

## **Phase 3 Data – Tier 0 Locomotive**

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Tier 0 Locomotive UP 9611  
**40 CFR Part 92**  
Line Haul Duty Cycle  
Second Test: February 1, 2008 (PM)

Notch Setting:

	Idle	DB2	1	2	3	4	5	6	7	8	
Uncorrected NO <sub>x</sub> (g/gal)	190.1	185.5	237.8	219.0	307.5	295.1	139.6	126.6	160.0	147.5	
PM (g/gal)	5.7	6.6	3.8	3.4	3.4	3.1	3.1	4.3	5.8	8.2	
CO (g/gal)	23.3	23.2	13.8	14.9	15.3	25.2	16.7	16.8	14.2	16.4	
THC (g/gal)	18.1	16.7	10.4	7.1	8.3	6.5	6.3	5.6	5.6	5.5	
Notch Weighting Factor	0.38	0.125	0.065	0.065	0.052	0.044	0.038	0.039	0.03	0.162	
Gross hp	19	28	188	474	1000	1510	2193	2882	3658	4486	
Observed Fuel Rate (lb/hr)	18.4	30.8	82.3	188.4	387.9	555.2	825.4	1079.3	1299.7	1635.5	
NO <sub>x</sub> Emissions (g / lb)	26.8	26.2	33.5	30.9	43.4	41.6	19.7	17.8	22.6	20.8	
NO <sub>x</sub> Emissions (g / hr)	493.1	805.7	2759	5818	16817	23099	16247	19264	29313	34004	
PM Emissions (g / lb)	0.80	0.93	0.54	0.47	0.48	0.44	0.44	0.61	0.82	1.15	
PM Emissions (g / hr)	15	29	44	89	187	244	365	658	1065	1885	
CO Emissions (g / lb)	3.28	3.27	1.95	2.10	2.16	3.55	2.36	2.38	2.00	2.32	
CO Emissions (g / hr)	60.4	100.7	160.2	396.1	838.2	1969.0	1946.8	2564.1	2600.8	3792.5	Total:
Weighted hp	7.2	3.5	12.2	30.8	52.0	66.4	83.3	112.4	109.7	726.7	1204.4
Weighted NO <sub>x</sub> Emissions (g/hr)	187.4	100.7	179.3	378.2	874.5	1016	617.4	751.3	879.4	5509	10493
Weighted PM Emissions (g/hr)	5.6	3.6	2.9	5.8	9.7	10.7	13.9	25.7	31.9	305.4	415.2
Weighted CO Emissions (g/hr)	22.95	12.59	10.41	25.75	43.59	86.64	73.98	100.00	78.02	614.39	1068

FTP Measurements over the Duty Cycle (g / bhp hr):      **NO<sub>x</sub>**      **PM**      **CO**  
8.71      0.345      0.887

Tier 0 Locomotive UP 9611  
**Indirect Remote Sensing Device**  
Line Haul Duty Cycle  
First Test: February 1, 2008 (AM)

Notch Setting:

