

Memo



To: Docket # EPA-HQ-OAR-2004-0008 "Control of Emissions From Nonroad Spark-Ignition Engines, Vessels, and Equipment"

From: Joseph McDonald, OTAQ-ASD *JM*

CC:

Date: 5/5/2006

Re: Supplemental Engine Dynamometer Data for Engine 6820

Attached to this memo are supplemental data for engine 6820. Pages 2, 3 and 4 show test results using an OEM muffler for the engine after an initial 10 hours of engine break-in. Pages 5, 6 and 7 show test results using an OEM muffler for the engine following approximately 110 hours of field operation. Pages 8, 9 and 10 show the final test results at the end of useful life for the field-aged catalyst muffler and engine.

Final Results

Briggs and Stratton			BG6820-1; 728714			June 23, 2004		
Quantum								
5 mode dilute emission results								
	NOx (Corr)	2.2 g/kWh				1.6 g/hph		
	HC	8.4 g/kWh				6.3 g/hph		
	CO	466 g/kWh				348 g/hph		
	CO2	1241 g/kWh				925 g/hph		
	NOx+HC	10.6 g/kWh				7.9 g/hph		
	NOx+NMHC	9.8 g/kWh				7.3 g/hph		

Note: Dilute bag CO, CO2, NOx; heated dilute HC

Lawn Mower Model: Yard Machine 6.0HP

BG6820-1; 728714

Notes: 5-mode test

Calculations

Mode #	1	2	3	4	5	6
Bag Data						
Emissions Rate						
g/hr						
NOx (Corr)	6.31	4.97	1.97	0.62	0.305	0.00000
HC	10.59	8.39	9.10	10.15	8.99	0.00
NMHC	9.33	7.47	8.20	9.17	8.06	0.00
CO	928.3	612.9	499.8	406.5	305.3	0.0
CO2	1955.4	1631.9	1393.8	1133.5	981.8	0.0
T (N-m)	6.87	5.14	3.42	1.70	0.70	0.00
N (rpm)	3060	3131	3223	3253	3271	0
Exhaust-λ	N/A	N/A	N/A	N/A	N/A	0

Includes catalyst (y/n)? No
Includes secondary air (y/n)? No

If yes, type:

Final Results

Briggs and Stratton			BG6820-2; 728715			June 23, 2004		
Quantum								
5 mode dilute emission results								
	NOx (Corr)	2.3 g/kWh		1.7 g/hph				
	HC	8.6 g/kWh		6.4 g/hph				
	CO	471 g/kWh		351 g/hph				
	CO2	1224 g/kWh		913 g/hph				
	NOx+HC	10.9 g/kWh		8.1 g/hph				
	NOx+NMHC	9.9 g/kWh		7.4 g/hph				

Note: Dilute bag CO, CO2, NOx; heated dilute HC

Lawn Mower Model: Yard Machine
Notes: 5-mode test
Calculations

BG6820-2; 728715

Mode #	1	2	3	4	5	6
Bag Data						
Emissions Rate						
g/hr						
NOx (Corr)	6.89	5.33	1.94	0.38	0.223	0.00000
HC	10.43	10.57	9.49	9.08	8.21	0.00
NMHC	9.20	9.46	8.52	7.93	7.17	0.00
CO	925.4	632.4	489.3	415.4	288.1	0.0
CO2	1952.1	1713.5	1327.1	1067.5	958.8	0.0
T (N-m)	6.77	5.10	3.40	1.70	0.70	0.00
N (rpm)	3061	3136	3245	3237	3273	0
Exhaust-λ	N/A	N/A	N/A	N/A	N/A	0

Includes catalyst (y/n)? No
 Includes secondary air (y/n)? No

If yes, type:

