Steel Co. Sioux Falls, SD								
Hyundai Steel Ind. Laguna Hills, CA								

Snowmobile Manufacturers	Model	Engine Manufacturer	Fuel	Cylinders	Stroke	Cooling	Power Output	Displacement
Polaris	17 Models	Fuji HI	Gasoline	1	2	Fan	30–100 hp @ 8000 rpm	244 cc
Minneapolis, MN			Gasoline	2	2	Fan		339 cc
			Gasoline	2	2	Fan/Liquid		432 cc
			Gasoline	2	2	Fan/Liquid		488 cc
			Gasoline	3	2	Liquid		648 cc
Arctco Inc.		Suzuki	Gasoline	2	2	Fan/Liq	30–130 hp @ 6–9000 rpm	340 cc
Theif River Falls, MN		10 models	Gasoline	2	2			440 cc
			Gasoline	2	2			550 cc
			Gasoline	2	2			700 cc
Bombardier Inc.		Bombardier/	Gasoline		2	Fan/Liq		
Montreal, Canada		Rotax						
Yamaha	BR250	Yamaha	Gasoline	1	2	Fan	18 hp @ 5700 rpm	246 cc
Cypress, CA	CS340E	Yamaha	Gasoline	2	2	Fan	32 hp @ 6600 rpm	337 cc
Shizuoka, Japan	ET410TR	Yamaha	Gasoline	2	2	Fan	36 hp @ 6500 rpm	408 cc
	VT480	Yamaha	Gasoline	2	2	Fan	52 hp @ 6800 rpm	485 cc
	PZ480	Yamaha	Gasoline	2	2	Fan	52 hp @ 6800 rpm	485 cc
	EX570	Yamaha	Gasoline	2	2	Liquid	76 hp @ 7300 rpm	569 cc
	VX750	Yamaha	Gasoline	4	2	Liquid	120 hp @ 8250 rpm	743 cc

Other Recreational Equipment Manufacturer	Model	Fuel	Cylinders	Stroke	Type	Cooling	Power Output	Displacement	Application
Honda	XR/Z Series	Gasoline	1	4	OHC	Air		49–591 cc	Off–road motorcycle
	Cub	Gasoline	1	2		Air		90 cc	Off–road motorcycle
Tokyo, Japan	CR Series	Gasoline	1	2		Liquid		83–491 cc	Competition m/c
	TRX250X	Gasoline	1	4	OHC	Air		246 cc	ATV
	TRX200/D	Gasoline	1	4	OHC	Air		199 cc	ATV
	TRX300/FW	Gasoline	1	4	OHC	Air		288 cc	ATV
	FT90	Gasoline	1	4	OHC	Air		86 cc	ATV
	Helix/Elite	Gasoline	1	2,4		Air/Liquid		49–244 cc	Scooter
	Pilot	Gasoline	1	2		Air		250 cc	Dune buggy
Kawasaki Heavy Ind.	FZ340D	Gasoline	1	4	SI	Air	11 hp @ 3600 rpm		Golf cart
Japan	Various	Gasoline	1	4	SI	Air	17 – ? hp		ATV & Mule
	KDX 200/250	Gasoline	1	2	SI	Air			OR Motorcycles
Suzuki	LT50,80,250	Gasoline	1	2	SI	Air	1–42 hp @5–7000 rpm	49–246 cc	ATV
Hamamatsu, Japan	LT Series	Gasoline	1	4	OHC	Air	13–22 hp @5–6500 rpm	158–280 cc	ATV
	DR250/350	Gasoline	1	4	OHC	Air	26–32 hp @ 8–8200 rpm	249, 349 cc	Off–road motorcycle
	JR50/DS80	Gasoline	1	2		Air	2–8 hp @ 50–7500 rpm	49, 79 cc	Off–road motorcycle
	RMX250	Gasoline	1	2		Water	51 hp @ 9000 rpm	249 cc	Off–road motorcycle
	RM Series	Gasoline	1	2		Water	27–53 hp @ 9–12000 rpm	79–249 cc	Competition m/c
Yamaha	RT180	Gasoline	1	2		Air	16.6 hp @ 7000 rpm	179 cc	Off–road motorcycle
Cypress, CA	RT100	Gasoline	1	2		Air	8.5 hp @ 7000 rpm	97 cc	Off–road motorcycle
Shizuoka, Japan	PW80	Gasoline	1	2		Air	4.6 hp @ 5500 rpm	79 cc	Off–road motorcycle
	PW50	Gasoline	1	2		Air	2.7 hp @ 5500 rpm	49 cc	Off–road motorcycle
	WR200R	Gasoline	1	2		Liquid	25.1 hp @ 7000 rpm	199 cc	Off–road motorcycle
	YFB250	Gasoline	1	4	OHV	Air	15.9 hp @ 7000 rpm	229 cc	ATV
	YFM350FW/ER	Gasoline	1	4	OHV	Air	20.3 hp @ 6500 rpm	349 cc	ATV
	YFZ350	Gasoline	2	2		Liquid	47.5 hp @ 7500 rpm	347 cc	ATV
	YFM350X	Gasoline	1	4	OHV	Air	27.1 hp @ 7000 rpm	349 cc	ATV
	YFS200	Gasoline	1	2		Air	20.5 hp @ 7000 rpm	195 cc	ATV
	YFA–1	Gasoline	1	4	OHV	Air	8.0 hp @ 7000 rpm	124 cc	ATV
	YFM80	Gasoline	1	4	OHV	Air	6.0 hp @ 8500 rpm	79 cc	ATV
KTM Australia									Off–road motorcycle
Husqvarna Sweden									Off–road motorcycle
ATK USA									Off–road motorcycle

APPENDIX B

75 HP NA DI DIESEL ENGINE (3.9L JOHN DEERE)
76 HP NA DI DIESEL ENGINE (4.5L JOHN DEERE)

- **FTP Transient Cycle and ISO 8178-C1 Baseline Test Results - Both Engines**

- **FTP Transient Cycle and ISO 8178-C1 Emission Results in Three Configurations - 75 HP NA DI Diesel Engine**

FTP Transient Cycle and ISO 8178-C1 Baseline Test Results

- **75 HP and 76 HP NA DI Diesel Engines**

EPA WORK ASSIGNMENT No.5
SwRI PROJECT No. 08-4855-150

JOHN DEERE 3.9L TEST DATA

TEST DATE	TEST NO.	MAX HP	EMISSIONS (G/HP-HR)				BSFC	8-MODE (G/HR)				SMOKE TEST %			SNAP-IDLE SMOKE TEST %				REMARKS
			BSHC	BSCO	BSNOx	PM	LB/HP-HR	BSHC	BSCO	BSNOx	PM	"A"	"B"	"C"	"1"	"2"	"3"	RESULT	
5/1/92	JD-3.9-TC3	75	1.58	4.40	8.03	0.773	0.519												NO TEOM*
5/1/92	JD-3.9-TH2	75	1.44	2.74	7.93	0.510	0.457												NO TEOM
5/1/92	JD-3.9-TH3	75	1.34	2.78	7.71	0.506	0.479												NO TEOM
5/1/92	JD-3.9-CH2	75	1.46	2.98	7.95	0.548	0.466												NO TEOM
5/4/92	JD-3.9-TC4	75	1.61	4.18	8.09	1.019	0.512												NO TEOM
5/4/92	JD-3.9-TH4	75	1.44	2.89	7.48	0.567	0.484												NO TEOM
5/4/92	JD-3.9-TH5	75	1.49	2.51	7.86	0.494	0.467												NO TEOM
5/4/92	JD-3.9-CH4	75	1.47	3.07	7.57	0.632	0.488												NO TEOM
5/6/92	JD-3.9-8M1	75	0.19	1.15	8.55	0.320	0.329	14.22	86.08	637.45	24.10								
5/6/92	JD-3.9-8M2	56	0.50	0.55	6.41	0.180	0.345	27.79	30.80	356.67	9.90								
5/6/92	JD-3.9-8M3	38	0.71	1.31	5.22	0.230	0.406	27.07	49.64	198.43	8.67								
5/6/92	JD-3.9-8M4	7	8.35	12.76	7.51	1.020	0.954	59.88	91.48	53.87	7.34								
5/6/92	JD-3.9-8M5	52	0.18	17.36	7.41	1.020	0.383	9.38	898.78	383.47	125.90								
5/6/92	JD-3.9-8M6	38	0.55	0.57	7.37	0.310	0.363	20.77	21.62	279.74	11.69								
5/6/92	JD-3.9-8M7	26	0.83	0.79	5.92	0.270	0.370	21.50	20.65	153.90	7.14								
5/6/92	JD-3.9-8M8	0	NA	NA	NA	NA	NA	12.71	14.25	20.83	1.99								
5/6/92	WTD. RESULT		0.62	3.47	7.17	0.584	0.376												
5/7/92	JD-3.9-8M21	74	0.22	1.58	8.51	0.340	0.339	16.38	117.77	633.16	25.22								
5/7/92	JD-3.9-8M22	57	0.46	0.70	6.67	0.200	0.368	25.93	39.67	380.03	11.43								
5/7/92	JD-3.9-8M23	36	0.80	1.44	5.41	0.190	0.410	29.00	52.45	197.11	6.99								
5/7/92	JD-3.9-8M24	7	8.91	13.22	7.14	1.150	0.923	66.55	98.77	53.31	8.60								
5/7/92	JD-3.9-8M25	52	0.18	16.51	7.65	2.360	0.383	9.51	851.67	394.99	121.73								
5/7/92	JD-3.9-8M26	38	0.53	0.54	7.39	0.380	0.362	20.18	20.77	282.99	14.41								
5/7/92	JD-3.9-8M27	26	0.81	0.87	5.97	0.350	0.377	21.02	22.66	155.63	9.04								
5/7/92	JD-3.9-8M28	0	NA	NA	NA	NA	NA	13.18	13.69	23.11	1.96								
5/7/92	WTD. RESULT		0.65	3.54	7.30	0.592	0.384												
5/12/92	JD-3.9-TC6	75	1.42	4.18	7.59	0.825	0.490												
5/12/92	JD-3.9-TH8	75	1.30	3.21	7.32	0.581	0.468												
5/12/92	JD-3.9-TH9R	75	1.36	2.66	7.41	0.472	0.463												
5/12/92	JD-3.9-CH8	75	1.32	3.35	7.36	0.616	0.471												
5/13/92	JD-3.9-TC7	75	1.52	4.19	8.66	0.783	0.497												
5/13/92	JD-3.9-TH10	75	1.36	3.25	7.32	0.589	0.459												
5/13/92	JD-3.9-TH11	75	1.37	2.76	7.33	0.530	0.446												
5/13/92	JD-3.9-CH11	75	1.38	3.39	7.51	0.617	0.464												
5/14/92	JD-3.9-S1											11.8	23.1	23.6					
5/14/92	JD-3.9-S2											12.0	23.2	24.1					
5/14/92	JD-3.9-SI1														16.1	16.8	16.5	16.7	

*No TEOM (Tapered Element Oscillating Microbalance) particulate data were taken.

John Deere 3.9L
Transient/8–Mode Comparison

TEST DATE	TEST NO.	MAPPED HP	EMISSIONS (G/HP–HR) BSHC	BSCO	BSNOx	PM	BSFC LB/HP–HR
TRANSIENT TESTS							
5/12/92	JD–3.9–CH8	75	1.32	3.35	7.36	0.616	0.471
5/13/92	JD–3.9–CH11	75	1.38	3.39	7.51	0.617	0.464
TRANSIENT AVERAGE		75	1.35	3.37	7.44	0.617	0.468
8–MODE TESTS							
5/6/92	8–MODE #1		0.62	3.47	7.17	0.584	0.376
5/7/92	8–MODE #2		0.65	3.54	7.30	0.592	0.384
8–MODE AVERAGE			0.64	3.51	7.24	0.588	0.380
PERCENT DIFFERENCE BETWEEN TRANSIENT & 8–MODE AVERAGES			–52.6	4.2	–2.7	–4.7	–18.8

EPA WORK ASSIGNMENT No.5
SwRI PROJECT No. 08-4855-150

JOHN DEERE 4.5L TEST DATA

TEST DATE	TEST NO.	MAX HP	EMISSIONS (G/HP-HR)				BSFC	8-MODE (G/HR)				SMOKE TEST %			SNAP-IDLE SMOKE TEST %				REMARKS
			BSHC	BSCO	BSNOx	PM	LB/HP-HR	BSHC	BSCO	BSNOx	PM	"A"	"B"	"C"	"1"	"2"	"3"	RESULT	
5/21/92	JD-4.5-TC2	77	1.72	2.57	7.52	0.717	0.520												
5/21/92	JD-4.5-TH1	77	1.65	1.97	7.09	0.525	0.466												
5/21/92	JD-4.5-TH2	77	1.73	1.95	7.01	0.532	0.467												
5/21/92	JD-4.5-CH1	77	1.66	2.06	7.15	0.552	0.474												
5/25/92	JD-4.5-TC4	77	1.79	2.45	7.31	0.811	0.494												
5/25/92	JD-4.5-TH4	77	1.68	2.08	6.93	0.593	0.475												
5/25/92	JD-4.5-TH5	77	1.80	1.89	6.86	0.687	0.476												
5/25/92	JD-4.5-CH4	77	1.70	2.13	6.99	0.625	0.479												
5/26/92	JD-4.5-8M1	75	0.42	1.82	5.18	0.391	0.349	31.16	136.74	388.51	29.31								
5/26/92	JD-4.5-8M2	56	0.76	1.18	5.19	0.268	0.372	42.43	65.81	288.17	14.89								
5/26/92	JD-4.5-8M3	38	1.20	2.21	5.44	0.382	0.424	45.84	84.18	207.70	14.57								
5/26/92	JD-4.5-8M4	8	8.01	11.35	12.34	1.405	0.966	62.22	88.14	95.91	10.91								
5/26/92	JD-4.5-8M5	54	0.45	0.74	7.37	0.593	0.343	24.22	40.17	399.33	32.09								
5/26/92	JD-4.5-8M6	41	0.60	0.48	6.95	0.163	0.338	24.41	19.67	283.48	6.67								
5/26/92	JD-4.5-8M7	27	1.01	1.00	6.77	0.254	0.366	27.42	27.40	184.53	6.91								
5/26/92	JD-4.5-8M8	0	N.A.	N.A.	N.A.	N.A.	N.A.	21.55	13.56	18.64	4.90								
5/26/92	WTD. RESULT		0.91	1.63	6.05	0.397	0.382												
5/26/92	JD-4.5-8M21	76	0.35	1.52	5.31	0.363	0.327	26.62	115.43	403.39	27.58								
5/26/92	JD-4.5-8M22	56	0.71	1.07	5.10	0.242	0.368	39.85	60.18	287.85	13.66								
5/26/92	JD-4.5-8M23	38	1.13	1.92	5.65	0.317	0.415	42.78	72.76	214.60	12.04								
5/26/92	JD-4.5-8M24	7	7.72	11.05	13.69	1.375	1.047	55.09	78.90	97.71	9.82								
5/26/92	JD-4.5-8M25	55	0.45	0.63	7.16	0.511	0.334	24.53	34.61	392.67	28.05								
5/26/92	JD-4.5-8M26	41	0.63	0.43	7.07	0.174	0.335	25.84	17.68	292.29	7.18								
5/26/92	JD-4.5-8M27	27	1.01	1.02	6.83	0.252	0.363	27.71	28.08	187.39	6.93								
5/26/92	JD-4.5-8M28	0	N.A.	N.A.	N.A.	N.A.	N.A.	23.71	15.32	21.50	4.56								
5/26/92	WTD. RESULT		0.86	1.44	6.11	0.359	0.373												
5/28/92	JD-4.5-S1											2.7	3.8	4.0					
5/28/92	JD-4.5-S2											2.9	3.9	4.1					
5/28/92	JD-4.5-SI1														5.5	5.5	5.5	5.5	

John Deere 4.5L
Transient/8–Mode Comparison

TEST DATE	TEST NO.	MAPPED HP	EMISSIONS (G/HP–HR) BSHC	BSCO	BSNOx	PM	BSFC LB/HP–HR
TRANSIENT TESTS							
5/21/92	JD–4.5–CH1	77	1.66	2.06	7.15	0.552	0.474
5/25/92	JD–4.5–CH4	77	1.70	2.13	6.99	0.625	0.479
TRANSIENT AVERAGE		77	1.68	2.10	7.07	0.589	0.477
8–MODE TESTS							
5/26/92	8–MODE #1		0.91	1.63	6.05	0.397	0.382
	8–MODE #2		0.86	1.44	6.11	0.359	0.373
8–MODE AVERAGE			0.89	1.54	6.08	0.378	0.378
PERCENT DIFFERENCE BETWEEN TRANSIENT & 8–MODE AVERAGES			–47.0	–26.7	–14.0	–35.8	–20.8

FTP Transient Cycle and ISO 8178-C1
Emission Results in Three Configurations

- **75 HP NA DI Diesel Engine**

C.A.R.B.
SwRI PROJECT No. 08-4820-100
75HP ENGINE
BASELINE

TEST DATE	TEST NO.	MAX HP	EMISSIONS (G/HP-HR)				BSFC	8-MODE (G/HR)				SMOKE TEST %			SNAP-IDLE SMOKE TEST %				REMARKS
			BSHC	BSCO	BSNOx	PM	LB/HP-HR	BSHC	BSCO	BSNOx	PM	"A"	"B"	"C"	"1"	"2"	"3"	RESULT	
5/1/92	75HP-C3	75	1.58	4.40	8.03	0.773	0.519												NO TEOM *
5/1/92	75HP-H2	75	1.44	2.74	7.93	0.510	0.457												NO TEOM
5/1/92	75HP-H3	75	1.34	2.78	7.71	0.506	0.479												NO TEOM
5/1/92	75HP-CH2	75	1.46	2.98	7.95	0.548	0.466												NO TEOM
5/4/92	75HP-C4	75	1.61	4.18	8.09	1.019	0.512												NO TEOM
5/4/92	75HP-H4	75	1.44	2.89	7.48	0.567	0.484												NO TEOM
5/4/92	75HP-H5	75	1.49	2.51	7.86	0.494	0.467												NO TEOM
5/4/92	75HP-CH4	75	1.47	3.07	7.57	0.632	0.488												NO TEOM
5/6/92	75HP-M1-R1	75	0.19	1.15	8.55	0.320	0.329	14.22	86.08	637.45	24.10								
5/6/92	75HP-M2-R1	56	0.50	0.55	6.41	0.180	0.345	27.79	30.80	356.67	9.90								
5/6/92	75HP-M3-R1	38	0.71	1.31	5.22	0.230	0.406	27.07	49.64	198.43	8.67								
5/6/92	75HP-M4-R1	7	8.35	12.76	7.51	1.020	0.954	59.88	91.48	53.87	7.34								
5/6/92	75HP-M5-R1	52	0.18	17.36	7.41	1.020	0.383	9.38	898.78	383.47	125.90								
5/6/92	75HP-M6-R1	38	0.55	0.57	7.37	0.310	0.363	20.77	21.62	279.74	11.69								
5/6/92	75HP-M7-R1	26	0.83	0.79	5.92	0.270	0.370	21.50	20.65	153.90	7.14								
5/6/92	75HP-M8-R1	0	NA	NA	NA	NA	NA	12.71	14.25	20.83	1.99								
5/6/92	WTD. RESULT		0.62	3.47	7.17	0.584	0.376												
5/7/92	75HP-M1-R2	74	0.22	1.58	8.51	0.340	0.339	16.38	117.77	633.16	25.22								
5/7/92	75HP-M2-R2	57	0.46	0.70	6.67	0.200	0.368	25.93	39.67	380.03	11.43								
5/7/92	75HP-M3-R2	36	0.80	1.44	5.41	0.190	0.410	29.00	52.45	197.11	6.99								
5/7/92	75HP-M4-R2	7	8.91	13.22	7.14	1.150	0.923	66.55	98.77	53.31	8.60								
5/7/92	75HP-M5-R2	52	0.18	16.51	7.65	2.360	0.383	9.51	851.67	394.99	121.73								
5/7/92	75HP-M6-R2	38	0.53	0.54	7.39	0.380	0.362	20.18	20.77	282.99	14.41								
5/7/92	75HP-M7-R2	26	0.81	0.87	5.97	0.350	0.377	21.02	22.66	155.63	9.04								
5/7/92	75HP-M8-R2	0	NA	NA	NA	NA	NA	13.18	13.69	23.11	1.96								
5/7/92	WTD. RESULT		0.65	3.54	7.30	0.592	0.384												
5/12/92	75HP-C6	75	1.42	4.18	7.59	0.825	0.490												
5/12/92	75HP-H8	75	1.30	3.21	7.32	0.581	0.468												
5/12/92	75HP-H9R	75	1.36	2.66	7.41	0.472	0.463												
5/12/92	75HP-CH8	75	1.32	3.35	7.36	0.616	0.471												
5/13/92	75HP-C7	75	1.52	4.19	8.66	0.783	0.497												
5/13/92	75HP-H10	75	1.36	3.25	7.32	0.589	0.459												
5/13/92	75HP-H11	75	1.37	2.76	7.33	0.530	0.446												
5/13/92	75HP-CH10	75	1.38	3.39	7.51	0.617	0.464												
5/14/92	75HP-S1											11.8	23.1	23.6					
5/14/92	75HP-S2											12.0	23.2	24.1					
5/14/92	75HP-SI1														16.1	16.8	16.5	16.7	

*No TEOM (Tapered Element Oscillating Microbalance) particulate data were taken.

C.A.R.B.
SwRI PROJECT No. 08-4820-100
75HP ENGINE
INJECTION TIMING RETARDED 4.5 DEGREES

TEST DATE	TEST NO.	MAX HP	EMISSIONS (G/HP-HR)				BSFC	8-MODE (G/HR)				SMOKE TEST %			SNAP-IDLE SMOKE TEST %				REMARKS
			BSHC	BSCO	BSNOx	PM	LB/HP-HR	BSHC	BSCO	BSNOx	PM	"A"	"B"	"C"	"1"	"2"	"3"	RESULT	
6/3/92	75HP-M1-R3	72	0.18	1.24	5.00	0.427	0.336	12.82	89.84	360.89	30.87								10 DEG.
6/3/92	75HP-M2-R3	55	0.45	0.80	4.23	0.241	0.328	24.43	43.67	231.64	13.17								10 DEG.
6/3/92	75HP-M3-R3	37	0.79	1.72	3.91	0.221	0.406	29.19	63.31	143.66	8.13								10 DEG.
6/3/92	75HP-M4-R3	8	26.81	32.60	4.30	4.370	1.020	209.12	254.25	33.56	34.09								10 DEG.
6/3/92	75HP-M5-R3	51	0.20	14.17	5.52	3.471	0.377	10.06	780.38	283.78	178.51								10 DEG.
6/3/92	75HP-M6-R3	39	0.56	0.78	4.94	0.566	0.365	21.79	30.56	192.27	22.03								10 DEG.
6/3/92	75HP-M7-R3	25	0.92	0.95	4.38	0.295	0.376	23.51	24.15	111.51	7.50								10 DEG.
6/3/92	75HP-M8-R3	0	N.A.	N.A.	N.A.	N.A.	N.A.	21.12	22.13	13.99	3.32								10 DEG.
6/3/92	WTD. RESULT		1.07	3.84	4.73	0.881	0.376												10 DEG.
6/4/92	75HP-M1-R4	74	0.18	1.43	4.81	0.468	0.334	12.98	105.14	354.49	34.51								10 DEG.
6/4/92	75HP-M2-R4	56	0.52	0.73	4.16	0.227	0.347	29.63	41.05	235.18	12.81								10 DEG.
6/4/92	75HP-M3-R4	36	0.95	1.85	3.60	0.245	0.396	34.52	67.11	130.83	8.90								10 DEG.
6/4/92	75HP-M4-R4	9	20.84	25.53	3.83	3.508	0.865	193.15	236.68	35.49	32.52								10 DEG.
6/4/92	75HP-M5-R4	53	0.22	12.20	5.28	3.288	0.367	11.57	646.06	279.84	174.17								10 DEG.
6/4/92	75HP-M6-R4	40	0.60	0.71	4.77	0.627	0.346	23.89	28.21	190.67	25.04								10 DEG.
6/4/92	75HP-M7-R4	26	0.90	0.90	4.27	0.295	0.368	23.42	23.36	111.41	7.69								10 DEG.
6/4/92	75HP-M8-R4	0	N.A.	N.A.	N.A.	N.A.	N.A.	20.42	17.81	13.00	3.68								10 DEG.
6/4/92	WTD. RESULT		1.05	3.39	4.54	0.871	0.372												10 DEG.

C.A.R.B.
SwRI PROJECT No. 08-4820-100
75HP ENGINE
TIMING RETARDED 4.5 DEGREES & TURBOCHARGER INSTALLED

TEST DATE	TEST NO.	MAX HP	EMISSIONS (G/HP-HR)				BSFC	8-MODE (G/HR)				SMOKE TEST %			SNAP-IDLE SMOKE TEST %				REMARKS
			BSHC	BSCO	BSNOx	PM	LB/HP-HR	BSHC	BSCO	BSNOx	PM	"A"	"B"	"C"	"1"	"2"	"3"	RESULT	
6/9/92	75HP-M1-R5	73	0.26	0.48	6.39	0.240	0.337	18.78	35.26	469.29	17.62								10 DEG.& T/C
6/9/92	75HP-M2-R5	55	0.51	0.78	4.84	0.352	0.362	28.46	42.89	267.71	19.49								10 DEG.& T/C
6/9/92	75HP-M3-R5	37	0.80	1.00	4.17	0.396	0.424	29.56	36.94	153.64	14.58								10 DEG.& T/C
6/9/92	75HP-M4-R5	9	5.88	8.72	5.70	0.938	0.933	52.91	78.50	51.30	8.44								10 DEG.& T/C
6/9/92	75HP-M5-R5	57	0.31	1.58	6.88	0.909	0.343	17.98	90.14	392.61	51.89								10 DEG.& T/C
6/9/92	75HP-M6-R5	44	0.44	0.54	5.55	0.492	0.337	19.39	23.78	242.27	21.47								10 DEG.& T/C
6/9/92	75HP-M7-R5	28	0.69	0.75	4.21	0.320	0.365	19.28	21.03	118.42	8.99								10 DEG.& T/C
6/9/92	75HP-M8-R5	0	N.A.	N.A.	N.A.	N.A.	N.A.	14.91	17.25	20.12	3.64								10 DEG.& T/C
6/9/92	WTD. RESULT		0.64	1.07	5.62	0.450	0.379												10 DEG.& T/C
6/10/92	75HP-M1-R6	74	0.26	0.45	6.41	0.256	0.327	19.00	33.44	471.71	18.83								10 DEG.& T/C
6/10/92	75HP-M2-R6	55	0.49	0.69	4.79	0.332	0.351	26.88	38.07	263.11	18.19								10 DEG.& T/C
6/10/92	75HP-M3-R6	37	0.81	0.98	4.04	0.395	0.416	30.31	36.45	150.28	14.71								10 DEG.& T/C
6/10/92	75HP-M4-R6	6	8.87	11.98	7.17	1.280	1.167	57.48	77.62	46.28	8.30								10 DEG.& T/C
6/10/92	75HP-M5-R6	58	0.31	1.71	6.62	1.050	0.334	17.71	98.43	381.27	60.50								10 DEG.& T/C
6/10/92	75HP-M6-R6	44	0.47	0.50	5.36	0.507	0.317	20.70	22.11	235.49	22.27								10 DEG.& T/C
6/10/92	75HP-M7-R6	29	0.75	0.83	4.27	0.316	0.349	21.62	23.95	123.82	9.16								10 DEG.& T/C
6/10/92	75HP-M8-R6	0	N.A.	N.A.	N.A.	N.A.	N.A.	17.90	13.81	17.47	3.57								10 DEG.& T/C
6/10/92	WTD. RESULT		0.67	1.05	5.55	0.475	0.368												10 DEG.& T/C

John Deere 3.9L Off Highway ISO 8178 8–Mode Test Data
08–4855–150 Test Date= 5–6–92
C:\123R3\DATA\JD39SS

BASELINE #1

ISO 8–Mode Test Points

Mode	Speed	Load %	Weighting Factor	---John Deere 3.9L Off–Highway--- Speed rpm	Torque ft–lb	BHP
1	Rated	100	15%	2,200	178	75
2	Rated	75	15%	2,200	134	56
3	Rated	50	15%	2,200	89	37
4	Rated	10	10%	2,200	18	7
5	Int	100	10%	1,300	210	52
6	Int	75	10%	1,300	158	39
7	Int	50	10%	1,300	105	26
8	Idle	0	15%	850	0	0

Mode g/hr Results

Mode	Hp	Fuel lb/hr	HC g/hr	CO g/hr	NOx g/hr	Part g/hr
1	75	24.6	14.22	86.08	637.45	24.10
2	56	19.2	27.79	30.80	356.67	9.90
3	38	15.4	27.07	49.64	198.43	8.67
4	7	6.8	59.88	91.48	53.87	7.34
5	52	19.9	9.38	898.78	383.47	125.90
6	38	13.7	20.77	21.62	279.74	11.69
7	26	9.6	21.50	20.65	153.90	7.14
8	0	1.3	12.71	14.25	20.83	1.99

Mode g/lb Fuel

Mode	Hp	Fuel lb/lb	HC g/lb	CO g/lb	NOx g/lb	Part g/lb
1	75	NA	0.58	3.50	25.92	0.98
2	56	NA	1.45	1.60	18.58	0.52
3	38	NA	1.75	3.21	12.84	0.56
4	7	NA	8.76	13.38	7.88	1.07
5	52	NA	0.47	45.20	19.28	6.33
6	38	NA	1.51	1.57	20.36	0.85
7	26	NA	2.23	2.14	15.98	0.74
8	0	NA	9.42	10.56	15.43	1.48

Mode g/hp–hr

Mode	Hp	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
1	75	0.329	0.19	1.15	8.55	0.32
2	56	0.345	0.50	0.55	6.41	0.18
3	38	0.406	0.71	1.31	5.22	0.23
4	7	0.954	8.35	12.76	7.51	1.02
5	52	0.383	0.18	17.36	7.41	2.43
6	38	0.363	0.55	0.57	7.37	0.31
7	26	0.370	0.83	0.79	5.92	0.27
8	0	NA	NA	NA	NA	NA

	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
8–Mode Weighted	0.376	0.62	3.47	7.17	0.584

John Deere 3.9L Off Highway ISO 8178 8–Mode Test (#2) Data
08–4855–150 Test Date= 5–7–92
C:\123R3\DATA\JD39SS2

BASELINE #2

ISO 8–Mode Test Points

Mode	Speed	Load %	Weighting Factor	John Deere 3.9L Off–Highway– Speed rpm	Torque ft–lb	BHP
1	Rated	100	15%	2,200	178	75
2	Rated	75	15%	2,200	134	56
3	Rated	50	15%	2,200	89	37
4	Rated	10	10%	2,200	18	7
5	Int	100	10%	1,300	210	52
6	Int	75	10%	1,300	158	39
7	Int	50	10%	1,300	105	26
8	Idle	0	15%	850	0	0

Mode g/hr Results

Mode	Hp	Fuel lb/hr	HC g/hr	CO g/hr	NOx g/hr	Part g/hr
1	74	25.2	16.38	117.77	633.16	25.22
2	57	20.9	25.93	39.67	380.03	11.43
3	36	14.9	29.00	52.45	197.11	6.99
4	7	6.9	66.55	98.77	53.31	8.60
5	52	19.7	9.51	851.67	394.99	121.73
6	38	13.9	20.18	20.77	282.99	14.41
7	26	9.8	21.02	22.66	155.63	9.04
8	0	1.4	13.18	13.69	23.11	1.96

Mode g/lb Fuel

Mode	Hp	Fuel lb/lb	HC g/lb	CO g/lb	NOx g/lb	Part g/lb
1	74	NA	0.65	4.67	25.13	1.00
2	57	NA	1.24	1.89	18.15	0.55
3	36	NA	1.94	3.52	13.22	0.47
4	7	NA	9.65	14.31	7.73	1.25
5	52	NA	0.48	43.20	20.04	6.17
6	38	NA	1.46	1.50	20.42	1.04
7	26	NA	2.14	2.30	15.82	0.92
8	0	NA	9.15	9.51	16.05	1.36

Mode g/hp–hr

Mode	Hp	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
1	74	0.339	0.22	1.58	8.51	0.34
2	57	0.368	0.46	0.70	6.67	0.20
3	36	0.410	0.80	1.44	5.41	0.19
4	7	0.923	8.91	13.22	7.14	1.15
5	52	0.383	0.18	16.51	7.65	2.36
6	38	0.362	0.53	0.54	7.39	0.38
7	26	0.377	0.81	0.87	5.97	0.35
8	0	NA	NA	NA	NA	NA

	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
8–Mode Weighted	0.384	0.65	3.54	7.30	0.592

John Deere 3.9L Off Highway ISO 8178 8–Mode Test (#3) Data
08–4820–100 Test Date= 6–3–92 **4.5° RETARD #1**
C:\123R3\DATA\JD39SS3

ISO 8–Mode Test Points ———John Deere 3.9L Off–Highway

Mode	Speed	Load %	Weighting Factor	Speed rpm	Torque ft–lb	BHP
1	Rated	100	15%	2,200	173	72
2	Rated	75	15%	2,200	130	54
3	Rated	50	15%	2,200	87	36
4	Rated	10	10%	2,200	17	7
5	Int	100	10%	1,300	209	52
6	Int	75	10%	1,300	157	39
7	Int	50	10%	1,300	105	26
8	Idle	0	15%	860	0	0

Mode g/hr Results

Mode	Hp	Fuel lb/hr	HC g/hr	CO g/hr	NOx g/hr	Part g/hr
1	72	24.2	12.82	89.84	360.89	30.87
2	55	17.9	24.43	43.67	231.64	13.17
3	37	14.9	29.19	63.31	143.66	8.13
4	8	8.0	209.12	254.25	33.56	34.09
5	51	19.4	10.06	780.38	283.78	178.51
6	39	14.2	21.79	30.56	192.27	22.03
7	25	9.6	23.51	24.15	111.51	7.50
8	0	1.4	21.12	22.13	13.99	3.32

Mode g/lb Fuel

Mode	Hp	Fuel lb/lb	HC g/lb	CO g/lb	NOx g/lb	Part g/lb
1	72	NA	0.53	3.71	14.89	1.27
2	55	NA	1.36	2.43	12.91	0.73
3	37	NA	1.96	4.25	9.64	0.55
4	8	NA	26.30	31.98	4.22	4.29
5	51	NA	0.52	40.28	14.65	9.22
6	39	NA	1.53	2.15	13.52	1.55
7	25	NA	2.46	2.52	11.65	0.78
8	0	NA	14.66	15.37	9.71	2.31

Mode g/hp–hr

Mode	Hp	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
1	72	0.336	0.18	1.24	5.00	0.43
2	55	0.328	0.45	0.80	4.23	0.24
3	37	0.406	0.79	1.72	3.91	0.22
4	8	1.020	26.81	32.60	4.30	4.37
5	51	0.377	0.20	14.17	5.52	3.47
6	39	0.365	0.56	0.78	4.94	0.57
7	25	0.376	0.92	0.95	4.38	0.29
8	0	NA	NA	NA	NA	NA

	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
8–Mode Weighted	0.376	1.07	3.84	4.73	0.881

John Deere 3.9L Off Highway ISO 8178 8–Mode Test (#4) Data
08–4820–100 Test Date= 6–4–92
C:\123R3\DATA\JD39SS4

4.5° RETARD #2

ISO 8–Mode Test Points ———John Deere 3.9L Off–Highway

Mode	Speed	Load %	Weighting Factor	Speed rpm	Torque ft–lb	BHP
1	Rated	100	15%	2,200	175	73
2	Rated	75	15%	2,200	131	55
3	Rated	50	15%	2,200	88	37
4	Rated	10	10%	2,200	18	7
5	Int	100	10%	1,300	214	53
6	Int	75	10%	1,300	161	40
7	Int	50	10%	1,300	107	26
8	Idle	0	15%	860	0	0

Mode g/hr Results

Mode	Hp	Fuel lb/hr	HC g/hr	CO g/hr	NOx g/hr	Part g/hr
1	74	24.6	12.98	105.14	354.49	34.51
2	56	19.6	29.63	41.05	235.18	12.81
3	36	14.4	34.52	67.11	130.83	8.90
4	9	8.0	193.15	236.68	35.49	32.52
5	53	19.4	11.57	646.06	279.84	174.17
6	40	13.9	23.89	28.21	190.67	25.04
7	26	9.6	23.42	23.36	111.41	7.69
8	0	1.3	20.42	17.81	13.00	3.68

Mode g/lb Fuel

Mode	Hp	Fuel lb/lb	HC g/lb	CO g/lb	NOx g/lb	Part g/lb
1	74	NA	0.53	4.27	14.41	1.40
2	56	NA	1.51	2.10	12.02	0.65
3	36	NA	2.40	4.66	9.09	0.62
4	9	NA	24.11	29.55	4.43	4.06
5	53	NA	0.60	33.35	14.45	8.99
6	40	NA	1.72	2.04	13.76	1.81
7	26	NA	2.44	2.43	11.61	0.80
8	0	NA	15.47	13.49	9.85	2.79

Mode g/hp–hr

Mode	Hp	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
1	74	0.334	0.18	1.43	4.81	0.47
2	56	0.347	0.52	0.73	4.16	0.23
3	36	0.396	0.95	1.85	3.60	0.24
4	9	0.865	20.84	25.53	3.83	3.51
5	53	0.367	0.22	12.20	5.28	3.29
6	40	0.346	0.60	0.71	4.77	0.63
7	26	0.368	0.90	0.90	4.27	0.30
8	0	NA	NA	NA	NA	NA

	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
8–Mode Weighted	0.372	1.05	3.39	4.54	0.871

HOT-TRANSIENTS,
4.5° RETARD

ENGINE EMISSION RESULTS
HOT-TRANS

PROJECT NO. 08-4820-100

ENGINE NUMBER
ENGINE MODEL 91 JD-4039D
ENGINE 4.5 L(275. CID) I-4
ENGINE CYCLE DIESEL

TEST JD-3.9-TH13 RUN
DATE 6/ 5/92 TIME 10:26
COMPUTER PROGRAM HDT 1.1-C
CELL 4 BAG CART 1

DIESEL 2D EM-1392-F
HCR 1.80

BAROMETER 736.1 MM HG (28.98 IN HG)
ENGINE AIR TEMP. 27.2 C (81.0)

CELL: 80.0 F RH 61.0 PCT AH 97.3 GR/LB
ENGINE ABS. HUM. 11.4 G/KG (79.5 GR/LB)

ENGINE DEW PT. 15.4 C (59.8 F)
NOX HUMIDITY C.F. 1.012
DRY-TO-WET C.F. .975

BAG RESULTS

BAG NUMBER	1
TIME SECONDS	1206.4
TOT. BLOWER RATE SCMM (SCFM)	32.20 (1136.9)
TOT. 90MM RATE SCMM (SCFM)	.04 (1.43)
TOT. 20X20 RATE SCMM (SCFM)	.00 (.0)
TOT. AUX. SAMPLE RATE SCMM (SCFM)	.00 (.00)
TOTAL FLOW STD. CU. METRES(SCF)	648.2 (22888.)
HC SAMPLE METER/RANGE/PPM	18.6/ 43/ 37.48
HC BCKGRD METER/RANGE/PPM	4.3/ 43/ 8.64
CO SAMPLE METER/RANGE/PPM	24.0/ 13/ 21.64
CO BCKGRD METER/RANGE/PPM	.9/ 13/ .79
CO2 SAMPLE METER/RANGE/PCT	46.6/ 11/ .3515
CO2 BCKGRD METER/RANGE/PCT	13.5/ 11/ .0833
NOX SAMPLE METER/RANGE/PPM (W)	.3/ 43/ 21.02
NOX BCKGRD METER/RANGE/PPM	2.1/ 1/ .56
DILUTION FACTOR	37.50
HC CONCENTRATION PPM	29.07
CO CONCENTRATION PPM	20.32
CO2 CONCENTRATION PCT	.2704
NOX CONCENTRATION PPM	20.48
HC MASS GRAMS	10.826
CO MASS GRAMS	15.331
CO2 MASS GRAMS	3206.51
NOX MASS GRAMS	25.687
FUEL KG (LB)	1.026 (2.26)
KW HR (HP HR)	3.72 (4.99)

TOTAL RESULTS

BSHC G/KW HR (G/HP HR)	2.909 (2.170) (2.17) (CONT)	90 MM FILTER NUMBERS P90-37 P90-38
BSCO G/KW HR (G/HP HR)	4.120 (3.072) (3.07)	90 MM FILTER WT. GAINS (MG) 3.959 .387
BSNOX G/KW HR (G/HP HR)	6.903 (5.148) (5.15) (CONT)	PARTICULATE GRAMS/TEST 3.452
PART. G/KW HR (G/HP HR)	.928 (.692) (.69)	
BSFC KG/KW HR (LB/HP HR)	.276 (.453)	
WORK KW HR (HP HR)	3.72 (4.99)	
BSCO2 G/KW HR (G/HP HR)	862. (643.)	