Final Results

Briggs and Stratton			BG6820-3; 728716			June 23, 2004		
Quantum								
5 mode dilute emission results								
	NOx (Corr)	2.1 g/kWh					1.6 g/hph	
	HC	8.9 g/kWh					6.6 g/hph	
	CO	437 g/kWh					326 g/hph	
	CO2	1173 g/kWh					875 g/hph	
	NOx+HC	11.0 g/kWh					8.2 g/hph	
	NOx+NMHC	10.1 g/kWh					7.6 g/hph	

Note: Dilute bag CO, CO2, NOx; heated dilute HC

Lawn Mower Model: Yard Machine
Notes: 5-mode test
Calculations

BG6820-3; 728716

Mode #	1	2	3	4	5	6
Bag Data						
Emissions Rate						
g/hr						
NOx (Corr)	7.06	5.00	1.61	0.54	0.247	0.00000
HC	10.69	9.94	8.49	11.10	12.08	0.00
NMHC	9.55	8.95	7.63	10.07	11.15	0.00
CO	902.0	612.7	450.6	390.8	292.9	0.0
CO2	1970.6	1689.8	1322.8	1021.6	869.2	0.0
T (N-m)	7.02	5.20	3.50	1.70	0.70	0.00
N (rpm)	3058	3150	3236	3247	3282	0
Exhaust-λ	N/A	N/A	N/A	N/A	N/A	0

Includes catalyst (y/n)? No
 Includes secondary air (y/n)? No

If yes, type:

Final Results

Briggs and Stratton	B6820-4b; 728771	September 8, 2004
Quantum		
6 mode dilute emission results		
NOx (Corr)	2.3 g/kWh	1.7 g/hph
HC	13.2 g/kWh	9.8 g/hph
CO	400 g/kWh	298 g/hph
CO2	1086 g/kWh	810 g/hph
NOx+HC	15.5 g/kWh	11.6 g/hph
NOx+NMHC	14.2 g/kWh	10.6 g/hph

Note: Dilute bag CO, CO2, NOx; heated dilute HC

Lawn Mower Model: Yard Machine

B6820-4b; 728771

Notes:

Calculations

Mode #	1	2	3	4	5	6
Bag Data						
Emissions Rate						
g/hr						
NOx (Corr)	8.32	5.16	1.64	0.53	1.185	0.94734
HC	22.40	18.77	13.61	10.82	10.66	12.16
NMHC	20.68	17.52	12.15	9.52	9.03	10.95
CO	796.1	584.4	414.3	318.3	259.1	240.9
CO2	1945.3	1495.6	1150.2	911.2	823.5	804.7
T (N-m)	7.21	5.40	3.60	1.80	0.72	0.25
N (rpm)	3060	2997	3061	3231	3334	3352

Exhaust-λ N/A N/A N/A N/A N/A N/A

Includes catalyst (y/n)? No
Includes secondary air (y/n)? No

If yes, type:

Final Results

Briggs and Stratton	B6820-5; 728772		September 9, 2004
Quantum			
6 mode dilute emission results			
NOx (Corr)	2.7 g/kWh	2.0 g/hph	
HC	12.7 g/kWh	9.5 g/hph	
CO	371 g/kWh	277 g/hph	
CO2	1044 g/kWh	779 g/hph	
NOx+HC	15.4 g/kWh	11.5 g/hph	
NOx+NMHC	14.1 g/kWh	10.5 g/hph	

Note: Dilute bag CO, CO2, NOx; heated dilute HC

Lawn Mower Model: Yard Machine

B6820-5; 728772

Notes:

Calculations

Mode #	1	2	3	4	5	6
Bag Data						
Emissions Rate						
g/hr						
NOx (Corr)	9.00	6.46	2.37	0.52	1.035	0.91902
HC	21.93	18.55	13.93	11.06	10.25	11.12
NMHC	19.42	16.70	12.60	10.01	9.21	10.00
CO	759.6	555.9	397.2	315.7	260.1	235.5
CO2	1967.4	1543.7	1060.5	981.5	801.3	713.6
T (N-m)	7.51	5.63	3.75	1.88	0.75	0.30
N (rpm)	3060	2988	3059	3194	3299	3347