HOT-TRANSIENTS, 4.5° RETARD

ENGINE EMISSION RESULTS
HOT-TRANS

PROJECT NO. 08-4820-100

ENGINE NUMBER
ENGINE MODEL 91 JD-4039D
ENGINE 4.5 L(275. CID) I-4
ENGINE CYCLE DIESEL

TEST JD-3.9-TH14 RUN
DATE 6/ 5/92 TIME 11:11
COMPUTER PROGRAM HDT 1.1-C
CELL 4 BAG CART 1

DIESEL 2D EM-1392-F
HCR 1.80

BAROMETER 735.8 MM HG (28.97 IN HG)
ENGINE AIR TEMP. 27.8 C (82.0)

CELL: 80.0 F RH 61.0 PCT AH 97.3 GR/LB
ENGINE ABS. HUM. 11.5 G/KG (80.4 GR/LB)

ENGINE DEW PT. 15.6 C (60.1 F)
NOX HUMIDITY C.F. 1.014
DRY-TO-WET C.F. .975

BAG RESULTS

BAG NUMBER	1
TIME SECONDS	1206.6
TOT. BLOWER RATE SCMM (SCFM)	32.16 (1135.7)
TOT. 90MM RATE SCMM (SCFM)	.04 (1.41)
TOT. 20X20 RATE SCMM (SCFM)	.00 (.0)
TOT. AUX. SAMPLE RATE SCMM (SCFM)	.00 (.00)
TOTAL FLOW STD. CU. METRES(SCF)	647.6 (22868.)
HC SAMPLE METER/RANGE/PPM	18.9/ 43/ 38.13
HC BCKGRD METER/RANGE/PPM	4.6/ 43/ 9.24
CO SAMPLE METER/RANGE/PPM	23.6/ 13/ 21.27
CO BCKGRD METER/RANGE/PPM	.4/ 13/ .35
CO2 SAMPLE METER/RANGE/PCT	46.5/ 11/ .3505
CO2 BCKGRD METER/RANGE/PCT	12.9/ 11/ .0793
NOX SAMPLE METER/RANGE/PPM (W)	.2/ 43/ 20.78
NOX BCKGRD METER/RANGE/PPM	2.1/ 1/ .56
DILUTION FACTOR	37.60
HC CONCENTRATION PPM	29.13
CO CONCENTRATION PPM	20.37
CO2 CONCENTRATION PCT	.2733
NOX CONCENTRATION PPM	20.24
HC MASS GRAMS	10.837
CO MASS GRAMS	15.358
CO2 MASS GRAMS	3238.20
NOX MASS GRAMS	25.423
FUEL KG (LB)	1.036 (2.28)
KW HR (HP HR)	3.72 (4.99)

TOTAL RESULTS

BSHC	G/KW HR (G/HP HR)	2.912 (2.172) (2.17) (CONT)
BSCO	G/KW HR (G/HP HR)	4.127 (3.078) (3.08)
BSNOX	G/KW HR (G/HP HR)	6.832 (5.095) (5.09) (CONT)
PART.	G/KW HR (G/HP HR)	.906 (.675) (.68)
BSFC	KG/KW HR (LB/HP HR)	.278 (.458)
WORK	KW HR (HP HR)	3.72 (4.99)
BSCO2	G/KW HR (G/HP HR)	870. (649.)

90 MM FILTER NUMBERS	P90-39	P90-40
90 MM FILTER WT. GAINS (MG)	3.958	.212
PARTICULATE GRAMS/TEST	3.370	

John Deere 3.9L Off Highway ISO 8178 8–Mode Test (#5) Data
08–4820–100 Test Date= 6–9–92
C:\123R3\DATA\JD39SS5

4.5° RETARD + T/C #1

ISO 8–Mode Test Points

Mode	Speed	Load %	Weighting Factor	---John Deere 3.9L Off–Highway--- Speed rpm	Torque ft–lb	BHP
1	Rated	100	15%	2,200	175	73
2	Rated	75	15%	2,200	131	55
3	Rated	50	15%	2,200	88	37
4	Rated	10	10%	2,200	18	7
5	Int	100	10%	1,300	234	58
6	Int	75	10%	1,300	176	43
7	Int	50	10%	1,300	117	29
8	Idle	0	15%	856	0	0

Mode g/hr Results

Mode	Hp	Fuel lb/hr	HC g/hr	CO g/hr	NOx g/hr	Part g/hr
1	73	24.8	18.78	35.26	469.29	17.62
2	55	20.0	28.46	42.89	267.71	19.49
3	37	15.6	29.56	36.94	153.64	14.58
4	9	8.4	52.91	78.50	51.30	8.44
5	57	19.5	17.98	90.14	392.61	51.89
6	44	14.7	19.39	23.78	242.27	21.47
7	28	10.3	19.28	21.03	118.42	8.99
8	0	1.8	14.91	17.25	20.12	3.64

Mode g/lb Fuel

Mode	Hp	Fuel lb/lb	HC g/lb	CO g/lb	NOx g/lb	Part g/lb
1	73	NA	0.76	1.42	18.94	0.71
2	55	NA	1.42	2.14	13.36	0.97
3	37	NA	1.89	2.36	9.83	0.93
4	9	NA	6.30	9.35	6.11	1.00
5	57	NA	0.92	4.61	20.09	2.66
6	44	NA	1.32	1.62	16.48	1.46
7	28	NA	1.88	2.05	11.54	0.88
8	0	NA	8.43	9.75	11.37	2.06

Mode g/hp–hr

Mode	Hp	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
1	73	0.337	0.26	0.48	6.39	0.24
2	55	0.362	0.51	0.78	4.84	0.35
3	37	0.424	0.80	1.00	4.17	0.40
4	9	0.933	5.88	8.72	5.70	0.94
5	57	0.343	0.31	1.58	6.88	0.91
6	44	0.337	0.44	0.54	5.55	0.49
7	28	0.365	0.69	0.75	4.21	0.32
8	0	NA	NA	NA	NA	NA

	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
8–Mode Weighted	0.379	0.64	1.07	5.62	0.450

John Deere 3.9L Off Highway ISO 8178 8–Mode Test (#6) Data
08–4820–100 Test Date= 6–10–92
C:\123R3\DATA\JD39SS6

4.5° RETARD + T/C #2

ISO 8–Mode Test Points

Mode	Speed	Load %	Weighting Factor	John Deere 3.9L Off–Highway– Speed rpm	Torque ft–lb	BHP
1	Rated	100	15%	2,200	176	74
2	Rated	75	15%	2,200	132	55
3	Rated	50	15%	2,200	88	37
4	Rated	10	10%	2,200	18	7
5	Int	100	10%	1,300	235	58
6	Int	75	10%	1,300	176	44
7	Int	50	10%	1,300	118	29
8	Idle	0	15%	856	0	0

Mode g/hr Results

Mode	Hp	Fuel lb/hr	HC g/hr	CO g/hr	NOx g/hr	Part g/hr
1	74	24.1	19.00	33.44	471.71	18.83
2	55	19.3	26.88	38.07	263.11	18.19
3	37	15.5	30.31	36.45	150.28	14.71
4	6	7.6	57.48	77.62	46.28	8.30
5	58	19.2	17.71	98.43	381.27	60.50
6	44	13.9	20.70	22.11	235.49	22.27
7	29	10.1	21.62	23.95	123.82	9.16
8	0	1.9	17.90	13.81	17.47	3.57

Mode g/lb Fuel

Mode	Hp	Fuel lb/lb	HC g/lb	CO g/lb	NOx g/lb	Part g/lb
1	74	NA	0.79	1.39	19.61	0.78
2	55	NA	1.40	1.98	13.66	0.94
3	37	NA	1.96	2.35	9.71	0.95
4	6	NA	7.61	10.27	6.12	1.10
5	58	NA	0.92	5.13	19.86	3.15
6	44	NA	1.49	1.59	16.92	1.60
7	29	NA	2.14	2.37	12.25	0.91
8	0	NA	9.63	7.43	9.39	1.92

Mode g/hp–hr

Mode	Hp	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
1	74	0.327	0.26	0.45	6.41	0.26
2	55	0.351	0.49	0.69	4.79	0.33
3	37	0.416	0.81	0.98	4.04	0.40
4	6	1.167	8.87	11.98	7.14	1.28
5	58	0.334	0.31	1.71	6.62	1.05
6	44	0.317	0.47	0.50	5.36	0.51
7	29	0.349	0.75	0.83	4.27	0.32
8	0	NA	NA	NA	NA	NA

	BSFC lb/hp–hr	HC g/hp–hr	CO g/hp–hr	NOx g/hp–hr	Part g/hp–hr
8–Mode Weighted	0.368	0.67	1.05	5.55	0.475

HOT-TRANSIENTS,
4.5° RETARD + T/C

ENGINE EMISSION RESULTS
HOT-TRANS

PROJECT NO. 08-4820-100

ENGINE NUMBER
ENGINE MODEL 91 JD-4039D
ENGINE 4.5 L(275. CID) I-4
ENGINE CYCLE DIESEL

TEST JD-3.9-TH15 RUN
DATE 6/ 8/92 TIME 5:02
COMPUTER PROGRAM HDT 1.1-C
CELL 4 BAG CART 1

DIESEL 2D EM-1392-F
HCR 1.80

BAROMETER 737.9 MM HG (29.05 IN HG)
ENGINE AIR TEMP. 30.6 C (87.0)

CELL: 81.0 F RH 55.0 PCT AH 89.7 GR/LB
ENGINE ABS. HUM. 11.0 G/KG (76.8 GR/LB)

ENGINE DEW PT. 14.9 C (58.9 F)
NOX HUMIDITY C.F. 1.005
DRY-TO-WET C.F. .976

BAG RESULTS

BAG NUMBER	1
TIME SECONDS	1207.0
TOT. BLOWER RATE SCMM (SCFM)	32.40 (1144.2)
TOT. 90MM RATE SCMM (SCFM)	.04 (1.46)
TOT. 20X20 RATE SCMM (SCFM)	.00 (.0)
TOT. AUX. SAMPLE RATE SCMM (SCFM)	.00 (.00)
TOTAL FLOW STD. CU. METRES(SCF)	652.7 (23047.)
HC SAMPLE METER/RANGE/PPM	22.7/ 42/ 22.77
HC BCKGRD METER/RANGE/PPM	5.2/ 42/ 5.21
CO SAMPLE METER/RANGE/PPM	13.4/ 13/ 11.91
CO BCKGRD METER/RANGE/PPM	.9/ 13/ .79
CO2 SAMPLE METER/RANGE/PCT	45.6/ 11/ .3419
CO2 BCKGRD METER/RANGE/PCT	8.6/ 11/ .0515
NOX SAMPLE METER/RANGE/PPM (W)	.3/ 43/ 25.25
NOX BCKGRD METER/RANGE/PPM	.4/ 2/ .42
DILUTION FACTOR	38.81
HC CONCENTRATION PPM	17.69
CO CONCENTRATION PPM	10.87
CO2 CONCENTRATION PCT	.2917
NOX CONCENTRATION PPM	24.85
HC MASS GRAMS	6.634
CO MASS GRAMS	8.256
CO2 MASS GRAMS	3483.33
NOX MASS GRAMS	31.158
FUEL KG (LB)	1.105 (2.44)
KW HR (HP HR)	3.91 (5.25)

TOTAL RESULTS

BSHC G/KW HR (G/HP HR)	1.695 (1.264) (1.26) (CONT)	90 MM FILTER NUMBERS P90-41 P90-42
BSCO G/KW HR (G/HP HR)	2.109 (1.573) (1.57)	90 MM FILTER WT. GAINS (MG) 3.076 .199
BSNOX G/KW HR (G/HP HR)	7.959 (5.935) (5.93) (CONT)	PARTICULATE GRAMS/TEST 2.566
PART. G/KW HR (G/HP HR)	.655 (.489) (.49)	
BSFC KG/KW HR (LB/HP HR)	.282 (.464)	
WORK KW HR (HP HR)	3.91 (5.25)	
BSCO2 G/KW HR (G/HP HR)	890. (663.)	

HOT-TRANSIENTS,
4.5° RETARD + T/C

ENGINE EMISSION RESULTS
HOT-TRANS

PROJECT NO. 08-4820-100

ENGINE NUMBER
ENGINE MODEL 91 JD-4039D
ENGINE 4.5 L(275. CID) I-4
ENGINE CYCLE DIESEL

TEST JD-3.9-TH16 RUN
DATE 6/ 8/92 TIME 5:42
COMPUTER PROGRAM HDT 1.1-C
CELL 4 BAG CART 1

DIESEL 2D EM-1392-F
HCR 1.80

BAROMETER 737.6 MM HG (29.04 IN HG)
ENGINE AIR TEMP. 30.6 C (87.0)

CELL: 82.0 F RH 55.0 PCT AH 93.6 GR/LB
ENGINE ABS. HUM. 10.5 G/KG (73.5 GR/LB)

ENGINE DEW PT. 14.3 C (57.7 F)
NOX HUMIDITY C.F. .996
DRY-TO-WET C.F. .976

BAG RESULTS

BAG NUMBER	1
TIME SECONDS	1207.1
TOT. BLOWER RATE SCMM (SCFM)	32.32 (1141.1)
TOT. 90MM RATE SCMM (SCFM)	.04 (1.44)
TOT. 20X20 RATE SCMM (SCFM)	.00 (.0)
TOT. AUX. SAMPLE RATE SCMM (SCFM)	.00 (.00)
TOTAL FLOW STD. CU. METRES(SCF)	651.0 (22986.)
HC SAMPLE METER/RANGE/PPM	22.9/ 42/ 22.97
HC BCKGRD METER/RANGE/PPM	4.9/ 42/ 4.91
CO SAMPLE METER/RANGE/PPM	12.6/ 13/ 11.18
CO BCKGRD METER/RANGE/PPM	.5/ 13/ .44
CO2 SAMPLE METER/RANGE/PCT	45.3/ 11/ .3390
CO2 BCKGRD METER/RANGE/PCT	8.7/ 11/ .0521
NOX SAMPLE METER/RANGE/PPM (W)	.3/ 43/ 25.11
NOX BCKGRD METER/RANGE/PPM	.4/ 2/ .42
DILUTION FACTOR	39.14
HC CONCENTRATION PPM	18.19
CO CONCENTRATION PPM	10.49
CO2 CONCENTRATION PCT	.2882
NOX CONCENTRATION PPM	24.71
HC MASS GRAMS	6.801
CO MASS GRAMS	7.952
CO2 MASS GRAMS	3432.58
NOX MASS GRAMS	30.639
FUEL KG (LB)	1.089 (2.40)
KW HR (HP HR)	3.91 (5.25)

TOTAL RESULTS

BSHC G/KW HR (G/HP HR)	1.737 (1.295) (1.30) (CONT)	90 MM FILTER NUMBERS	P90-43 P90-44
BSCO G/KW HR (G/HP HR)	2.031 (1.515) (1.51)	90 MM FILTER WT. GAINS (MG)	3.039 .176
BSNOX G/KW HR (G/HP HR)	7.826 (5.836) (5.84) (CONT)	PARTICULATE GRAMS/TEST	2.549
PART. G/KW HR (G/HP HR)	.651 (.486) (.49)		
BSFC KG/KW HR (LB/HP HR)	.278 (.457)		
WORK KW HR (HP HR)	3.91 (5.25)		
BSCO2 G/KW HR (G/HP HR)	877. (654.)		

APPENDIX C

30 HP AIR-COOLED DIESEL ENGINE (LISTER-PETTER TS3)
BASELINE EMISSION TEST RESULTS
(ISO 8178-C1)

- **ACD-1**
- **ACD-2**

DIESEL ENGINE #/RUN ACD-1: 7/29/92	AVERAGE MODE 1	AVERAGE MODE 2	AVERAGE MODE 3	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 11	WEIGHTED 8178-C1
Weighting factor	15%	15%	15%	10%	10%	10%	10%	15%	
Air/fuel ratio	21.9	29.4	39.2	70.2	19.9	26.7	39.0	96.9	**43.7**
Fuel flow rate, lb/h	13.1	10.1	7.56	4.38	10.5	7.88	5.66	0.91	**3.45**
Engine speed, rpm	2500	2500	2500	2500	1800	1800	1800	760	**2029**
Engine torque, lb-ft	62.6	46.6	31.2	6.00	73.2	58.2	36.2	0.00	**38.4**
Power output, hp	29.8	22.2	14.9	2.86	25.1	19.9	12.4	0.00	**16.05**
Air inlet temp, deg. F	89	93	92	93	92	100	92	91	**92**
Humidity, grains/lb	90	105	106	98	97	95	102	98	**99**
HC ppmc, wet	950	775	677	788	820	645	674	755	**766**
CO ppm, wet	874	402	331	475	3927	421	320	444	**822**
CO2 %, wet	8.98	6.78	5.13	2.82	9.55	7.48	5.15	2.02	**5.94**
NOx ppm, wet	849	680	538	242	1073	974	698	307	**655**
O2 %, wet	7.08	10.34	12.64	15.93	5.45	8.96	12.47	17.28	**11.38**
RAW ISO 8178-C1									
THC, g/h	62.0	51.8	44.7	53.5	39.2	30.6	33.1	14.6	**41.6**
THC, g/hp-h	2.08	2.33	3.01	18.7	1.56	1.53	2.67		**2.59**
CH4, g/h	0.55	0.24	0.25	0.31	1.71	0.16	0.22	0.09	**0.41**
CH4, g/hp-h	0.02	0.01	0.02	0.11	0.07	0.01	0.02		**0.03**
RHC, g/h	61.4	51.5	44.4	53.1	37.5	30.4	32.9	14.5	**41.2**
RHC, g/hp-h	2.06	2.32	2.99	18.6	1.50	1.53	2.65		**2.57**
CO, g/h	115	54.2	44.1	65.0	379	40.3	31.7	17.3	**86.2**
CO, g/hp-h	3.86	2.44	2.97	22.8	15.1	2.02	2.56		**5.37**
NOx, g/h	201	172	136	62	188	169	130	22.7	**135**
NOx, g/hp-h	6.75	7.76	9.19	21.7	7.49	8.47	10.5		**8.40**
CO2, g/h	18574	14364	10730	6061	14486	11247	8032	1243	**10719**
CO2, g/hp-h	623	648	722	2122	577	564	647		**668**
Fuel, lb/h	13.1	10.1	7.56	4.38	10.5	7.88	5.66	0.91	**7.60**
Fuel, lb/hp-h	0.44	0.46	0.51	1.53	0.42	0.40	0.46		**0.47**
DILUTE PARTICULATE									
PM, g/h	33.8	16.3	10.7	15.5	81	17.9	9.5	1.78	**21.8**
PM, g/hp-h	1.13	0.74	0.72	5.4	3.23	0.90	0.76		**1.36**

DIESEL ENGINE #/RUN ACD-2: 7/29/92	AVERAGE MODE 1	AVERAGE MODE 2	AVERAGE MODE 3	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 11	WEIGHTED 8178-C1
Weighting factor	15%	15%	15%	10%	10%	10%	10%	15%	
Air/fuel ratio	23.3	28.6	38.5	68.3	20.2	26.4	37.9	102.4	**44.2**
Fuel flow rate, lb/h	12.6	10.2	7.82	4.40	10.4	7.98	5.63	0.88	**3.43**
Engine speed, rpm	2500	2500	2500	2500	1800	1800	1800	763	**2029**
Engine torque, lb-ft	59.2	46.4	31.4	6.00	70.8	55.4	36.6	0.00	**37.4**
Power output, hp	28.2	22.1	14.9	2.86	24.3	19.0	12.5	0.00	**15.65**
Air inlet temp, deg. F	98	101	99	96	95	100	92	97	**98**
Humidity, grains/lb	103	101	102	98	98	97	93	98	**99**
HC ppmc, wet	1088	818	762	765	875	694	692	757	**816**
CO ppm, wet	815	424	331	463	4209	443	304	444	**844**
CO2 %, wet	8.46	6.96	5.21	2.90	9.38	7.55	5.30	1.91	**5.89**
NOx ppm, wet	822	663	546	280	1088	1004	709	291	**656**
O2 %, wet	7.22	10.03	12.53	16.11	5.44	8.74	12.16	17.39	**11.32**
RAW ISO 8178-C1									
THC, g/h	72.2	53.8	51.1	50.7	41.9	33.0	33.0	15.1	**44.7**
THC, g/hp-h	2.56	2.43	3.42	17.7	1.73	1.74	2.63		**2.85**
CH4, g/h	0.52	0.32	0.26	0.37	1.84	0.20	0.32	0.08	**0.45**
CH4, g/hp-h	0.02	0.01	0.02	0.13	0.08	0.01	0.03		**0.03**
RHC, g/h	71.6	53.4	50.9	50.3	40.1	32.8	32.6	15.0	**44.2**
RHC, g/hp-h	2.54	2.42	3.40	17.6	1.65	1.73	2.60		**2.83**
CO, g/h	109	56.1	44.8	61.9	406	42.5	29.2	17.8	**88.2**
CO, g/hp-h	3.87	2.54	3.00	21.7	16.8	2.24	2.33		**5.63**
NOx, g/h	203	161	136	69	192	175	125	21.5	**134**
NOx, g/hp-h	7.21	7.31	9.12	24.2	7.91	9.22	9.9		**8.59**
CO2, g/h	17795	14497	11079	6098	14243	11373	8000	1203	**10657**
CO2, g/hp-h	631	656	741	2135	587	599	638		**681**
Fuel, lb/h	12.6	10.2	7.82	4.40	10.4	7.98	5.63	0.88	**7.56**
Fuel, lb/hp-h	0.45	0.46	0.52	1.54	0.43	0.42	0.45		**0.48**
DILUTE PARTICULATE									
PM, g/h	36.3	20.0	11.3	11.9	81	17.6	9.9	1.08	**22.3**
PM, g/hp-h	1.29	0.91	0.76	4.2	3.32	0.93	0.79		**1.43**

APPENDIX D

35 HP WATER-COOLED DIESEL ENGINE (LISTER-PETTER LPWS4) BASELINE AND 4° RETARD EMISSION TEST RESULTS (ISO 8178-C1)

- **WCD-1 (BASELINE)**
- **WCD-2 (BASELINE)**
- **WCDR-1 (4° RETARD)**
- **WCDR-2 (4° RETARD)**

DIESEL ENGINE #/RUN WCD-1: 8/11/92	AVERAGE MODE 1	AVERAGE MODE 2	AVERAGE MODE 3	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 11	WEIGHTED 8178-C1
Weighting factor	15%	15%	15%	10%	10%	10%	10%	15%	
Air/fuel ratio	21.3	27.3	38.0	66.8	20.2	25.1	36.1	89.3	**41.2**
Fuel flow rate, lb/h	16.9	13.0	9.62	5.33	11.2	8.09	6.02	1.37	**4.17**
Engine speed, rpm	3000	3000	3000	3000	1900	1900	1900	1100	**2385**
Engine torque, lb-ft	61.6	46.2	30.0	6.00	70.2	53.4	35.2	0.00	**37.2**
Power output, hp	35.2	26.4	17.1	3.43	25.4	19.3	12.7	0.00	**17.89**
Air inlet temp, deg. F	79	85	84	85	86	85	82	87	**84**
Humidity, grains/lb	91	89	89	93	98	111	95	106	**96**
HC ppmc, wet	315	185	219	530	164	205	1123	167	**335**
CO ppm, wet	424	212	276	804	264	290	374	229	**344**
CO2 %, wet	9.36	7.39	5.33	2.96	9.87	8.00	5.51	2.28	**6.29**
NOx ppm, wet	284	249	162	67	347	388	372	290	**265**
O2 %, wet	5.90	8.94	12.04	15.54	5.31	8.31	12.14	16.87	**10.69**
RAW ISO 8178-C1									
THC, g/h	25.7	14.8	17.9	41.7	8.4	9.4	54.5	4.5	**20.8**
THC, g/hp-h	0.73	0.56	1.04	12.2	0.33	0.49	4.28		**1.16**
CH4, g/h	1.98	0.18	0.25	0.86	0.25	0.20	1.05	0.12	**0.61**
CH4, g/hp-h	0.06	0.01	0.01	0.25	0.01	0.01	0.08		**0.03**
RHC, g/h	23.7	14.6	17.6	40.8	8.2	9.2	53.5	4.4	**20.2**
RHC, g/hp-h	0.67	0.55	1.03	11.9	0.32	0.48	4.20		**1.13**
CO, g/h	70	34.1	45.4	127.3	27	26.8	36.6	12.4	**46.1**
CO, g/hp-h	1.98	1.29	2.65	37.2	1.1	1.39	2.88		**2.57**
NOx, g/h	84	73	49	20	66	68	69	31.2	**58**
NOx, g/hp-h	2.39	2.76	2.87	5.9	2.58	3.54	5.4		**3.23**
CO2, g/h	24223	18715	13796	7377	16109	11635	8478	1946	**13162**
CO2, g/hp-h	688	709	805	2153	634	602	666		**736**
Fuel, lb/h	16.9	13.0	9.62	5.33	11.2	8.09	6.02	1.37	**9.19**
Fuel, lb/hp-h	0.48	0.49	0.56	1.56	0.44	0.42	0.47		**0.51**
DILUTE PARTICULATE									
PM, g/h	18.0	5.5	6.8	16.8	20	4.5	8.1	1.35	**9.7**
PM, g/hp-h	0.51	0.21	0.40	4.9	0.80	0.23	0.63		**0.54**

DIESEL ENGINE #/RUN WCD-2: 8/13/92	AVERAGE MODE 1	AVERAGE MODE 2	AVERAGE MODE 3	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 11	WEIGHTED 8178-C1
Weighting factor	15%	15%	15%	10%	10%	10%	10%	15%	
Air/fuel ratio	21.0	28.4	40.4	70.2	20.6	27.6	37.5	89.5	**42.5**
Fuel flow rate, lb/h	16.7	12.1	9.50	5.20	10.6	7.93	5.87	1.31	**4.04**
Engine speed, rpm	3000	3000	3000	3000	1900	1900	1900	1085	**2383**
Engine torque, lb-ft	61.8	45.4	30.4	6.40	70.0	53.2	35.8	0.00	**37.2**
Power output, hp	35.3	25.9	17.4	3.66	25.3	19.2	13.0	0.00	**17.91**
Air inlet temp, deg. F	85	86	86	86	86	87	86	87	**86**
Humidity, grains/lb	94	95	95	95	93	95	93	98	**95**
HC ppmc, wet	225	167	175	420	129	240	1173	152	**304**
CO ppm, wet	381	225	387	768	233	346	397	207	**354**
CO2 %, wet	9.48	7.11	5.02	2.83	9.69	7.27	5.30	2.28	**6.09**
NOx ppm, wet	279	237	142	60	352	417	376	389	**278**
O2 %, wet	6.03	9.53	12.73	15.97	5.43	9.16	12.16	16.75	**11.03**
RAW ISO 8178-C1									
THC, g/h	18.0	12.9	15.0	33.8	6.4	11.8	57.6	3.9	**18.4**
THC, g/hp-h	0.51	0.50	0.86	9.2	0.25	0.62	4.45		**1.03**
CH4, g/h	1.45	0.20	0.25	0.69	0.23	0.29	1.11	0.07	**0.53**
CH4, g/hp-h	0.04	0.01	0.01	0.19	0.01	0.01	0.09		**0.03**
RHC, g/h	16.5	12.7	14.7	33.1	6.2	11.6	56.5	3.9	**17.9**
RHC, g/hp-h	0.47	0.49	0.85	9.1	0.24	0.60	4.36		**1.00**
CO, g/h	61	35.1	66.7	124.6	23	34.4	39.3	10.7	**48.3**
CO, g/hp-h	1.74	1.35	3.84	34.1	0.9	1.79	3.03		**2.70**
NOx, g/h	81	68	46	19	64	76	69	39.0	**58**
NOx, g/hp-h	2.31	2.63	2.65	5.1	2.52	3.97	5.3		**3.24**
CO2, g/h	24038	17456	13593	7211	15336	11382	8249	1868	**12761**
CO2, g/hp-h	681	673	783	1972	606	591	637		**713**
Fuel, lb/h	16.7	12.1	9.50	5.20	10.6	7.93	5.87	1.31	**8.91**
Fuel, lb/hp-h	0.47	0.47	0.55	1.42	0.42	0.41	0.45		**0.50**
DILUTE PARTICULATE									
PM, g/h	14.6	5.5	6.5	13.3	16	4.1	7.8	1.04	**8.2**
PM, g/hp-h	0.41	0.21	0.37	3.7	0.62	0.21	0.60		**0.46**

DIESEL ENGINE #/RUN WCDR1: 8/17/92	AVERAGE MODE 1	AVERAGE MODE 2	AVERAGE MODE 3	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 11	WEIGHTED 8178-C1
Weighting factor	15%	15%	15%	10%	10%	10%	10%	15%	
Air/fuel ratio	23.3	27.2	38.1	60.2	22.7	30.8	41.4	89.1	**42.2**
Fuel flow rate, lb/h	14.8	12.6	9.19	5.96	9.6	7.60	5.63	1.55	**3.90**
Engine speed, rpm	3000	3000	3000	3000	1900	1900	1900	1104	**2386**
Engine torque, lb-ft	53.0	44.2	26.6	5.80	63.0	47.2	32.0	0.00	**33.4**
Power output, hp	30.3	25.2	15.2	3.31	22.8	17.1	11.6	0.00	**16.08**
Air inlet temp, deg. F	86	89	85	83	85	86	84	85	**86**
Humidity, grains/lb	81	86	85	77	77	77	80	78	**80**
HC ppmc, wet	255	172	320	2745	245	630	490	202	**553**
CO ppm, wet	309	228	408	845	204	316	191	257	**336**
CO2 %, wet	8.57	7.40	5.30	3.07	8.81	6.52	4.89	2.28	**5.86**
NOx ppm, wet	245	203	125	52	360	336	284	270	**230**
O2 %, wet	7.58	9.38	12.45	15.65	6.95	10.25	12.69	16.57	**11.45**
RAW ISO 8178-C1									
THC, g/h	20.0	13.2	25.0	217.5	12.1	33.1	25.4	6.1	**38.5**
THC, g/hp-h	0.66	0.52	1.64	65.7	0.53	1.94	2.19		**2.39**
CH4, g/h									
CH4, g/hp-h									
RHC, g/h									
RHC, g/hp-h									
CO, g/h	49	35.4	64.2	135.0	20	33.4	20.0	15.7	**45.5**
CO, g/hp-h	1.61	1.40	4.23	40.7	0.9	1.96	1.72		**2.83**
NOx, g/h	69	56	36	15	63	63	53	29.8	**48**
NOx, g/hp-h	2.27	2.24	2.36	4.5	2.77	3.68	4.6		**2.99**
CO2, g/h	21269	18070	13116	7701	13798	10841	8030	2194	**12234**
CO2, g/hp-h	703	716	863	2325	605	635	694		**761**
Fuel, lb/h	14.8	12.6	9.19	5.96	9.6	7.60	5.63	1.55	**8.59**
Fuel, lb/hp-h	0.49	0.50	0.60	1.80	0.42	0.45	0.49		**0.53**
DILUTE PARTICULATE									
PM, g/h	9.1	5.3	6.5	80.7	7	4.8	4.9	1.20	**13.1**
PM, g/hp-h	0.30	0.21	0.43	24.4	0.32	0.28	0.43		**0.81**

DIESEL ENGINE #/RUN WCDR-2: 8/18/92	AVERAGE MODE 1	AVERAGE MODE 2	AVERAGE MODE 3	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 11	WEIGHTED 8178-C1
Weighting factor	15%	15%	15%	10%	10%	10%	10%	15%	
Air/fuel ratio	23.3	26.9	38.5	62.3	22.6	29.4	39.6	89.0	**42.0**
Fuel flow rate, lb/h	15.2	12.8	9.21	5.75	9.6	7.41	5.59	1.33	**3.91**
Engine speed, rpm	3000	3000	3000	3000	1900	1900	1900	1092	**2384**
Engine torque, lb-ft	53.2	44.6	26.6	5.60	63.6	47.0	31.6	0.00	**33.4**
Power output, hp	30.4	25.5	15.2	3.20	23.0	17.0	11.4	0.00	**16.12**
Air inlet temp, deg. F	84	85	86	90	84	84	84	84	**85**
Humidity, grains/lb	78	73	75	93	78	76	76	77	**77**
HC ppmc, wet	255	195	265	2022	300	560	555	202	**481**
CO ppm, wet	278	239	397	832	217	304	233	273	**337**
CO2 %, wet	8.61	7.48	5.25	3.03	8.85	6.83	5.09	2.28	**5.92**
NOx ppm, wet	249	211	128	55	350	349	288	248	**229**
O2 %, wet	7.47	9.25	12.56	15.78	7.05	10.03	12.72	16.94	**11.49**
RAW ISO 8178-C1									
THC, g/h	20.5	15.1	20.9	159.8	14.8	27.4	27.4	5.3	**32.2**
THC, g/hp-h	0.67	0.59	1.38	49.9	0.64	1.61	2.40		**2.00**
CH4, g/h									
CH4, g/hp-h									
RHC, g/h									
RHC, g/hp-h									
CO, g/h	45	37.4	63.3	132.6	22	30.0	23.2	14.4	**44.7**
CO, g/hp-h	1.48	1.47	4.17	41.5	0.9	1.77	2.03		**2.77**
NOx, g/h	71	58	36	16	61	61	51	23.5	**47**
NOx, g/hp-h	2.33	2.27	2.36	5.1	2.66	3.58	4.5		**2.92**
CO2, g/h	21882	18423	13166	7587	13840	10590	7960	1890	**12302**
CO2, g/hp-h	720	723	867	2372	602	623	696		**763**
Fuel, lb/h	15.2	12.8	9.21	5.75	9.6	7.41	5.59	1.33	**8.62**
Fuel, lb/hp-h	0.50	0.50	0.61	1.80	0.42	0.44	0.49		**0.53**
DILUTE PARTICULATE									
PM, g/h	8.7	4.9	5.8	46.0	8	4.8	5.3	1.17	**9.5**
PM, g/hp-h	0.29	0.19	0.38	14.4	0.34	0.28	0.47		**0.59**

APPENDIX E

50 HP WATER-COOLED DIESEL ENGINE (KUBOTA V2203DI-B) BASELINE AND 6° RETARD EMISSION TEST RESULTS (ISO 8178-C1)

- 50HPDI-1 (BASELINE)
- 50HPDI-2 (BASELINE)
- 46HPDIR-1 (6° RETARD)
- 46HPDIR-2 (6° RETARD)

DIESEL ENGINE #/RUN # 50 HP DI-1	AVERAGE MODE 1	AVERAGE MODE 2	AVERAGE MODE 3	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 11	WEIGHTED 8178-C1
Weighting factor	15%	15%	15%	10%	10%	10%	10%	15%	
Air/fuel ratio	21.9	29.8	40.3	83.4	17.6	24.9	37.7	132.7	**50.1**
Fuel flow rate, lb/h	16.6	12.3	9.13	4.15	12.1	8.91	5.93	0.90	**4.06**
Engine speed, rpm	2601	2599	2600	2598	1599	1602	1600	858	**2039**
Engine torque, lb-ft	93.2	69.1	46.2	9.00	110.2	83.0	54.8	2.20	**57.3**
Power output, hp	46.2	34.2	22.9	4.45	33.6	25.3	16.7	0.36	**23.54**
Air inlet temp, deg. F	81	82	80	82	82	79	79	77	**80**
Humidity, grains/lb	92	92	93	91	89	102	117	97	**96**
HC ppmc, wet	605	605	725	868	635	573	685	681	**669**
CO ppm, wet	525	476	547	584	7055	441	287	584	**1157**
CO2 %, wet	9.05	6.70	4.95	2.34	10.49	8.00	5.33	1.44	**5.94**
NOx ppm, wet	913	724	498	161	1274	1426	971	278	**745**
O2 %, wet	6.53	10.09	12.73	16.56	3.39	8.11	12.11	17.96	**11.11**
RAW ISO 8178-C1									
THC, g/h	50.1	50.0	59.4	66.1	31.1	28.8	34.1	17.8	**42.6**
THC, g/hp-h	1.09	1.46	2.60	14.8	0.93	1.14	2.04		**1.81**
CH4, g/h	0.25	0.35	0.52	0.53	1.34	0.20	0.17	0.25	**0.43**
CH4, g/hp-h	0.01	0.01	0.02	0.12	0.04	0.01	0.01		**0.02**
RHC, g/h	49.9	49.6	58.9	65.5	29.8	28.6	33.9	17.5	**42.2**
RHC, g/hp-h	1.08	1.45	2.58	14.7	0.89	1.13	2.03		**1.79**
CO, g/h	88	79.3	90.4	89.7	697	44.7	28.8	30.7	**129.2**
CO, g/hp-h	1.90	2.32	3.95	20.1	20.8	1.76	1.73		**5.49**
NOx, g/h	276	223	156	47	222	271	199	29.7	**176**
NOx, g/hp-h	5.97	6.52	6.81	10.6	6.61	10.69	11.9		**7.50**
CO2, g/h	23775	17549	12873	5649	16286	12737	8421	1191	**12617**
CO2, g/hp-h	515	513	563	1269	485	503	504		**536**
Fuel, lb/h	16.6	12.3	9.13	4.15	12.1	8.91	5.93	0.90	**8.96**
Fuel, lb/hp-h	0.36	0.36	0.40	0.93	0.36	0.35	0.36		**0.38**
DILUTE PARTICULATE									
PM, g/h	16.7	9.4	9.7	10.1	55	6.7	4.9	1.95	**13.4**
PM, g/hp-h	0.36	0.28	0.43	2.3	1.65	0.26	0.29		**0.57**

DIESEL ENGINE #/RUN # 50HP D1-2	AVERAGE MODE 1	AVERAGE MODE 2	AVERAGE MODE 3	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 11	WEIGHTED 8178-C1
Weighting factor	15%	15%	15%	10%	10%	10%	10%	15%	
Air/fuel ratio	21.9	30.5	40.6	88.6	17.5	25.5	37.2	128.3	**50.1**
Fuel flow rate, lb/h	15.9	12.1	8.98	4.14	12.4	8.75	6.15	0.89	**4.00**
Engine speed, rpm	2599	2604	2598	2601	1601	1598	1598	850	**2037**
Engine torque, lb-ft	92.4	68.8	46.2	9.20	110.0	82.4	55.2	1.60	**57.0**
Power output, hp	45.7	34.1	22.9	4.56	33.5	25.1	16.8	0.26	**23.44**
Air inlet temp, deg. F	83	79	78	78	80	81	80	78	**80**
Humidity, grains/lb	106	86	88	89	89	89	89	89	**91**
HC ppmc, wet	515	513	670	852	615	482	588	760	**623**
CO ppm, wet	617	414	512	595	7501	398	276	651	**1206**
CO2 %, wet	9.05	6.58	4.93	2.20	10.56	7.83	5.41	1.48	**5.90**
NOx ppm, wet	664	731	515	149	1320	1441	994	309	**723**
O2 %, wet	6.68	10.41	12.83	16.78	3.43	8.37	12.00	17.86	**11.23**
RAW ISO 8178-C1									
THC, g/h	40.8	42.5	54.4	68.7	30.5	24.3	30.0	19.1	**38.9**
THC, g/hp-h	0.89	1.25	2.38	15.1	0.91	0.97	1.79		**1.66**
CH4, g/h	0.33	0.40	0.52	0.57	1.46	0.17	0.15	0.15	**0.44**
CH4, g/hp-h	0.01	0.01	0.02	0.13	0.04	0.01	0.01		**0.02**
RHC, g/h	40.4	42.1	53.9	68.1	29.0	24.1	29.9	19.0	**38.4**
RHC, g/hp-h	0.88	1.23	2.36	15.0	0.87	0.96	1.78		**1.64**
CO, g/h	98	69.1	83.9	96.7	750	40.5	28.4	33.0	**134.2**
CO, g/hp-h	2.15	2.03	3.67	21.2	22.4	1.62	1.69		**5.73**
NOx, g/h	197	223	158	47	232	266	191	30.7	**165**
NOx, g/hp-h	4.31	6.55	6.94	10.3	6.91	10.62	11.4		**7.04**
CO2, g/h	22724	17274	12686	5618	16600	12522	8752	1180	**12429**
CO2, g/hp-h	497	506	555	1233	495	499	521		**530**
Fuel, lb/h	15.9	12.1	8.98	4.14	12.4	8.75	6.15	0.89	**8.82**
Fuel, lb/hp-h	0.35	0.35	0.39	0.91	0.37	0.35	0.37		**0.38**
DILUTE PARTICULATE									
PM, g/h	15.7	9.7	10.2	10.2	62	5.6	3.9	2.38	**13.9**
PM, g/hp-h	0.34	0.28	0.45	2.2	1.86	0.22	0.23		**0.59**