Exhaust-λ N/A N/A N/A N/A N/A N/A

Includes catalyst (y/n)? No
Includes secondary air (y/n)? No

If yes, type:

Final Results

Briggs and Stratton	B6820-6; 728773	September 9, 2004
Quantum		
6 mode dilute emission results		
NOx (Corr)	2.7 g/kWh	2.0 g/hph
HC	12.5 g/kWh	9.3 g/hph
CO	370 g/kWh	276 g/hph
CO2	1104 g/kWh	823 g/hph
NOx+HC	15.2 g/kWh	11.3 g/hph
NOx+NMHC	13.9 g/kWh	10.4 g/hph

Note: Dilute bag CO, CO2, NOx; heated dilute HC

Lawn Mower Model: Yard Machine

B6820-6; 728773

Notes:

Calculations

Mode #	1	2	3	4	5	6
Bag Data						
Emissions Rate						
g/hr						
NOx (Corr)	7.91	7.05	2.17	0.56	1.042	0.80257
HC	23.48	18.17	13.59	10.88	9.75	11.44
NMHC	20.87	16.39	12.31	9.82	8.71	10.29
CO	827.7	528.7	393.2	321.5	248.4	228.9
CO2	1948.0	1601.3	1196.2	1020.1	938.1	760.6
T (N-m)	7.59	5.66	3.78	1.89	0.75	0.18
N (rpm)	3060	2989	3054	3191	3300	3327

Exhaust-λ N/A N/A N/A N/A N/A N/A

Includes catalyst (y/n)? No
Includes secondary air (y/n)? No

If yes, type:

Final Results

B&S Quantum 6820, 125 hours, with 40cc catalyst and passive secondary-air

6 mode dilute bag results

NOx (Corr)	2.38 g/kWh	1.78 g/hph
HC	6.66 g/kWh	4.97 g/hph
CO	162 g/kWh	120.45 g/hph
CO2	1255 g/kWh	935.82 g/hph
NOx+HC	9.04 g/kWh	6.74 g/hph

B&S Quantum 6820, 125 hours, with 40cc catalyst and passive secondary-air

6 mode dilute modal results

NOx (Corr)	2.57 g/kWh	1.92 g/hph
HC	6.66 g/kWh	4.96 g/hph
CO	163 g/kWh	121.73 g/hph
CO2	1261 g/kWh	940.19 g/hph
Pm	0.30273 g/kWh	0.226 g/hph
NOx+HC	9.23 g/kWh	6.88 g/hph

Enter Engine Model: B&S Quantum 6820, 125 hours, with 40cc catalyst and passive secondary-air November 1, 2004

Notes:

Calculations

Mode #	1	2	3	4	5	6
Bag Data						
Emissions Rate						
g/hr						
NOx (Corr)	7.72	4.32	2.47	1.22	0.97	0.95
HC	20.16	13.18	7.64	2.71	1.74	2.03
CO	674	352	159	25	20	15
CO2	2123	1737	1533	1180	990	901

Mode #	1	2	3	4	5	6
Modal Data						
Emissions Rate						
g/hr						
NOx (Corr)	7.20	6.82	2.44	0.88	0.01	-0.16
HC	20.16	13.18	7.63	2.71	1.74	2.03
CO	692	359	157	24	18	16
CO2	2174	1797	1512	1172	967	909
Pm	0.9535	0.8680	0.3131	-0.0002	-0.0001	-0.0001
Torque (Nm)	7.7922	6	4	2	0.8	0
Speed RPM	3060.271	2858.515	2984.816	3041.378	3079.655	3119.824

Exhaust-λ 0.96 0.9773 0.9869 1.0005 1.0035 1.006
 Includes catalyst? y
 Includes secondary air (y/n)? y

Final Results

B&S Quantum 6820, 125 hours, with 40cc catalyst and passive secondary-air

6 mode dilute bag results		
NOx (Corr)	2.60 g/kWh	1.94 g/hph
HC	6.87 g/kWh	5.12 g/hph
CO	176 g/kWh	131.46 g/hph
CO2	1270 g/kWh	947.38 g/hph
NOx+HC	9.47 g/kWh	7.06 g/hph