DIESEL ENGINE #/RUN # 46 HP DI-1 6 DEG. RET.	AVERAGE MODE 1	AVERAGE MODE 2	AVERAGE MODE 3	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 11	WEIGHTED 8178-C1
Weighting factor	15%	15%	15%	10%	10%	10%	10%	15%	
Air/fuel ratio	21.7	28.7	40.5	84.3	17.4	25.5	37.9	139.3	**51.1**
Fuel flow rate, lb/h	17.2	12.9	9.41	4.47	13.2	9.07	6.26	0.91	**4.25**
Engine speed, rpm	2600	2600	2600	2600	1600	1600	1600	870	**2041**
Engine torque, lb-ft	91.6	68.6	45.6	9.00	112	84.2	56.2	0.00	**57.1**
Power output, hp	45.3	34.0	22.6	4.46	34.2	25.7	17.1	0.00	**23.4**
Air inlet temp, deg. F	79	80	80	79	81	82	80	79	**80**
Humidity, grains/lb	102	98	101	97	95	95	93	94	**97**
HC ppmc, wet	555	645	750	1078	660	525	585	622	**671**
CO ppm, wet	723	571	630	671	5771	322	353	393	**1059**
CO2 %, wet	9.11	6.94	4.92	2.28	10.8	7.83	5.30	1.39	**5.97**
NOx ppm, wet	628	498	335	98.5	942	945	688	244	**523**
O2 %, wet	6.31	9.78	12.7	16.7	2.92	8.18	12.0	17.9	**11.0**
RAW ISO 8178-C1									
THC, g/h	47.1	53.8	63.7	89.3	34.9	27.5	31.0	17.3	**45.6**
THC, g/hp-h	1.04	1.59	2.82	20.0	1.02	1.07	1.81		**1.94**
CH4, g/h									
CH4, g/hp-h									
RHC, g/h									
RHC, g/hp-h									
CO, g/h	124	96.1	108	112	615	34.0	37.6	22.0	**132**
CO, g/hp-h	2.73	2.83	4.78	25.1	18.0	1.33	2.20		**5.65**
NOx, g/h	198	158	112	32.7	178	184	139	27.2	**127**
NOx, g/hp-h	4.37	4.64	4.94	7.35	5.20	7.16	8.11		**5.44**
CO2, g/h	24523	18369	13246	5997	18065	12980	8894	1229	**13199**
CO2, g/hp-h	541	541	587	1346	528	506	519		**563**
Fuel, lb/h	17.2	12.9	9.41	4.47	13.2	9.07	6.26	0.91	**9.37**
Fuel, lb/hp-h	0.38	0.38	0.42	1.00	0.39	0.35	0.37		**0.40**
DILUTE PARTICULATE									
PM, g/h	19.0	10.0	9.56	12.5	97.1	7.13	3.47	1.56	**18.0**
PM, g/hp-h	0.42	0.29	0.42	2.81	2.84	0.28	0.20		**0.77**

DIESEL ENGINE #/RUN # 46 HP DI-2 6 DEG. RET.	AVERAGE MODE 1	AVERAGE MODE 2	AVERAGE MODE 3	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 11	WEIGHTED 8178-C1
Weighting factor	15%	15%	15%	10%	10%	10%	10%	15%	
Air/fuel ratio	21.6	29.8	41.4	83.6	17.6	26.1	38.5	139.5	**51.4**
Fuel flow rate, lb/h	17.2	12.8	9.32	4.35	13.3	9.03	6.09	0.89	**4.22**
Engine speed, rpm	2600	2600	2600	2600	1600	1600	1600	870	**2041**
Engine torque, lb-ft	91.6	68.4	45.8	9.20	113	84.4	56.4	0.00	**57.2**
Power output, hp	45.3	33.9	22.7	4.55	34.4	25.7	17.2	0.00	**23.5**
Air inlet temp, deg. F	78	79	78	78	79	80	79	78	**79**
Humidity, grains/lb	101	101	100	102	101	101	98	98	**100**
HC ppmc, wet	575	685	775	1103	640	536	595	626	**687**
CO ppm, wet	723	573	607	658	5869	304	351	372	**1059**
CO2 %, wet	9.17	6.70	4.82	2.30	10.6	7.67	5.23	1.39	**5.90**
NOx ppm, wet	598	444	303	96.0	965	963	662	234	**505**
O2 %, wet	6.25	10.0	12.9	16.7	2.95	8.33	12.1	17.9	**11.1**
RAW ISO 8178-C1									
THC, g/h	48.4	58.8	66.5	88.3	34.4	28.5	31.1	17.1	**46.9**
THC, g/hp-h	1.07	1.74	2.93	19.4	1.00	1.11	1.81		**2.00**
CH4, g/h									
CH4, g/hp-h									
RHC, g/h									
RHC, g/hp-h									
CO, g/h	123	99.1	105	106	637	32.5	36.9	20.5	**133**
CO, g/hp-h	2.71	2.93	4.63	23.3	18.5	1.27	2.15		**5.68**
NOx, g/h	186	146	102	31.7	187	193	134	26.2	**124**
NOx, g/hp-h	4.11	4.32	4.50	6.95	5.44	7.53	7.80		**5.27**
CO2, g/h	24490	18244	13102	5843	18150	12922	8656	1205	**13113**
CO2, g/hp-h	540	539	578	1283	528	503	504		**559**
Fuel, lb/h	17.2	12.8	9.32	4.35	13.3	9.03	6.09	0.89	**9.31**
Fuel, lb/hp-h	0.38	0.38	0.41	0.96	0.39	0.35	0.35		**0.40**
DILUTE PARTICULATE									
PM, g/h	19.9	10.4	9.84	12.2	93.4	6.94	3.65	1.24	**17.8**
PM, g/hp-h	0.44	0.31	0.43	2.69	2.72	0.27	0.21		**0.76**

APPENDIX F

8.5 HP GOLF CAR ENGINE (FUJI FE290)
BASELINE EMISSION TEST RESULTS
(J1088)

- **Golf 1**
- **Golf 2**

Engine # / run # GOLF 1	AVERAGE MODE 3	AVERAGE MODE 4	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 1	WEIGHTED J1088
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	14.3	14.9	13.4	12.0	12.9	13.5	**13.3**
Fuel flow rate, lb/h	2.76	2.23	1.84	1.61	1.18	0.54	**1.82**
Engine speed, rpm	2545	2556	2554	2551	2538	1507	**2499**
Engine torque, lb–ft	10.26	7.73	5.15	2.62	0.63	0.01	**4.79**
Power output, hp	4.97	3.76	2.50	1.27	0.31	0.00	**2.33**
Air inlet temp, F	76	78	78	77	78	80	**78**
Humidity, grains/lb	99	102	102	99	98	101	**100**
HC ppmc wet	2287	2267	3127	3790	3203	9660	**3410**
CO % wet	1.00	0.44	1.96	4.83	3.07	1.80	**2.50**
CO2 % wet	12.3	12.4	12.0	10.3	11.2	11.4	**11.5**
NOx ppm wet	1766	1640	567	104	86.3	36.7	**691**
O2 % wet	0.85	1.13	0.48	0.39	0.40	1.15	**0.65**
J1088 RESULTS							
THC, g/h	21.2	17.6	18.3	17.8	11.7	16.7	**17.8**
THC, g/hp–h	4.27	4.67	7.33	14.0	38.6		**7.62**
CH4, g/h	0.79	0.42	0.85	1.42	1.01	0.49	**0.92**
CH4, g/hp–h	0.16	0.11	0.34	1.12	3.30		**0.40**
RHC, g/h	20.4	17.2	17.5	16.4	10.7	16.2	**16.8**
RHC, g/hp–h	4.11	4.56	6.99	12.9	35.1		**7.22**
CO, g/h	188	69.2	233	459	228	62.9	**255**
CO, g/hp–h	37.8	18.4	92.9	361	748		**109**
NOx, g/h	61.2	48.4	12.7	1.83	1.18	0.24	**19.5**
NOx, g/hp–h	12.3	12.9	5.07	1.44	3.86		**8.37**
CO2, g/h	3614	3049	2230	1533	1307	623	**2164**
CO2, g/hp–h	727	810	891	1205	4289		**929**
Fuel, lb/h	2.76	2.23	1.84	1.61	1.18	0.54	**1.82**
Fuel, lb/hp–h	0.56	0.59	0.74	1.26	3.88		**0.78**
DILUTE PARTICULATE							
PM, g/h	0.94	0.40	0.36	0.29	0.13	0.08	**0.37**
PM, g/hp–h	0.19	0.11	0.14	0.23	0.38		**0.16**

Engine # / run # GOLF 2	AVERAGE MODE 3	AVERAGE MODE 4	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 1	WEIGHTED J1088
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	14.3	15.1	13.5	12.0	12.9	13.6	**13.4**
Fuel flow rate, lb/h	2.72	2.20	1.84	1.55	1.20	0.50	**1.79**
Engine speed, rpm	2544	2553	2551	2552	2552	1462	**2497**
Engine torque, lb-ft	10.30	7.69	5.17	2.59	0.62	0.08	**4.79**
Power output, hp	4.99	3.74	2.51	1.26	0.30	0.02	**2.32**
Air inlet temp, F	75	76	76	76	76	78	**76**
Humidity, grains/lb	102	100	101	102	102	107	**101**
HC ppmc wet	2413	2093	3103	3900	2657	9060	**3345**
CO % wet	0.97	0.37	2.10	4.81	3.20	1.72	**2.52**
CO2 % wet	12.3	12.3	11.7	10.2	11.2	11.4	**11.4**
NOx ppm wet	1959	1580	507	101	85.3	36.2	**678**
O2 % wet	0.72	1.21	0.45	0.39	0.38	1.17	**0.64**
J1088 RESULTS							
THC, g/h	22.0	16.2	18.3	17.8	9.8	14.7	**17.3**
THC, g/hp-h	4.41	4.34	7.30	14.1	32.9		**7.44**
CH4, g/h	0.72	0.38	0.88	1.40	1.02	0.45	**0.91**
CH4, g/hp-h	0.14	0.10	0.35	1.11	3.42		**0.39**
RHC, g/h	21.3	15.8	17.4	16.4	8.8	14.2	**16.4**
RHC, g/hp-h	4.26	4.24	6.95	13.0	29.3		**7.05**
CO, g/h	178	58	250	443	239	56.2	**253**
CO, g/hp-h	35.7	15.4	100	352	800		**109**
NOx, g/h	67.7	46.1	11.3	1.76	1.20	0.23	**19.2**
NOx, g/hp-h	13.6	12.3	4.52	1.39	4.03		**8.27**
CO2, g/h	3560	3028	2200	1481	1317	585	**2129**
CO2, g/hp-h	713	810	877	1175	4418		**916**
Fuel, lb/h	2.72	2.20	1.84	1.55	1.20	0.50	**1.79**
Fuel, lb/hp-h	0.54	0.59	0.73	1.23	4.01		**0.77**
DILUTE PARTICULATE							
PM, g/h	0.81	0.39	0.38	0.26	0.16	0.10	**0.36**
PM, g/hp-h	0.16	0.11	0.15	0.21	0.60		**0.15**

APPENDIX G

40 HP LPG LIFT TRUCK ENGINE (TOYOTA 4Y)
BASELINE, EGR, AND EMA/ITA CYCLE EMISSION TEST RESULTS

- **Lift 1 (Baseline, ISO 8178-G1)**
- **Lift 2 (Baseline, ISO 8178-G1)**
- **Lift 1-EGR (EGR, ISO 8178-G1)**
- **Lift 2-EGR (EGR, ISO 8178-G1)**
- **Lift 1-EMA (Baseline, EMA/ITA Proposed Cycle)**
- **Lift 2-EMA (Baseline, EMA/ITA Proposed Cycle)**

Engine # / run # LIFT 1	AVERAGE MODE 3	AVERAGE MODE 4	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 1	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	16.2	16.1	17.6	16.3	15.6	14.7	16.5
Fuel flow rate, lb/h	15.29	12.33	8.36	6.20	4.47	2.08	8.54
Engine speed, rpm	2041	2040	2041	2043	2042	1036	1991
Engine torque, lb-ft	96.3	72.2	47.4	24.3	9.53	0.00	44.8
Power output, hp	37.4	28.0	18.4	9.47	3.71	0.00	17.4
Air inlet temp, F	85	91	88	95	96	88	91
Humidity, grains/lb	107	92	91	107	106	96	99
HC ppmc wet	400	420	367	637	547	1050	508
CO % wet	0.11	0.05	0.05	0.05	0.10	1.08	0.11
CO2 % wet	11.1	11.2	10.3	11.1	11.4	11.0	10.9
NOx ppm wet	3074	2571	2002	1950	747.1	38.9	2011
O2 % wet	0.78	0.56	1.93	1.19	0.71	0.32	1.16
RAW ISO 8178-G1							
THC, g/h	24.7	20.8	13.4	16.0	9.58	8.13	16.1
THC, g/hp-h	0.66	0.74	0.73	1.69	2.58		0.93
CH4, g/h	0.38	0.79	0.26	0.36	0.47	1.11	0.46
CH4, g/hp-h	0.01	0.03	0.01	0.04	0.13		0.03
RHC, g/h	24.3	20.0	13.1	15.7	9.11	7.0	15.7
RHC, g/hp-h	0.65	0.71	0.71	1.66	2.46		0.90
CO, g/h	130	50.7	34.7	24.5	32.3	159.4	49.5
CO, g/hp-h	3.48	1.81	1.88	2.59	8.70		2.84
NOx, g/h	699	432	247	180	47.9	1.04	278
NOx, g/hp-h	18.7	15.4	13.4	19.1	12.9		16.0
CO2, g/h	20469	16582	11247	8327	5991	2547	11465
CO2, g/hp-h	547	591	611	880	1617		658
Fuel, lb/h	15.3	12.3	8.36	6.20	4.47	2.08	8.54
Fuel, lb/hp-h	0.41	0.44	0.45	0.66	1.21		0.49
DILUTE PARTICULATE							
PM, g/h	0.83	0.45	0.29	0.44	0.36	0.37	0.42
PM, g/hp-h	0.02	0.02	0.02	0.05	0.09		0.02

Engine # / run # LIFT 2	AVERAGE MODE 3	AVERAGE MODE 4	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 1	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	15.5	15.3	16.1	15.7	15.2	14.1	**15.6**
Fuel flow rate, lb/h	15.22	12.52	9.02	6.35	4.47	1.79	**8.80**
Engine speed, rpm	2040	2041	2041	2040	2043	1043	**1991**
Engine torque, lb-ft	96.13	72.33	46.67	24.73	9.40	0.00	**44.73**
Power output, hp	37.35	28.11	18.14	9.61	3.66	0.00	**17.38**
Air inlet temp, F	89	97	100	103	104	99	**100**
Humidity, grains/lb	110	108	106	105	103	106	**107**
HC ppmc wet	357	399	370	583	630	1223	**499**
CO % wet	0.12	0.05	0.04	0.05	0.16	1.54	**0.14**
CO2 % wet	11.6	11.7	11.2	11.4	11.6	10.9	**11.4**
NOx ppm wet	2802	2553	2316	2547	897.5	48.5	**2264**
O2 % wet	0.74	0.63	1.38	1.16	0.49	0.32	**0.99**
RAW ISO 8178-G1							
THC, g/h	21.0	19.2	13.4	14.5	10.8	7.87	**15.1**
THC, g/hp-h	0.56	0.68	0.74	1.51	2.94		**0.87**
CH4, g/h	1.06	0.79	0.34	0.39	0.86	1.36	**0.60**
CH4, g/hp-h	0.03	0.03	0.02	0.04	0.23		**0.03**
RHC, g/h	20.0	18.4	13.1	14.1	9.9	6.50	**14.5**
RHC, g/hp-h	0.53	0.65	0.72	1.47	2.71		**0.84**
CO, g/h	139	43.2	29.5	24.9	51.8	188	**50.3**
CO, g/hp-h	3.73	1.54	1.63	2.59	14.2		**2.89**
NOx, g/h	617	455	308	232	55.3	1.14	**309**
NOx, g/hp-h	16.5	16.2	17.0	24.1	15.1		**17.8**
CO2, g/h	20375	16857	12157	8528	5945	2107	**11811**
CO2, g/hp-h	546	600	670	888	1626		**680**
Fuel, lb/h	15.2	12.5	9.02	6.35	4.47	1.79	**8.80**
Fuel, lb/hp-h	0.41	0.45	0.50	0.66	1.22		**0.51**
DILUTE PARTICULATE							
PM, g/h	0.23	0.21	0.17	0.27	0.36	0.31	**0.23**
PM, g/hp-h	0.01	0.01	0.01	0.03	0.10		**0.01**

Engine # / run # LIFT 1–EGR	AVERAGE MODE 3	AVERAGE MODE 4	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 1	WEIGHTED 8178–G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	16.0	16.3	17.2	16.6	15.7	14.3	**16.5**
Fuel flow rate, lb/h	15.10	12.67	9.96	6.39	4.38	1.88	**9.10**
Engine speed, rpm	2037	2038	2040	2040	2040	710	**1973**
Engine torque, lb–ft	90.4	69.4	47.6	23.8	8.20	0.00	**43.5**
Power output, hp	35.1	26.9	18.5	9.24	3.19	0.00	**16.9**
Air inlet temp, F	92	102	102	102	105	91	**101**
Humidity, grains/lb	107	97	94	92	90	83	**94**
HC ppmc wet	512	497	520	1025	1025	9000	**1125**
CO % wet	0.23	0.05	0.05	0.07	0.30	1.97	**0.18**
CO2 % wet	11.0	11.0	10.5	10.7	11.1	9.4	**10.7**
NOx ppm wet	1550	891	411	122	120.3	19.5	**483**
O2 % wet	0.45	0.43	1.41	1.00	0.24	1.29	**0.92**
RAW ISO 8178–G1							
THC, g/h	31.0	25.7	22.2	27.2	17.72	62.28	**26.9**
THC, g/hp–h	0.88	0.96	1.20	2.94	5.56		**1.59**
CH4, g/h							
CH4, g/hp–h							
RHC, g/h							
RHC, g/hp–h							
CO, g/h	265	51.2	39.3	34.1	97.1	259.3	**75.5**
CO, g/hp–h	7.57	1.90	2.13	3.69	30.49		**4.47**
NOx, g/h	345	161	60	11	7.0	0.44	**85**
NOx, g/hp–h	9.8	6.0	3.3	1.2	2.2		**5.0**
CO2, g/h	19984	17038	13382	8529	5740	1955	**12145**
CO2, g/hp–h	570	633	724	923	1802		**719**
Fuel, lb/h	15.1	12.7	9.96	6.39	4.38	1.88	**9.10**
Fuel, lb/hp–h	0.43	0.47	0.54	0.69	1.38		**0.54**

Engine # / run # LIFT 2-EGR	AVERAGE MODE 3	AVERAGE MODE 4	AVERAGE MODE 5	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 1	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	16.1	16.4	17.5	16.9	15.9	14.3	**16.7**
Fuel flow rate, lb/h	14.72	12.84	9.33	6.39	4.60	2.16	**8.94**
Engine speed, rpm	2039	2039	2040	2039	2041	713	**1973**
Engine torque, lb-ft	91.5	69.9	47.9	23.9	8.20	0.00	**43.8**
Power output, hp	35.5	27.1	18.6	9.26	3.19	0.00	**17.0**
Air inlet temp, F	86	89	88	91	89	87	**89**
Humidity, grains/lb	73	85	89	81	92	88	**84**
HC ppmc wet	467	453	553	1048	918	9250	**1134**
CO % wet	0.17	0.05	0.05	0.07	0.19	1.82	**0.16**
CO2 % wet	11.0	11.0	10.3	10.6	11.1	9.6	**10.6**
NOx ppm wet	1534	953	434	148	109.5	18.9	**508**
O2 % wet	0.53	0.65	1.56	1.11	0.33	1.48	**1.06**
RAW ISO 8178-G1							
THC, g/h	27.8	23.9	22.5	28.3	16.82	73.39	**27.1**
THC, g/hp-h	0.78	0.88	1.21	3.05	5.28		**1.59**
CH4, g/h							
CH4, g/hp-h							
RHC, g/h							
RHC, g/hp-h							
CO, g/h	197	45.8	39.0	34.1	66.2	275.0	**66.8**
CO, g/hp-h	5.54	1.69	2.10	3.68	20.78		**3.92**
NOx, g/h	282	165	59	13	6.8	0.50	**80**
NOx, g/hp-h	7.9	6.1	3.2	1.4	2.1		**4.7**
CO2, g/h	19583	17274	12531	8531	6090	2279	**11951**
CO2, g/hp-h	551	636	674	921	1911		**702**
Fuel, lb/h	14.7	12.8	9.33	6.39	4.60	2.16	**8.94**
Fuel, lb/hp-h	0.41	0.47	0.50	0.69	1.44		**0.53**

Engine # / run # LIFT 1 – EMA	AVERAGE MODE 4	AVERAGE MODE 6	AVERAGE MODE 8	AVERAGE MODE 9	AVERAGE MODE 10	AVERAGE MODE 11	AVERAGE MODE 7	WEIGHTED EMA Cycle
Weighting Factor	6%	2%	32%	30%	10%	15%	5%	
Air/fuel ratio	16.3	15.1	16.6	16.1	15.3	14.7	17.3	**16.0**
Fuel flow rate, lb/h	7.07	14.00	8.39	5.50	4.27	2.08	10.7	**6.31**
Engine speed, rpm	2400	1800	1800	1800	1804	1036	1800	**1722**
Engine torque, lb–ft	21.4	97.2	48.8	24.2	10.4	0.00	72.8	**30.8**
Power output, hp	9.78	33.3	16.7	8.29	3.57	0.00	25.0	**10.7**
Air inlet temp, F	106	93	98	100	99	88	99	**97.7**
Humidity, grains/lb	111	109	105	106	101	96	87	**103**
HC ppmc wet	527	503	430	610	757	1050	510	**621**
CO % wet	0.07	0.64	0.05	0.05	0.31	1.08	0.04	**0.24**
CO2 % wet	11.0	11.2	10.9	11.2	11.4	11.0	10.4	**11.0**
NOx ppm wet	1955	2035	1880	1491	523.1	38.9	2300	**1380**
O2 % wet	1.15	0.35	1.25	0.96	0.37	0.32	0.63	**0.88**
EMA RESULTS								
THC, g/h	15.1	26.9	14.9	13.5	12.41	8.13	23.5	**13.9**
THC, g/hp–h	1.55	0.81	0.89	1.63	3.47		0.94	**1.30**
CH4, g/h								
CH4, g/hp–h								
RHC, g/h								
RHC, g/hp–h								
CO, g/h	38.7	653	32.7	23.0	97.8	159	36.8	**68.3**
CO, g/hp–h	3.96	19.6	1.96	2.78	27.4		1.47	**6.38**
NOx, g/h	211	404	237	121	30.6	1.04	352	**154**
NOx, g/hp–h	21.6	12.1	14.2	14.6	8.57		14.1	**14.4**
CO2, g/h	9487	17895	11288	7380	5603	2547	14362	**8414**
CO2, g/hp–h	970	537	675	890	1568		576	**786**
Fuel, lb/h	7.07	14.0	8.39	5.50	4.27	2.08	10.7	**6.31**
Fuel, lb/hp–h	0.72	0.42	0.50	0.66	1.20		0.43	**0.59**

Engine # / run # LIFT 2 – EMA	AVERAGE MODE 4	AVERAGE MODE 6	AVERAGE MODE 8	AVERAGE MODE 9	AVERAGE MODE 10	AVERAGE MODE 11	AVERAGE MODE 7	WEIGHTED EMA Cycle
Weighting Factor	6%	2%	32%	30%	10%	15%	5%	
Air/fuel ratio	17.0	16.1	17.2	16.5	15.8	14.1	17.3	**16.4**
Fuel flow rate, lb/h	5.13	11.41	7.09	5.06	3.89	1.79	10.8	**5.52**
Engine speed, rpm	2400	1800	1800	1800	1806	1043	1800	**1723**
Engine torque, lb–ft	21.2	95.0	48.8	25.0	11.0	0.00	72.8	**31.0**
Power output, hp	9.69	32.6	16.7	8.57	3.78	0.00	25.0	**10.8**
Air inlet temp, F	102	95	93	97	95	99	102	**96.3**
Humidity, grains/lb	105	101	95	93	93	106	86	**96**
HC ppmc wet	467	360	360	520	657	1223	512	**581**
CO % wet	0.06	0.16	0.04	0.06	0.17	1.54	0.04	**0.29**
CO2 % wet	10.6	11.0	10.5	10.9	11.2	10.9	10.4	**10.8**
NOx ppm wet	1761	2501	2053	1681	639	48.5	2277	**1502**
O2 % wet	1.62	0.87	1.82	1.11	0.47	0.32	0.61	**1.16**
EMA RESULTS								
THC, g/h	10.1	16.6	10.9	10.9	10.1	7.87	24.0	**11.1**
THC, g/hp–h	1.05	0.51	0.65	1.27	2.68		0.96	**1.03**
CH4, g/h								
CH4, g/hp–h								
RHC, g/h								
RHC, g/hp–h								
CO, g/h	25.8	138	25.8	24.1	50.9	188	37.8	**55.0**
CO, g/hp–h	2.67	4.23	1.54	2.81	13.4		1.52	**5.10**
NOx, g/h	139	411	215	120	33.6	1.14	351	**142**
NOx, g/hp–h	14.3	12.6	12.9	14.0	8.89		14.1	**13.2**
CO2, g/h	6896	15222	9540	6796	5163	2107	14570	**7371**
CO2, g/hp–h	712	468	570	793	1365		584	**684**
Fuel, lb/h	5.13	11.4	7.09	5.06	3.89	1.79	10.8	**5.52**
Fuel, lb/hp–h	0.53	0.35	0.42	0.59	1.03		0.43	**0.51**

APPENDIX H

60 HP SPARK-IGNITED UTILITY ENGINE (TELEDYNE TM27) GASOLINE, LPG AND CNG-FUELED EMISSION TEST RESULTS (ISO 8178-G1)

- 60HPSI-1 (Gasoline Baseline)
- 60HPSI-2 (Gasoline Baseline)
- 60HPSI LPG-1 (LPG)
- 60HPSI LPG-2 (LPG)
- 60HPSI CNG-1 (CNG)
- 60HPSI CNG-2 (CNG)

Engine # / run #	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	WEIGHTED
60 HP SI-1 (gasoline)	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	13.6	13.1	12.9	13.0	12.9	11.2	**12.9**
Fuel flow rate, lb/h	30.1	25.2	18.9	12.3	9.78	2.22	**17.7**
Engine speed, rpm	2550	2550	2550	2550	2550	822	**2464**
Engine torque, lb-ft	125	94.0	62.6	31.4	15.40	0.00	**58.7**
Power output, hp	60.7	45.6	30.4	15.25	7.48	0.00	**28.5**
Air inlet temp, F	90	97	99	94	97	100	**96**
Humidity, grains/lb	123	123	123	122	122	124	**123**
HC ppmc wet	855	945	985	1293	1413	4417	**1259**
CO % wet	2.53	3.31	3.49	3.50	3.67	6.82	**3.55**
CO2 % wet	11.4	11.0	11.1	10.9	10.8	8.96	**10.9**
NOx ppm wet	1259	963	1081	842	504	32.4	**909**
O2 % wet	0.05	0.04	0.06	0.07	0.09	0.75	**0.10**
RAW ISO 8178-G1							
THC, g/h	83.5	75.0	57.4	49.7	42.8	27.4	**58.4**
THC, g/hp-h	1.38	1.64	1.89	3.26	5.72		**2.05**
CH4, g/h	15.3	13.1	9.15	7.32	6.57	6.14	**9.60**
CH4, g/hp-h	0.25	0.29	0.30	0.48	0.88		**0.34**
RHC, g/h	68.2	62.0	48.2	42.4	36.2	21.2	**48.8**
RHC, g/hp-h	1.12	1.36	1.59	2.78	4.85		**1.71**
CO, g/h	4981	5298	4108	2717	2243	853	**3714**
CO, g/hp-h	82.1	116	135	178	300		**130**
NOx, g/h	527	328	270	138	65.1	0.86	**237**
NOx, g/hp-h	8.69	7.18	8.88	9.05	8.71		**8.33**
CO2, g/h	35230	27674	20497	13311	10404	1760	**19459**
CO2, g/hp-h	580	606	674	873	1391		**683**
Fuel, lb/h	30.1	25.2	18.9	12.3	9.78	2.22	**17.7**
Fuel, lb/hp-h	0.50	0.55	0.62	0.81	1.31		**0.62**
DILUTE PARTICULATE							
PM, g/h	0.63	0.18	0.35	0.47	0.28	0.33	**0.37**
PM, g/hp-h	0.01	0.00	0.01	0.03	0.04		**0.01**

Engine # / run #	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	WEIGHTED
60 HP SI-2 (gasoline)	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	13.6	13.2	13.3	13.0	13.1	11.1	**13.1**
Fuel flow rate, lb/h	29.6	24.0	17.9	11.3	9.07	2.53	**16.8**
Engine speed, rpm	2550	2550	2550	2550	2550	806	**2463**
Engine torque, lb-ft	125	93.8	62.4	31.6	16.4	0.00	**58.7**
Power output, hp	60.6	45.5	30.3	15.34	7.96	0.00	**28.5**
Air inlet temp, F	93	98	98	97	96	97	**97**
Humidity, grains/lb	129	123	121	120	117	115	**121**
HC ppmc wet	908	955	990	1273	1308	4764	**1272**
CO % wet	2.34	3.21	3.28	3.67	3.41	7.62	**3.52**
CO2 % wet	11.6	11.0	10.9	10.7	10.8	8.13	**10.8**
NOx ppm wet	1344	985	1128	821	561	25.4	**932**
O2 % wet	0.07	0.04	0.07	0.07	0.10	0.71	**0.10**
RAW ISO 8178-G1							
THC, g/h	86.8	72.6	56.4	45.0	37.4	33.8	**56.5**
THC, g/hp-h	1.43	1.60	1.86	2.93	4.70		**1.98**
CH4, g/h	15.5	12.8	9.47	6.85	5.91	9.35	**9.65**
CH4, g/hp-h	0.26	0.28	0.31	0.45	0.74		**0.34**
RHC, g/h	71.3	59.8	46.9	38.1	31.5	24.4	**46.8**
RHC, g/hp-h	1.18	1.31	1.55	2.48	3.96		**1.64**
CO, g/h	4510	4931	3767	2618	1969	1090	**3463**
CO, g/hp-h	74.4	108	124	171	247		**121**
NOx, g/h	570	320	272	122	66.2	0.74	**235**
NOx, g/hp-h	9.41	7.03	8.99	7.93	8.32		**8.26**
CO2, g/h	35194	26534	19667	11957	9841	1826	**18545**
CO2, g/hp-h	581	583	649	779	1236		**651**
Fuel, lb/h	29.6	24.0	17.9	11.3	9.07	2.53	**16.8**
Fuel, lb/hp-h	0.49	0.53	0.59	0.73	1.14		**0.59**
DILUTE PARTICULATE							
PM, g/h	0.80	0.21	0.43	0.55	0.31	0.48	**0.45**
PM, g/hp-h	0.01	0.00	0.01	0.04	0.04		**0.02**

Engine # / run #	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	WEIGHTED
60 HP SI LPG-1	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	17.8	18.5	19.3	20.0	19.9	22.2	**19.4**
Fuel flow rate, lb/h	20.7	16.2	13.0	8.80	6.49	2.49	**12.1**
Engine speed, rpm	2550	2550	2550	2550	2550	760	**2461**
Engine torque, lb-ft	107	80.2	53.4	27.0	16.2	0.00	**50.4**
Power output, hp	52.0	38.9	25.9	13.1	7.87	0.00	**24.5**
Air inlet temp, F	94	94	94	94	93	94	**94**
Humidity, grains/lb	54	55	55	57	57	57	**56**
HC ppmc wet	227	198	210	230	256	3244	**370**
CO % wet	0.04	0.05	0.05	0.07	0.07	0.09	**0.06**
CO2 % wet	10.2	9.82	9.45	9.10	9.13	7.92	**9.39**
NOx ppm wet	3352	2706	2084	916	468	17.3	**1756**
O2 % wet	1.79	2.47	3.12	3.88	4.10	6.56	**3.34**
RAW ISO 8178-G1							
THC, g/h	20.7	14.7	13.0	10.0	8.16	44.0	**14.3**
THC, g/hp-h	0.40	0.38	0.50	0.76	1.04		**0.59**
CH4, g/h							
CH4, g/hp-h							
RHC, g/h							
RHC, g/hp-h							
CO, g/h	74.9	63.9	59.6	57.3	44.7	22.1	**58.3**
CO, g/hp-h	1.44	1.64	2.30	4.37	5.68		**2.38**
NOx, g/h	871	575	368	115	43.0	0.68	**338**
NOx, g/hp-h	16.8	14.8	14.2	8.76	5.47		**13.8**
CO2, g/h	27857	21851	17480	11822	8706	3214	**16263**
CO2, g/hp-h	536	561	674	902	1107		**665**
Fuel, lb/h	20.7	16.2	13.0	8.80	6.49	2.49	**12.1**
Fuel, lb/hp-h	0.40	0.42	0.50	0.67	0.82		**0.49**

Engine # / run #	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	WEIGHTED
60 HP SI LPG-2	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	17.8	18.2	18.5	18.8	19.1	22.3	**18.7**
Fuel flow rate, lb/h	21.1	18.0	14.2	9.28	6.55	1.65	**12.9**
Engine speed, rpm	2550	2550	2550	2550	2550	760	**2461**
Engine torque, lb-ft	107	80.4	53.6	26.6	16.4	0.00	**50.4**
Power output, hp	52.0	39.0	26.0	12.92	7.96	0.00	**24.5**
Air inlet temp, F	92	92	94	92	90	92	**92**
Humidity, grains/lb	56	51	55	52	57	56	**53**
HC ppmc wet	178	168	178	218	255	3493	**359**
CO % wet	0.04	0.04	0.05	0.06	0.07	0.10	**0.06**
CO2 % wet	10.2	10.0	9.82	9.67	9.50	7.83	**9.72**
NOx ppm wet	3835	3124	2050	844	370	15.5	**1844**
O2 % wet	1.79	2.58	3.19	3.93	4.32	6.89	**3.43**
RAW ISO 8178-G1							
THC, g/h	16.6	13.7	11.6	9.41	7.90	31.5	**12.5**
THC, g/hp-h	0.32	0.35	0.44	0.73	0.99		**0.51**
CH4, g/h							
CH4, g/hp-h							
RHC, g/h							
RHC, g/hp-h							
CO, g/h	72.1	65.7	62.2	51.4	42.2	17.0	**56.9**
CO, g/hp-h	1.39	1.68	2.39	3.98	5.29		**2.33**
NOx, g/h	1029	713	381	103	33.1	0.40	**379**
NOx, g/hp-h	19.8	18.3	14.6	7.94	4.16		**15.5**
CO2, g/h	28513	24330	19069	12484	8796	2111	**17428**
CO2, g/hp-h	548	623	733	967	1105		**712**
Fuel, lb/h	21.1	18.0	14.2	9.28	6.55	1.65	**12.9**
Fuel, lb/hp-h	0.41	0.46	0.54	0.72	0.82		**0.53**

Engine # / run # 60 HP SI CNG-1	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 9	AVERAGE MODE 10	AVERAGE MODE 11	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	19.9	20.7	21.2	20.9	19.1	14.4	**20.4**
Fuel flow rate, lb/h	20.1	15.5	11.9	8.04	6.07	2.58	**11.3**
Engine speed, rpm	2550	2550	2550	2550	2550	805	**2463**
Engine torque, lb-ft	97.4	73.0	49.0	24.4	9.60	0.00	**45.6**
Power output, hp	47.3	35.4	23.8	11.85	4.66	0.00	**22.1**
Air inlet temp, F	93	95	94	95	94	93	**94**
Humidity, grains/lb	87	83	84	85	86	88	**85**
HC ppmc wet	138	116	170	197	152	20181	**1164**
CO % wet	0.03	0.03	0.03	0.05	0.06	3.73	**0.23**
CO2 % wet	8.27	7.99	7.82	7.90	8.59	5.00	**7.83**
NOx ppm wet	1769	1351	1188	882	1373	25.7	**1136**
O2 % wet	2.39	2.97	3.26	2.85	1.20	4.12	**2.90**
RAW ISO 8178-G1							
THC, g/h	15.1	10.2	11.6	9.00	4.81	220	**20.8**
THC, g/hp-h	0.32	0.29	0.49	0.76	1.03		**0.94**
CH4, g/h							
CH4, g/hp-h							
RHC, g/h							
RHC, g/hp-h							
CO, g/h	64.2	51.8	40.5	40.6	32.4	713	**78.0**
CO, g/hp-h	1.36	1.46	1.70	3.43	6.95		**3.52**
NOx, g/h	590	354	244	122	132	0.86	**240**
NOx, g/hp-h	12.5	10.0	10.2	10.3	28.4		**10.9**
CO2, g/h	24932	19294	14720	9959	7515	1501	**13960**
CO2, g/hp-h	527	544	619	841	1612		**631**
Fuel, lb/h	20.1	15.5	11.86	8.04	6.07	2.58	**11.32**
Fuel, lb/hp-h	0.42	0.44	0.50	0.68	1.30		**0.51**

Note: Hydrocarbon levels have been corrected for FID response to methane.

Engine # / run #	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	WEIGHTED
60 HP SI CNG-2	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	19.5	20.5	20.8	20.1	18.3	14.9	**19.9**
Fuel flow rate, lb/h	19.9	15.9	12.0	8.21	6.36	2.51	**11.5**
Engine speed, rpm	2550	2550	2550	2550	2550	790	**2462**
Engine torque, lb-ft	97.2	73.2	48.8	24.4	9.80	0.00	**45.5**
Power output, hp	47.2	35.5	23.7	11.8	4.76	0.00	**22.1**
Air inlet temp, F	94	98	98	99	96	98	**98**
Humidity, grains/lb	84	84	83	84	85	84	**83**
HC ppmc wet	105	101	138	147	126	19274	**1086**
CO % wet	0.03	0.03	0.04	0.04	0.06	3.53	**0.22**
CO2 % wet	8.45	8.07	7.93	8.19	8.93	5.00	**8.01**
NOx ppm wet	1959	1401	1311	980	663	24.0	**1178**
O2 % wet	2.05	2.65	2.77	2.47	1.11	4.25	**2.55**
RAW ISO 8178-G1							
THC, g/h	11.2	8.94	9.42	6.64	4.03	210	**18.3**
THC, g/hp-h	0.24	0.25	0.40	0.56	0.85		**0.83**
CH4, g/h							
CH4, g/hp-h							
RHC, g/h							
RHC, g/hp-h							
CO, g/h	62.3	52.2	50.5	33.2	32.4	674	**76.6**
CO, g/hp-h	1.32	1.47	2.13	2.80	6.81		**3.46**
NOx, g/h	626	373	267	133	64.1	0.78	**253**
NOx, g/hp-h	13.3	10.5	11.3	11.2	13.5		**11.4**
CO2, g/h	24799	19701	14910	10188	7890	1498	**14180**
CO2, g/hp-h	525	554	629	860	1658		**641**
Fuel, lb/h	19.9	15.9	12.0	8.21	6.36	2.51	**11.5**
Fuel, lb/hp-h	0.42	0.45	0.51	0.69	1.34		**0.52**

Note: Hydrocarbon levels have been corrected for FID response to methane.