B&S Quantum 6820, 125 hours, with 40cc catalyst and passive secondary-air

6 mode dilute modal results		
NOx (Corr)	2.65 g/kWh	1.97 g/hph
HC	6.87 g/kWh	5.12 g/hph
CO	176 g/kWh	131.06 g/hph
CO2	1264 g/kWh	942.59 g/hph
Pm	n/a g/kWh	n/a g/hph
NOx+HC	9.51 g/kWh	7.09 g/hph

Enter Engine Model: B&S Quantum 6820, 125 hours, with 40cc catalyst and passive secondary-air November 1, 2004

Notes:

Calculations

Mode #	1	2	3	4	5	6
Bag Data						
Emissions Rate						
g/hr						
NOx (Corr)	7.67	4.21	2.43	2.03	1.51	1.26
HC	21.42	13.26	7.76	2.70	2.41	2.82
CO	737	383	174	27	24	22
CO2	2084	1829	1523	1193	1011	947

Mode #	1	2	3	4	5	6
Modal Data						
Emissions Rate						
g/hr						
NOx (Corr)	6.65	7.25	2.53	0.90	0.15	0.01
HC	21.42	13.26	7.76	2.70	2.41	2.82
CO	761	374	170	27	25	21
CO2	2146	1808	1512	1179	1000	931
Pm						
Torque (Nm)	7.8526	6	3.9998	2	0.8	0
Speed RPM	3060.393	2853.897	2984.228	3045.901	3084.729	3122.227
Exhaust-A	0.9567	0.9772	0.9867	1.0011	1.0029	1.0067
Includes catalyst? y						
Includes secondary air (y/n)? y						

Final Results

B&S Quantum 6820, 125 hours, with 40cc catalyst and passive secondary-air

6 mode dilute bag results		
NOx (Corr)	3.33 g/kWh	2.48 g/hph
HC	6.27 g/kWh	4.68 g/hph
CO	167 g/kWh	124.68 g/hph
CO2	1291 g/kWh	962.74 g/hph
NOx+HC	9.60 g/kWh	7.16 g/hph

B&S Quantum 6820, 125 hours, with 40cc catalyst and passive secondary-air

6 mode dilute modal results		
NOx (Corr)	1.65 g/kWh	1.23 g/hph
HC	6.27 g/kWh	4.68 g/hph
CO	166 g/kWh	124.05 g/hph
CO2	1285 g/kWh	958.06 g/hph
Pm	0.3192 g/kWh	0.238 g/hph
NOx+HC	7.92 g/kWh	5.90 g/hph

Enter Engine Model: B&S Quantum 6820, 125 hours, with 40cc catalyst and passive secondary-air November 1, 2004

Notes:

Calculations

Mode #	1	2	3	4	5	6
Bag Data						
Emissions Rate						
g/hr						
NOx (Corr)	8.95	5.40	3.55	2.17	3.15	1.54
HC	19.28	11.76	7.38	2.61	2.09	2.43
CO	676	352	175	31	27	19
CO2	2125	1864	1543	1222	1035	954

Mode #	1	2	3	4	5	6
Modal Data						
Emissions Rate						
g/hr						
NOx (Corr)	5.54	6.02	0.72	0.00	0.00	0.00
HC	19.27	11.76	7.38	2.61	2.08	2.43
CO	695	345	174	28	26	19
CO2	2190	1854	1530	1204	1017	940
Pm	0.9641	0.8767	0.3163	0.0440	0.0318	0.0228
Torque (Nm)	7.8179	6.0003	4	2	0.8	0
Speed RPM	3060.371	2859.318	3001.648	3057.322	3085.047	3113.026
Exhaust-A	0.9624	0.9805	0.9877	1.002	1.0033	1.0101
Includes catalyst? y						
Includes secondary air (y/n)? y						