APPENDIX I

60 HP SPARK-IGNITED UTILITY ENGINE (TELEDYNE TM27) LPG CLOSED-LOOP CONTROL AND THREE-WAY CATALYST (ISO 8178-G1)

- **60HPSI LPG CL-1 (Analog)**
- **60HPSI LPG CL-2 (Digital)**

Engine # / run # 60 HP SI LPG CL-1	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 9	AVERAGE MODE 10	AVERAGE MODE 11	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	15.7	15.5	15.6	15.5	15.9	17.2	**15.7**
Fuel flow rate, lb/h	23.95	19.27	14.75	9.96	6.86	1.69	**13.84**
Engine speed, rpm	2550	2550	2550	2550	2550	802	**2463**
Engine torque, lb-ft	120.4	90.2	60.4	30.0	11.80	0.00	**56.2**
Power output, hp	58.5	43.8	29.3	14.57	5.73	0.00	**27.3**
Air inlet temp, F	95	104	99	97	97	97	**99**
Humidity, grains/lb	40	40	39	38	38	35	**39**
HC ppmc wet	45	21	31	22	32	1497	**101**
CO % wet	0.06	0.01	0.01	0.00	0.01	0.00	**0.01**
CO2 % wet	11.5	11.6	11.6	11.6	11.4	10.4	**11.5**
NOx ppm wet	250	292	13.0	208	259	43.1	**167**
O2 % wet	0.00	0.00	0.00	0.00	0.21	2.16	**0.12**
RAW ISO 8178-G1							
THC, g/h	4.22	1.57	1.79	0.87	0.89	10.9	**2.08**
THC, g/hp-h	0.07	0.04	0.06	0.06	0.15		**0.08**
CH4, g/h	0.05	0.03	0.06	0.18	0.24	0.29	**0.11**
CH4, g/hp-h	0.00	0.00	0.00	0.01	0.04		**0.00**
RHC, g/h	4.17	1.55	1.73	0.70	0.64	10.6	**1.97**
RHC, g/hp-h	0.07	0.04	0.06	0.05	0.11		**0.07**
CO, g/h	102	10.7	16.5	3.43	3.08	0.52	**17.3**
CO, g/hp-h	1.74	0.24	0.56	0.24	0.54		**0.64**
NOx, g/h	63.1	58.8	2.01	21.5	18.8	0.82	**25.8**
NOx, g/hp-h	1.08	1.34	0.07	1.48	3.29		**0.95**
CO2, g/h	32319	26123	19988	13506	9301	2264	**18746**
CO2, g/hp-h	553	596	682	927	1623		**687**
Fuel, lb/h	23.9	19.3	14.8	9.96	6.86	1.69	**13.8**
Fuel, lb/hp-h	0.41	0.44	0.50	0.68	1.20		**0.51**
DILUTE PARTICULATE							
PM, g/h	0.08	0.23	0.17	0.21	0.17	0.29	**0.19**
PM, g/hp-h	0.00	0.01	0.01	0.01	0.03		**0.01**

Engine # / run #	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	WEIGHTED
60 HP SI LPG CL-2	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	15.7	15.8	15.6	15.8	16.0	17.2	**15.8**
Fuel flow rate, lb/h	24.55	19.46	15.06	10.21	7.16	1.68	**14.12**
Engine speed, rpm	2550	2550	2550	2550	2550	805	**2463**
Engine torque, lb-ft	119.4	90.2	60.2	29.6	12.20	0.00	**56.0**
Power output, hp	58.0	43.8	29.2	14.37	5.92	0.00	**27.2**
Air inlet temp, F	93	98	98	97	96	97	**97**
Humidity, grains/lb	51	46	45	46	46	46	**46**
HC ppmc wet	47.4	34.9	44.9	39.9	34.9	1248	**101**
CO % wet	0.23	0.10	0.15	0.06	0.02	0.01	**0.10**
CO2 % wet	11.3	11.4	11.4	11.4	11.3	10.5	**11.3**
NOx ppm wet	10.9	9.6	27.3	17.2	21.5	38.8	**19.4**
O2 % wet	0.00	0.00	0.00	0.00	0.00	1.30	**0.06**
RAW ISO 8178-G1							
THC, g/h	4.58	2.68	2.66	1.61	1.00	8.95	**2.72**
THC, g/hp-h	0.08	0.06	0.09	0.11	0.17		**0.10**
CH4, g/h	0.37	0.22	0.68	0.32	0.14	0.30	**0.40**
CH4, g/hp-h	0.01	0.01	0.02	0.02	0.02		**0.01**
RHC, g/h	4.21	2.47	1.97	1.29	0.86	8.65	**2.32**
RHC, g/hp-h	0.07	0.06	0.07	0.09	0.15		**0.09**
CO, g/h	422	141	171	45.5	12.9	0.8	**130**
CO, g/hp-h	7.28	3.22	5.85	3.16	2.17		**4.80**
NOx, g/h	2.95	2.03	4.43	1.92	1.69	0.77	**2.69**
NOx, g/hp-h	0.05	0.05	0.15	0.13	0.29		**0.10**
CO2, g/h	32631	26178	20160	13772	9697	2245	**18941**
CO2, g/hp-h	563	598	690	958	1637		**697**
Fuel, lb/h	24.5	19.5	15.1	10.2	7.16	1.68	**14.1**
Fuel, lb/hp-h	0.42	0.44	0.52	0.71	1.21		**0.52**
DILUTE PARTICULATE							
PM, g/h	0.13	0.14	0.08	0.15	0.19	0.12	**0.13**
PM, g/hp-h	0.00	0.00	0.00	0.01	0.03		**0.00**

APPENDIX J

100 HP SPARK-IGNITED UTILITY ENGINE (FORD 4.9L) GASOLINE-FUELED EMISSION TEST RESULTS (ISO 8178-G1)

- **100HP Utility 3***
- **100HP Utility 4**

***Tests 1 and 2 run with wrong carburetor**

Engine # / run #	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	WEIGHTED
100 HP UTILITY-3	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	10.8	14.0	13.4	13.7	14.2	14.0	**13.5**
Fuel flow rate, lb/h	56.2	34.6	27.3	17.5	12.3	3.74	**26.2**
Engine speed, rpm	2380	2380	2380	2380	2380	709	**2296**
Engine torque, lb-ft	214	160	107	53.4	21.4	0.00	**99.7**
Power output, hp	97.1	72.4	48.4	24.2	9.70	0.00	**45.2**
Air inlet temp, F	89	94	93	91	87	100	**92**
Humidity, grains/lb	80	81	80	74	72	72	**78**
HC ppmc wet	2027	1273	1572	1522	1023	4071	**1625**
CO % wet	7.76	1.33	2.15	1.48	0.71	0.83	**2.12**
CO2 % wet	8.67	12.3	12.0	12.4	12.8	12.6	**12.0**
NOx ppm wet	283	2260	1723	1319	516	34.6	**1410**
O2 % wet	0.04	0.15	0.08	0.07	0.15	0.53	**0.12**
RAW ISO 8178-G1							
THC, g/h	310	145	137	86.0	42.0	50.0	**128**
THC, g/hp-h	3.20	2.00	2.82	3.55	4.33		**2.83**
CH4, g/h	39.4	11.0	9.79	6.51	3.34	1.57	**10.9**
CH4, g/hp-h	0.41	0.15	0.20	0.27	0.34		**0.24**
RHC, g/h	271	134	127	79.4	38.7	48.4	**117**
RHC, g/hp-h	2.79	1.85	2.62	3.28	3.99		**2.59**
CO, g/h	23997	3070	3770	1687	589	205	**4425**
CO, g/hp-h	247	42.4	77.9	69.7	60.7		**97.9**
NOx, g/h	147	878	509	246	69.1	1.39	**415**
NOx, g/hp-h	1.52	12.1	10.5	10.2	7.13		**9.19**
CO2, g/h	42122	44523	32956	22277	16653	4896	**30346**
CO2, g/hp-h	434	615	681	921	1717		**671**
Fuel, lb/h	56.2	34.6	27.3	17.5	12.31	3.74	**26.2**
Fuel, lb/hp-h	0.58	0.48	0.56	0.72	1.27		**0.58**
DILUTE PARTICULATE							
PM, g/h	0.28	0.37	0.26	0.32	0.34	0.36	**0.31**
PM, g/hp-h	0.00	0.01	0.01	0.01	0.03		**0.01**

Engine # / run #	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	WEIGHTED
100 HP UTILITY-4	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	10.8	14.0	13.6	13.9	14.4	13.8	**13.6**
Fuel flow rate, lb/h	55.6	34.4	27.2	17.1	11.74	3.47	**25.9**
Engine speed, rpm	2380	2380	2380	2380	2380	680	**2295**
Engine torque, lb-ft	215	161	107	52.8	21.4	0.00	**99.9**
Power output, hp	97.2	72.8	48.6	23.9	9.70	0.00	**45.3**
Air inlet temp, F	86	88	87	86	83	100	**87**
Humidity, grains/lb	67	68	68	68	69	66	**68**
HC ppmc wet	1917	1243	1577	1457	973	4664	**1617**
CO % wet	7.35	1.18	1.96	1.35	0.69	1.12	**1.97**
CO2 % wet	9.14	12.5	12.0	12.3	12.7	12.3	**12.0**
NOx ppm wet	326	2610	1999	1267	488	35.1	**1547**
O2 % wet	0.00	0.13	0.04	0.06	0.11	0.51	**0.09**
RAW ISO 8178-G1							
THC, g/h	290	141	138	81.7	38.5	52.7	**124**
THC, g/hp-h	2.98	1.93	2.83	3.41	3.97		**2.74**
CH4, g/h	38.0	10.4	9.66	5.96	3.03	1.91	**10.4**
CH4, g/hp-h	0.39	0.14	0.20	0.25	0.31		**0.23**
RHC, g/h	252	130	128	75.7	35.5	50.8	**114**
RHC, g/hp-h	2.59	1.79	2.63	3.16	3.66		**2.51**
CO, g/h	22438	2706	3444	1529	547	255	**4069**
CO, g/hp-h	231	37.2	70.9	63.9	56.4		**89.9**
NOx, g/h	158	947	559	228	62.2	1.26	**438**
NOx, g/hp-h	1.62	13.0	11.5	9.52	6.41		**9.69**
CO2, g/h	43868	44723	33220	21934	15910	4424	**30441**
CO2, g/hp-h	451	615	684	917	1641		**673**
Fuel, lb/h	55.6	34.4	27.2	17.1	11.74	3.47	**25.9**
Fuel, lb/hp-h	0.57	0.47	0.56	0.71	1.21		**0.57**
DILUTE PARTICULATE							
PM, g/h	0.44	0.26	0.27	0.16	0.44	0.22	**0.26**
PM, g/hp-h	0.00	0.00	0.01	0.01	0.04		**0.01**

APPENDIX K

50 HP SNOWMIBILE ENGINE (ROTAX 503) GASOLINE-FUELED EMISSION TEST RESULTS (ISO 8178-G1)

- **Snowmobile**

Engine # / run # Snowmobile	AVERAGE MODE 6	AVERAGE MODE 7	AVERAGE MODE 8	AVERAGE MODE 9	AVERAGE MODE 10	AVERAGE MODE 11	WEIGHTED ISO-8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Air/fuel ratio	8.3	8.1	8.2	9.5	10.4	14.9	9.1
Fuel flow rate, lb/h	37.99	28.66	20.18	9.37	6.77	1.37	18.36
Engine speed, rpm	5784	5770	5772	5768	5772	1600	5563
Engine torque, lb-ft	34.50	26.60	17.60	8.90	5.80	0.00	16.61
Power output, hp	37.99	29.22	19.34	9.77	6.37	0.00	18.25
Air inlet temp, F	70	70	70	70	70	78	70
Humidity, grains/lb	86	82	68	64	64	76	71
HC ppmc wet	57500	49700	44210	23190	14510	68900	39354
CO % wet	7.96	8.53	8.31	6.25	5.31	1.50	7.15
CO2 % wet	7.39	7.96	8.58	10.6	11.0	4.18	8.90
NOx ppm wet	59.5	52.4	36.6	40.8	29.9	9.6	41.3
O2 % wet	5.06	4.39	4.04	2.64	1.89	12.3	4.04
J1088 RESULTS							
THC, g/h	4695	3010	1899	515	250	341	1764
THC, g/hp-h	124	103	98.2	52.7	39.3		96.7
CH4, g/h	32.2	30.0	30.62	8.05	4.38	1.13	20.54
CH4, g/hp-h	0.85	1.03	1.58	0.82	0.69		1.13
RHC, g/h	4663	2980	1868	507	246	340	1744
RHC, g/hp-h	123	102	96.6	51.9	38.6		95.5
CO, g/h	13128	10441	7210	2803	1851	150	6338
CO, g/hp-h	346	357	373	287	290		347
NOx, g/h	16.1	10.5	5.22	3.01	1.71	0.16	6.10
NOx, g/hp-h	0.42	0.36	0.27	0.31	0.27		0.33
CO2, g/h	19159	15297	11696	7455	6045	657	10868
CO2, g/hp-h	504	523	605	763	948		595
Fuel, lb/h	38.0	28.7	20.2	9.37	6.77	1.37	18.4
Fuel, lb/hp-h	1.00	0.98	1.04	0.96	1.06		1.01
DILUTE PARTICULATE							
PM, g/h	105	83.3	55.7	42.4	23.2	3.37	56.8
PM, g/hp-h	2.75	2.85	2.88	4.34	3.64		3.11

APPENDIX L

DETAILED MODAL ALDEHYDE SPECIATION RESULTS
BASELINE CONFIGURATIONS

- **30 HP Air-Cooled Diesel Engine (Lister-Petter TS3)**
  - **ACD1**
  - **ACD2**

- **35 HP Water-Cooled Diesel Engine (Lister-Petter LPWS4)**
  - **WCD1**
  - **WCD2**

- **50 HP Water-Cooled Diesel Engine (Kubota V2203DI-B)**
  - **50 HP DI-1**
  - **50 HP DI-2**

- **8.5 HP Golf Car Engine (Fuji FE290)**
  - **Golf 1**
  - **Golf 2**

- **40 HP LPG Lift Truck Engine (Toyota 4Y)**
  - **Lift 1**
  - **Lift 2**

- **60 HP Spark-Ignited Utility Engine (Teledyne TM27)**
  - **60 HPSI-1**
  - **60 HPSI-2**

- **60 HP SI Utility Engine, CLC-TWC (Teledyne TM27)**
  - **60 HPCL-1**
  - **60 HPCL-2**

- **100 HP Spark-Ignited Utility Engine (Ford 4.9L)**
  - **100 HP Utility-3**
  - **100 HP Utility-4**

- **50 HP Snowmobile Engine (Rotax 503)**
  - **Snowmobile**

Engine#/run# ACD1 Aldehydes	MODE 1	MODE 2	MODE 3	MODE 5	MODE 6	MODE 7	MODE 8	MODE 11	WEIGHTED 8178-C1
Weighting Factor	15%	15%	15%	10%	10%	10%	10%	15%	
Formaldehyde, mg/hr	5994	2116	1259	2554	3617	1132	901	508	2302
Formaldehyde, mg/hp-hr	201	95	85	894	144	57	73		143
Acetaldehyde, mg/hr	1382	543	413	914	824	308	300	183	613
Acetaldehyde, mg/hp-hr	46	24	28	320	33	15	24		38
Acrolein, mg/hr	937	265	193	464	543	137	134	72	348
Acrolein, mg/hp-hr	31	12	13	162	22	7	11		22
Acetone, mg/hr	360	186	154	316	253	104	110	90	197
Acetone, mg/hp-hr	12	8	10	111	10	5	9		12
Propionaldehyde, mg/hr	243	145	109	247	138	73	68	49	135
Propionaldehyde, mg/hp-hr	8	7	7	87	6	4	5		8
Crotonaldehyde, mg/hr	317	76	55	131	177	39	37	18	108
Crotonaldehyde, mg/hp-hr	11	3	4	46	7	2	3		7
Isobutyraldehyde/MEK, mg/hr	102	84	59	151	61	40	35	18	68
Isobutyraldehyde/MEK, mg/hp-hr	3	4	4	53	2	2	3		4
Benzaldehyde, mg/hr	279	58	35	85	152	28	27	13	87
Benzaldehyde, mg/hp-hr	9	3	2	30	6	1	2		5
Hexanaldehyde, mg/hr	51	33	16	56	26	15	0	0	25
Hexanaldehyde, mg/hp-hr	2	1	1	20	1	1	0		2
Total Aldehydes, mg/hr	9665	3507	2291	4918	5791	1877	1613	951	3882
Total Aldehydes, mg/hp-hr	324	158	154	1722	231	94	130		242

Engine#/run# ACD2 Aldehydes	MODE 1	MODE 2	MODE 3	MODE 5	MODE 6	MODE 7	MODE 8	MODE 11	WEIGHTED 8178-C1
Weighting Factor	15%	15%	15%	10%	10%	10%	10%	15%	
Formaldehyde, mg/hr	4828	2097	1266	2293	3942	1029	820	502	2112
Formaldehyde, mg/hp-hr	171	95	85	802	163	54	65		135
Acetaldehyde, mg/hr	1124	512	406	814	889	275	279	180	559
Acetaldehyde, mg/hp-hr	40	23	27	285	37	14	22		36
Acrolein, mg/hr	764	248	182	349	531	102	105	57	296
Acrolein, mg/hp-hr	27	11	12	122	22	5	8		19
Acetone, mg/hr	300	150	147	270	262	94	108	88	176
Acetone, mg/hp-hr	11	7	10	94	11	5	9		11
Propionaldehyde, mg/hr	203	123	104	206	154	61	62	49	120
Propionaldehyde, mg/hp-hr	7	6	7	72	6	3	5		8
Crotonaldehyde, mg/hr	256	86	55	118	204	33	35	16	101
Crotonaldehyde, mg/hp-hr	9	4	4	41	8	2	3		6
Isobutyraldehyde/MEK, mg/hr	136	109	73	147	83	52	47	31	85
Isobutyraldehyde/MEK, mg/hp-hr	5	5	5	51	3	3	4		5
Benzaldehyde, mg/hr	202	64	39	74	169	27	29	17	78
Benzaldehyde, mg/hp-hr	7	3	3	26	7	1	2		5
Hexanaldehyde, mg/hr	47	32	15	44	25	11	11	0	23
Hexanaldehyde, mg/hp-hr	2	1	1	15	1	1	1		1
Total Aldehydes, mg/hr	7861	3421	2287	4315	6260	1684	1496	941	3552
Total Aldehydes, mg/hp-hr	279	155	153	1509	258	89	119		227

Engine#/run# WCD1 Aldehydes	MODE 1	MODE 2	MODE 3	MODE 5	MODE 6	MODE 7	MODE 8	MODE 11	WEIGHTED 8178-C1
Weighting Factor	15%	15%	15%	10%	10%	10%	10%	15%	
Formaldehyde, mg/hr	787	380	815	3360	175	412	3550	158	1071
Formaldehyde, mg/hp-hr	22	14	48	980	7	21	279		60
Acetaldehyde, mg/hr	159	116	254	1161	35	87	884	35	301
Acetaldehyde, mg/hp-hr	5	4	15	338	1	5	69		17
Acrolein, mg/hr	90	59	124	482	32	90	678	25	173
Acrolein, mg/hp-hr	3	2	7	141	1	5	53		10
Acetone, mg/hr	155	56	153	336	115	55	224	50	135
Acetone, mg/hp-hr	4	2	9	98	5	3	18		8
Propionaldehyde, mg/hr	24	16	54	282	0	14	173	12	63
Propionaldehyde, mg/hp-hr	1	1	3	82	0	1	14		4
Crotonaldehyde, mg/hr	27	20	42	188	1	18	221	3	57
Crotonaldehyde, mg/hp-hr	1	1	2	55	0	1	17		3
Isobutyraldehyde/MEK, mg/hr	0	0	19	184	0	0	84	0	30
Isobutyraldehyde/MEK, mg/hp-hr	0	0	1	54	0	0	7		2
Benzaldehyde, mg/hr	62	18	32	146	0	20	171	0	51
Benzaldehyde, mg/hp-hr	2	1	2	42	0	1	13		3
Hexanaldehyde, mg/hr	0	0	0	95	0	0	47	0	14
Hexanaldehyde, mg/hp-hr	0	0	0	28	0	0	4		1
Total Aldehydes, mg/hr	1305	665	1493	6234	359	697	6033	284	1894
Total Aldehydes, mg/hp-hr	37	25	87	1817	14	36	474		106

Engine#/run# WCD2 Aldehydes	MODE 1	MODE 2	MODE 3	MODE 5	MODE 6	MODE 7	MODE 8	MODE 11	WEIGHTED 8178-C1
Weighting Factor	15%	15%	15%	10%	10%	10%	10%	15%	
Formaldehyde, mg/hr	682	547	725	3483	139	506	3207	118	1044
Formaldehyde, mg/hp-hr	19	21	42	952	5	26	248		58
Acetaldehyde, mg/hr	75	103	166	1106	0	60	767	0	245
Acetaldehyde, mg/hp-hr	2	4	10	302	0	3	59		14
Acrolein, mg/hr	85	96	123	609	20	67	445	10	161
Acrolein, mg/hp-hr	2	4	7	166	1	4	34		9
Acetone, mg/hr	41	49	55	329	23	32	180	38	84
Acetone, mg/hp-hr	1	2	3	90	1	2	14		5
Propionaldehyde, mg/hr	19	25	42	250	9	15	155	10	57
Propionaldehyde, mg/hp-hr	1	1	2	68	0	1	12		3
Crotonaldehyde, mg/hr	20	25	41	189	0	25	211	2	56
Crotonaldehyde, mg/hp-hr	1	1	2	52	0	1	16		3
Isobutyraldehyde/MEK, mg/hr	5	6	18	150	0	0	98	0	29
Isobutyraldehyde/MEK, mg/hp-hr	0	0	1	41	0	0	8		2
Benzaldehyde, mg/hr	47	21	30	156	0	31	166	0	50
Benzaldehyde, mg/hp-hr	1	1	2	43	0	2	13		3
Hexanaldehyde, mg/hr	0	0	30	139	0	0	78	0	26
Hexanaldehyde, mg/hp-hr	0	0	2	38	0	0	6		1
Total Aldehydes, mg/hr	973	872	1230	6411	190	736	5306	178	1752
Total Aldehydes, mg/hp-hr	28	34	71	1752	8	38	410		98

Engine#/run# 50HP DI–1	MODE 1	MODE 2	MODE 3	MODE 5	MODE 6	MODE 7	MODE 8	MODE 11	WEIGHTED 8178–C1
Weighting Factor	15%	15%	15%	10%	10%	10%	10%	15%	
Formaldehyde, mg/hr	1765	454	1510	3366	2113	475	228	878	1309
Formaldehyde, mg/hp–hr	38	13	66	756	63	19	14		56
Acetaldehyde, mg/hr	378	134	499	1273	391	147	90	317	389
Acetaldehyde, mg/hp–hr	8	4	22	286	12	6	5		17
Acrolein, mg/hr	96	10	101	236	105	21	7	54	76
Acrolein, mg/hp–hr	2	0	4	53	3	1	0		3
Acetone, mg/hr	92	56	226	546	166	60	36	146	159
Acetone, mg/hp–hr	2	2	10	123	5	2	2		7
Propionaldehyde, mg/hr	72	33	96	266	44	0	20	59	72
Propionaldehyde, mg/hp–hr	2	1	4	60	1	0	1		3
Crotonaldehyde, mg/hr	61	0	54	165	70	17	0	32	47
Crotonaldehyde, mg/hp–hr	1	0	2	37	2	1	0		2
Isobutyraldehyde/MEK, mg/hr	98	22	80	226	42	48	17	49	71
Isobutyraldehyde/MEK, mg/hp–hr	2	1	3	51	1	2	1		3
Benzaldehyde, mg/hr	97	43	59	125	88	22	0	170	79
Benzaldehyde, mg/hp–hr	2	1	3	28	3	1	0		3
Hexanaldehyde, mg/hr	0	0	40	209	29	25	0	28	36
Hexanaldehyde, mg/hp–hr	0	0	2	47	1	1	0		2
Total Aldehydes, mg/hr	2658	752	2664	6411	3047	814	397	1732	2238
Total Aldehydes, mg/hp–hr	58	22	116	1440	91	32	24		95

Engine#/run# 50HP DI-2	MODE 1	MODE 2	MODE 3	MODE 5	MODE 6	MODE 7	MODE 8	MODE 11	WEIGHTED 8178-C1
Weighting Factor	15%	15%	15%	10%	10%	10%	10%	15%	
Formaldehyde, mg/hr	787	1320	745	2029	1189	256	599	998	985
Formaldehyde, mg/hp-hr	17	39	33	445	35	10	36		42
Acetaldehyde, mg/hr	184	377	231	735	72	86	213	379	286
Acetaldehyde, mg/hp-hr	4	11	10	161	2	3	13		12
Acrolein, mg/hr	24	81	29	91	27	8	33	82	48
Acrolein, mg/hp-hr	1	2	1	20	1	0	2		2
Acetone, mg/hr	0	52	21	225	0	0	0	100	48
Acetone, mg/hp-hr	0	2	1	49	0	0	0		2
Propionaldehyde, mg/hr	33	75	0	151	28	14	54	111	57
Propionaldehyde, mg/hp-hr	1	2	0	33	1	1	3		2
Crotonaldehyde, mg/hr	51	54	22	88	40	34	24	36	43
Crotonaldehyde, mg/hp-hr	1	2	1	19	1	1	1		2
Isobutyraldehyde/MEK, mg/hr	33	79	74	177	81	28	35	75	71
Isobutyraldehyde/MEK, mg/hp-hr	1	2	3	39	2	1	2		3
Benzaldehyde, mg/hr	28	135	224	491	74	26	27	241	156
Benzaldehyde, mg/hp-hr	1	4	10	108	2	1	2		7
Hexanaldehyde, mg/hr	36	69	29	140	31	0	29	62	50
Hexanaldehyde, mg/hp-hr	1	2	1	31	1	0	2		2
Total Aldehydes, mg/hr	1176	2241	1374	4127	1542	451	1013	2084	1745
Total Aldehydes, mg/hp-hr	26	66	60	905	46	18	60		74

Engine#/run# GOLF–1	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	WEIGHTED 8178–G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Formaldehyde, mg/hr	1002	948	341	179	138	196	**452**
Formaldehyde, mg/hp–hr	202	252	136	140			**194**
Acetaldehyde, mg/hr	185	185	64	30	23	33	**84**
Acetaldehyde, mg/hp–hr	37	49	26	23			**36**
Acrolein, mg/hr	47	50	12	5	4	7	**20**
Acrolein, mg/hp–hr	10	13	5	4			**8**
Acetone, mg/hr	76	71	29	11	9	13	**34**
Acetone, mg/hp–hr	15	19	12	9			**15**
Propionaldehyde, mg/hr	37	38	18	8	7	9	**20**
Propionaldehyde, mg/hp–hr	7	10	7	6			**8**
Crotonaldehyde, mg/hr	25	30	11	5	3	5	**13**
Crotonaldehyde, mg/hp–hr	5	8	4	4			**6**
Isobutyraldehyde/MEK, mg/hr	18	19	13	7	5	6	**12**
Isobutyraldehyde/MEK, mg/hp–hr	4	5	5	5			**5**
Benzaldehyde, mg/hr	302	300	113	55	37	46	**141**
Benzaldehyde, mg/hp–hr	61	80	45	43			**61**
Hexanaldehyde, mg/hr	0	0	0	0	0	0	**0**
Hexanaldehyde, mg/hp–hr	0	0	0	0			**0**
Total Aldehydes, mg/hr	1692	1640	601	299	226	316	**776**
Total Aldehydes, mg/hp–hr	340	436	240	235			**333**

Engine#/run# GOLF-2	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Formaldehyde, mg/hr	942	845	346	215	173	232	**442**
Formaldehyde, mg/hp-hr	189	226	138	171			**190**
Acetaldehyde, mg/hr	171	161	62	35	27	38	**80**
Acetaldehyde, mg/hp-hr	34	43	25	27			**34**
Acrolein, mg/hr	50	43	11	5	5	7	**18**
Acrolein, mg/hp-hr	10	12	4	4			**8**
Acetone, mg/hr	78	68	30	22	13	19	**38**
Acetone, mg/hp-hr	16	18	12	17			**16**
Propionaldehyde, mg/hr	45	39	19	12	9	13	**22**
Propionaldehyde, mg/hp-hr	9	10	8	10			**10**
Crotonaldehyde, mg/hr	25	25	10	5	5	6	**12**
Crotonaldehyde, mg/hp-hr	5	7	4	4			**5**
Isobutyraldehyde/MEK, mg/hr	20	15	12	7	5	8	**11**
Isobutyraldehyde/MEK, mg/hp-hr	4	4	5	6			**5**
Benzaldehyde, mg/hr	309	260	109	64	43	54	**136**
Benzaldehyde, mg/hp-hr	62	70	43	51			**59**
Hexanaldehyde, mg/hr	0	0	0	0	0	0	**0**
Hexanaldehyde, mg/hp-hr	0	0	0	0			**0**
Total Aldehydes, mg/hr	1640	1457	599	365	279	376	**761**
Total Aldehydes, mg/hp-hr	329	390	239	290			**327**

Engine#/run# LIFT-1	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Formaldehyde, mg/hr	2824	1600	1875	1512	682	147	**1627**
Formaldehyde, mg/hp-hr	75	57	102	160			**93**
Acetaldehyde, mg/hr	343	233	331	327	140	17	**282**
Acetaldehyde, mg/hp-hr	9	8	18	35			**16**
Acrolein, mg/hr	133	65	74	58	10	0	**65**
Acrolein, mg/hp-hr	4	2	4	6			**4**
Acetone, mg/hr	15	3	158	43	29	0	**63**
Acetone, mg/hp-hr	0	0	9	5			**4**
Propionaldehyde, mg/hr	31	23	33	31	17	0	**27**
Propionaldehyde, mg/hp-hr	1	1	2	3			**2**
Crotonaldehyde, mg/hr	3	0	0	8	4	0	**3**
Crotonaldehyde, mg/hp-hr	0	0	0	1			**0**
Isobutyraldehyde/MEK, mg/hr	1	0	0	2	0	0	**1**
Isobutyraldehyde/MEK, mg/hp-hr	0	0	0	0			**0**
Benzaldehyde, mg/hr	19	0	0	0	0	0	**2**
Benzaldehyde, mg/hp-hr	0	0	0	0			**0**
Hexanaldehyde, mg/hr	0	0	0	0	0	0	**0**
Hexanaldehyde, mg/hp-hr	0	0	0	0			**0**
Total Aldehydes, mg/hr	3369	1923	2471	1981	882	164	**2069**
Total Aldehydes, mg/hp-hr	90	69	134	209			**119**

Engine#/run# LIFT 2	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Formaldehyde, mg/hr	2153	1573	1824	1478	740	205	1543
Formaldehyde, mg/hp-hr	58	56	101	154			89
Acetaldehyde, mg/hr	290	256	350	309	162	41	285
Acetaldehyde, mg/hp-hr	8	9	19	32			16
Acrolein, mg/hr	105	87	80	43	3	0	63
Acrolein, mg/hp-hr	3	3	4	5			4
Acetone, mg/hr	18	26	38	32	21	0	29
Acetone, mg/hp-hr	0	1	2	3			2
Propionaldehyde, mg/hr	22	20	33	25	17	7	24
Propionaldehyde, mg/hp-hr	1	1	2	3			1
Crotonaldehyde, mg/hr	2	1	2	4	0	0	2
Crotonaldehyde, mg/hp-hr	0	0	0	0			0
Isobutyraldehyde/MEK, mg/hr	0	0	0	6	11	8	3
Isobutyraldehyde/MEK, mg/hp-	0	0	0	1			0
Benzaldehyde, mg/hr	14	0	0	0	0	0	1
Benzaldehyde, mg/hp-hr	0	0	0	0			0
Hexanaldehyde, mg/hr	0	0	0	0	0	0	0
Hexanaldehyde, mg/hp-hr	0	0	0	0			0
Total Aldehydes, mg/hr	2603	1963	2326	1896	955	260	1950
Total Aldehydes, mg/hp-hr	70	70	128	197			112

Engine#/run# 60 HP SI-1	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Formaldehyde, mg/hr	1541	1376	659	960	868	243	**966**
Formaldehyde, mg/hp-hr	25	30	22	63			**34**
Acetaldehyde, mg/hr	327	290	120	168	140	28	**184**
Acetaldehyde, mg/hp-hr	5	6	4	11			**6**
Acrolein, mg/hr	73	47	18	34	27	7	**34**
Acrolein, mg/hp-hr	1	1	1	2			**1**
Acetone, mg/hr	0	0	0	0	0	0	**0**
Acetone, mg/hp-hr	0	0	0	0			**0**
Propionaldehyde, mg/hr	59	60	31	51	33	21	**45**
Propionaldehyde, mg/hp-hr	1	1	1	3			**2**
Crotonaldehyde, mg/hr	12	18	9	17	17	3	**14**
Crotonaldehyde, mg/hp-hr	0	0	0	1			**0**
Isobutyraldehyde/MEK, mg/hr	21	45	18	41	48	4	**32**
Isobutyraldehyde/MEK, mg/hp-hr	0	1	1	3			**1**
Benzaldehyde, mg/hr	907	710	275	364	346	92	**441**
Benzaldehyde, mg/hp-hr	15	16	9	24			**15**
Hexanaldehyde, mg/hr	8	66	0	23	22	0	**22**
Hexanaldehyde, mg/hp-hr	0	1	0	2			**1**
Total Aldehydes, mg/hr	2948	2611	1129	1658	1502	398	**1737**
Total Aldehydes, mg/hp-hr	49	57	37	109			**61**

Engine#/run# 60 HP SI-2	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Formaldehyde, mg/hr	1244	1328	1220	861	759	516	1069
Formaldehyde, mg/hp-hr	21	29	40	56			37
Acetaldehyde, mg/hr	257	264	225	163	141	69	203
Acetaldehyde, mg/hp-hr	4	6	7	11			7
Acrolein, mg/hr	59	69	55	28	18	16	45
Acrolein, mg/hp-hr	1	2	2	2			2
Acetone, mg/hr	0	0	0	0	0	0	0
Acetone, mg/hp-hr	0	0	0	0			0
Propionaldehyde, mg/hr	46	44	40	38	31	19	39
Propionaldehyde, mg/hp-hr	1	1	1	2			1
Crotonaldehyde, mg/hr	13	23	29	17	20	2	21
Crotonaldehyde, mg/hp-hr	0	1	1	1			1
Isobutyraldehyde/MEK, mg/hr	4	53	53	41	51	14	43
Isobutyraldehyde/MEK, mg/hp-hr	0	1	2	3			2
Benzaldehyde, mg/hr	703	719	644	366	332	182	536
Benzaldehyde, mg/hp-hr	12	16	21	24			19
Hexanaldehyde, mg/hr	0	50	45	19	17	11	31
Hexanaldehyde, mg/hp-hr	0	1	1	1			1
Total Aldehydes, mg/hr	2326	2550	2311	1532	1369	830	1987
Total Aldehydes, mg/hp-hr	38	56	76	100			70

Engine#/run# 60 HP CL-1	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Formaldehyde, mg/hr	1	1	1	2	7	4	2
Formaldehyde, mg/hp-hr	0	0	0	0	1		0
Acetaldehyde, mg/hr	7	3	3	4	6	3	4
Acetaldehyde, mg/hp-hr	0	0	0	0	1		0
Acrolein, mg/hr	0	0	0	0	0	0	0
Acrolein, mg/hp-hr	0	0	0	0	0		0
Acetone, mg/hr	0	0	0	0	0	0	0
Acetone, mg/hp-hr	0	0	0	0	0		0
Propionaldehyde, mg/hr	0	0	0	0	0	0	0
Propionaldehyde, mg/hp-hr	0	0	0	0	0		0
Crotonaldehyde, mg/hr	0	0	0	0	0	0	0
Crotonaldehyde, mg/hp-hr	0	0	0	0	0		0
Isobutyraldehyde/MEK, mg/hr	0	0	0	0	0	0	0
Isobutyraldehyde/MEK, mg/hp-hr	0	0	0	0	0		0
Benzaldehyde, mg/hr	0	0	0	0	0	0	0
Benzaldehyde, mg/hp-hr	0	0	0	0	0		0
Hexanaldehyde, mg/hr	0	0	0	0	0	0	0
Hexanaldehyde, mg/hp-hr	0	0	0	0	0		0
Total Aldehydes, mg/hr	8	5	4	7	13	7	6
Total Aldehydes, mg/hp-hr	0	0	0	0	2		0

Engine#/run# 60 HP CL-2	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Formaldehyde, mg/hr	1	0	0	0	0	7	**1**
Formaldehyde, mg/hp-hr	0	0	0	0	0		**0**
Acetaldehyde, mg/hr	9	3	4	0	0	8	**3**
Acetaldehyde, mg/hp-hr	0	0	0	0	0		**0**
Acrolein, mg/hr	0	0	0	0	0	0	**0**
Acrolein, mg/hp-hr	0	0	0	0	0		**0**
Acetone, mg/hr	0	0	0	0	0	0	**0**
Acetone, mg/hp-hr	0	0	0	0	0		**0**
Propionaldehyde, mg/hr	0	9	0	0	0	0	**2**
Propionaldehyde, mg/hp-hr	0	0	0	0	0		**0**
Crotonaldehyde, mg/hr	3	0	0	0	0	0	**0**
Crotonaldehyde, mg/hp-hr	0	0	0	0	0		**0**
Isobutyraldehyde/MEK, mg/hr	0	0	0	0	0	0	**0**
Isobutyraldehyde/MEK, mg/hp-hr	0	0	0	0	0		**0**
Benzaldehyde, mg/hr	0	0	0	0	0	0	**0**
Benzaldehyde, mg/hp-hr	0	0	0	0	0		**0**
Hexanaldehyde, mg/hr	0	0	0	0	0	0	**0**
Hexanaldehyde, mg/hp-hr	0	0	0	0	0		**0**
Total Aldehydes, mg/hr	13	12	5	0	0	15	**6**
Total Aldehydes, mg/hp-hr	0	0	0	0	0		**0**

Engine#/run# Snowmobile	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	WEIGHTED ISO-8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Formaldehyde, g/hr	13.22	11.43	8.87	3.61	1.14	0.68	7.24
Formaldehyde, g/hp-hr		0.39	0.46	0.37	0.18		0.40
Acetaldehyde, g/hr	3.81	2.70	1.84	0.88	0.26	0.16	1.71
Acetaldehyde, g/hp-hr		0.09	0.10	0.09	0.04		0.09
Acrolein, g/hr	1.09	0.99	0.92	0.46	0.07	0.03	0.71
Acrolein, g/hp-hr		0.03	0.05	0.05	0.01		0.04
Acetone, g/hr	2.00	1.90	1.66	1.61	0.10	0.09	1.54
Acetone, g/hp-hr		0.06	0.09	0.17	0.02		0.08
Propionaldehyde, g/hr	0.81	0.59	0.33	0.22	0.07	0.06	0.36
Propionaldehyde, g/hp-hr		0.02	0.02	0.02	0.01		0.02
Crotonaldehyde, g/hr	0.38	0.32	0.30	0.15	0.04	0.01	0.23
Crotonaldehyde, g/hp-hr		0.01	0.02	0.02	0.01		0.01
Isobutyraldehyde/MEK, g/hr	1.10	0.90	0.74	0.61	0.06	0.05	0.69
Isobutyraldehyde/MEK, g/hp-hr		0.03	0.04	0.06	0.01		0.04
Benzaldehyde, g/hr	7.24	6.15	4.65	1.56	0.42	0.22	3.74
Benzaldehyde, g/hp-hr		0.21	0.24	0.16	0.07		0.20
Hexanaldehyde, g/hr	0.43	0.30	0.22	0.02	0.03	0.00	0.17
Hexanaldehyde, g/hp-hr		0.01	0.01	0.00	0.00		0.01
Total Aldehydes, g/hr	30.08	25.27	19.54	9.13	2.20	1.29	16.38
Total Aldehydes, g/hp-hr		0.86	1.01	0.93	0.35		0.90

Engine#/run# 100 HP UTILITY-3	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Formaldehyde, mg/hr	2050	3694	2161	1553	1179	768	**2137**
Formaldehyde, mg/hp-hr	21	51	45	64			**47**
Acetaldehyde, mg/hr	401	554	368	256	181	130	**350**
Acetaldehyde, mg/hp-hr	4	8	8	11			**8**
Acrolein, mg/hr	206	379	176	109	87	59	**187**
Acrolein, mg/hp-hr	2	5	4	4			**4**
Acetone, mg/hr	164	241	241	82	51	34	**163**
Acetone, mg/hp-hr	2	3	5	3			**4**
Propionaldehyde, mg/hr	55	61	45	28	13	14	**40**
Propionaldehyde, mg/hp-hr	1	1	1	1			**1**
Crotonaldehyde, mg/hr	44	111	66	31	37	37	**59**
Crotonaldehyde, mg/hp-hr	0	2	1	1			**1**
Isobutyraldehyde/MEK, mg/hr	92	68	53	41	17	37	**53**
Isobutyraldehyde/MEK, mg/hp-hr	1	1	1	2			**1**
Benzaldehyde, mg/hr	1127	1696	915	603	367	238	**924**
Benzaldehyde, mg/hp-hr	12	23	19	25			**20**
Hexanaldehyde, mg/hr	0	0	0	0	0	0	**0**
Hexanaldehyde, mg/hp-hr	0	0	0	0			**0**
Total Aldehydes, mg/hr	4138	6803	4025	2702	1933	1317	**3912**
Total Aldehydes, mg/hp-hr	43	94	83	112			**87**

Engine#/run# 100 HP UTILITY-4	MODE 6	MODE 7	MODE 8	MODE 9	MODE 10	MODE 11	WEIGHTED 8178-G1
Weighting Factor	9%	20%	29%	30%	7%	5%	
Formaldehyde, mg/hr	2420	3981	2383	1603	868	732	**2283**
Formaldehyde, mg/hp-hr	25	55	49	67			**50**
Acetaldehyde, mg/hr	480	568	386	267	131	124	**364**
Acetaldehyde, mg/hp-hr	5	8	8	11			**8**
Acrolein, mg/hr	263	479	245	151	74	129	**247**
Acrolein, mg/hp-hr	3	7	5	6			**5**
Acetone, mg/hr	293	253	223	154	79	109	**199**
Acetone, mg/hp-hr	3	3	5	6			**4**
Propionaldehyde, mg/hr	82	101	68	37	17	21	**60**
Propionaldehyde, mg/hp-hr	1	1	1	2			**1**
Crotonaldehyde, mg/hr	46	78	38	30	11	16	**41**
Crotonaldehyde, mg/hp-hr	0	1	1	1			**1**
Isobutyraldehyde/MEK, mg/hr	121	81	79	69	29	35	**75**
Isobutyraldehyde/MEK, mg/hp-hr	1	1	2	3			**2**
Benzaldehyde, mg/hr	1322	1692	964	576	255	228	**939**
Benzaldehyde, mg/hp-hr	14	23	20	24			**21**
Hexanaldehyde, mg/hr	0	0	0	0	0	0	**0**
Hexanaldehyde, mg/hp-hr	0	0	0	0			**0**
Total Aldehydes, mg/hr	5027	7234	4386	2887	1464	1393	**4210**
Total Aldehydes, mg/hp-hr	52	99	90	121			**93**