		Idle	DB2	1	2	3	4	5	6	7	8	
NO <sub>x</sub> (g/gal):	Avg.	216.1	209.1	256.2	244.6	309.2	288.3	146.0	135.6	166.4	143.9	
	St. Dev.	117.8	18.3	14.8	12.4	32.1	13.1	30.5	7.9	6.2	5.4	
	Max.	608.6	255.1	287.7	284.7	558.0	345.8	384.0	181.3	187.2	165.1	
	Min.	62.0	190.9	232.1	202.2	268.5	246.8	127.6	83.2	122.9	121.9	
PM (g/gal):	Avg.	5.1	2.2	-2.7	-0.4	1.7	3.1	2.5	4.0	5.5	9.0	
	St. Dev.	4.4	3.4	4.1	3.6	1.4	0.5	0.3	2.1	0.8	0.8	
	Max.	26.6	7.6	3.3	6.1	4.3	5.6	4.7	17.4	7.2	12.3	
	Min.	-2.4	-6.0	-13.8	-15.1	-9.4	1.3	1.6	2.0	3.0	5.2	
CO (g/gal):	Avg.	10.9	8.0	-4.2	2.9	9.6	17.7	8.2	8.7	7.3	8.7	
THC (g/gal):	Avg.	51.1	23.0	8.2	7.9	24.8	28.7	10.7	13.1	16.0	23.7	
CO <sub>2</sub> (g/gal):	Avg.	10115	10148	10181	10171	10143	10127	10160	10156	10156	10146	
Notch Weighting Factor		0.38	0.125	0.065	0.065	0.052	0.044	0.038	0.039	0.03	0.162	
Gross hp		21	28	181	470	998	1516	2203	2895	3777	4506	
Observed Fuel Rate (lb/hr)		20.4	33.1	81.5	187.9	387.2	559.3	825.6	1079.0	1313.6	1627.0	
NO <sub>x</sub> Emissions (g / lb)		30.5	29.5	36.1	34.5	43.6	40.6	20.6	19.1	23.5	20.3	
NO <sub>x</sub> Emissions (g / hr)		622	976	2944	6481	16882	22735	16992	20630	30829	33014	
PM Emissions (g / lb)		0.72	0.31	-0.38	-0.06	0.24	0.44	0.35	0.56	0.77	1.26	
PM Emissions (g / hr)		15	10	-31	-11	93	248	286	602	1017	2055	Total:
CO Emissions (g / lb)		1.53	1.13	-0.59	0.41	1.36	2.50	1.15	1.22	1.03	1.23	
CO Emissions (g / hr)		31.3	37.3	-47.7	77.9	525.5	1397.9	948.9	1317.2	1354.8	1994.2	
Weighted hp		8.0	3.5	11.8	30.6	51.9	66.7	83.7	112.9	113.3	730.0	1212
Weighted NO <sub>x</sub> Emissions (g/hr)		236.2	122.0	191.4	421.2	877.9	1000.3	645.7	804.6	924.9	5348.3	10572
Weighted PM Emissions (g/hr)		5.6	1.3	-2.0	-0.7	4.8	10.9	10.9	23.5	30.5	332.9	417.6
Weighted CO Emissions (g/hr)		11.90	4.66	-3.10	5.06	27.33	61.51	36.06	51.37	40.64	323.06	558

	<b>NO<sub>x</sub></b>	<b>PM</b>	<b>CO</b>
<b>RSD Measurements over the Duty Cycle (g / bhp hr):</b>	<b>8.72</b>	<b>0.344</b>	<b>0.461</b>

Tier 0 Locomotive UP 9611  
**Indirect Remote Sensing Device**  
Line Haul Duty Cycle  
Second Test: February 1, 2008 (PM)

Notch Setting:

		Idle	DB2	1	2	3	4	5	6	7	8	
NO <sub>x</sub> (g/gal):	Avg.	250.2	215.3	218.7	213.8	297.2	283.5	137.5	120.8	151.7	130.0	
	St. Dev.	122.3	52.3	17.1	11.5	17.6	16.6	33.1	7.3	6.2	5.6	
	Max.	592.7	551.1	411.5	338.7	402.4	410.6	375.9	168.2	169.4	147.3	
	Min.	107.6	171.6	180.9	175.1	204.0	240.4	116.0	94.4	116.4	113.6	
PM (g/gal):	Avg.	6.0	7.5	3.3	2.7	3.2	3.6	3.1	3.8	4.8	8.2	
	St. Dev.	3.3	2.4	0.6	0.5	0.4	0.4	0.5	2.0	0.7	1.0	
	Max.	31.9	14.9	8.2	6.9	6.0	6.4	5.6	14.5	6.3	10.2	
	Min.	-13.8	3.3	2.8	1.6	2.2	2.3	2.2	2.0	2.6	5.0	
CO (g/gal:)	Avg.	6.6	8.2	6.3	6.7	8.1	16.3	7.1	6.9	6.0	6.2	
THC (g/gal:)	Avg.	32.4	48.9	53.6	34.3	35.1	33.7	23.4	23.1	29.7	37.4	
CO <sub>2</sub> (g/gal):	Avg.	10140	10121	10120	10138	10135	10124	10149	10149	10144	10136	
Notch Weighting Factor		0.38	0.125	0.065	0.065	0.052	0.044	0.038	0.039	0.03	0.162	
Gross hp		19	28	188	474	1000	1510	2193	2882	3658	4486	
Observed Fuel Rate (lb/hr)		18.4	30.8	82.3	188.4	387.9	555.2	825.4	1079.3	1299.7	1635.5	
NO <sub>x</sub> Emissions (g / lb)		35.3	30.4	30.8	30.1	41.9	40.0	19.4	17.0	21.4	18.3	
NO <sub>x</sub> Emissions (g / hr)		649	935	2538	5680	16257	22196	16000	18380	27801	29981	
PM Emissions (g / lb)		0.84	1.05	0.47	0.38	0.45	0.50	0.44	0.53	0.68	1.16	
PM Emissions (g / hr)		15	32	38	72	175	278	364	575	881	1889	Total:
CO Emissions (g / lb)		0.93	1.15	0.88	0.94	1.15	2.30	1.00	0.97	0.84	0.88	
CO Emissions (g / hr)		17.2	35.5	72.7	177.6	445.4	1277.0	825.5	1049.4	1091.8	1438.6	
Weighted hp		7.2	3.5	12.2	30.8	52.0	66.4	83.3	112.4	109.7	726.7	1204
Weighted NO <sub>x</sub> Emissions (g/hr)		246.6	116.9	165.0	369.2	845.4	976.6	608.0	716.8	834.0	4856.9	9735
Weighted PM Emissions (g/hr)		5.9	4.1	2.5	4.7	9.1	12.2	13.8	22.4	26.4	306.0	407.2
Weighted CO Emissions (g/hr)		6.52	4.44	4.73	11.54	23.16	56.19	31.37	40.93	32.75	233.05	445

RSD Measurements over the Duty Cycle (g / bhp hr):

<b>NO<sub>x</sub></b>	<b>PM</b>	<b>CO</b>
<b>8.08</b>	<b>0.338</b>	<b>0.369</b>

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## Phase 3 Data – Tier 2 Locomotive



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Tier 2 Locomotive UP 5436  
**40 CFR Part 92**  
Line Haul Duty Cycle  
First Test: January 28, 2008

Notch Setting:

	Low Idle	Idle	DB2	1	2	3	4	5	6	7	8	
Uncorrected NO <sub>x</sub> (g/gal):	150.3	150.3	138.8	136.6	113.0	97.2	97.3	91.1	104.6	110.6	104.8	
PM (g/gal):	2.6	2.6	5.2	5.1	5.7	4.9	5.1	2.1	1.8	1.7	1.6	
CO (g/gal:)	16.6	16.6	14.1	12.5	13.1	22.4	36.7	14.1	10.3	7.1	7.1	
THC (g/gal:)	8.5	8.5	5.1	4.3	4.1	2.4	1.5	2.1	2.4	2.9	2.9	
Notch Weighting Factor	0.19	0.19	0.125	0.065	0.065	0.052	0.044	0.038	0.039	0.03	0.162	
Gross hp	16	16	205	286	575	1213	1706	2284	3035	3717	4399	
Observed Fuel Rate (lb/hr)	21.1	21.1	98.6	111.1	218.1	436.2	621.5	819.3	1020	1236	1478	
NO <sub>x</sub> Emissions (g / lb)	21.4	21.4	19.8	19.5	16.1	13.9	13.9	13.0	14.9	15.8	14.9	
NO <sub>x</sub> Emissions (g / hr)	452	452	1953	2164	3514	6048	8629	10647	15228	19495	22098	
PM Emissions (g / lb)	0.37	0.37	0.74	0.73	0.81	0.70	0.73	0.30	0.25	0.24	0.22	
PM Emissions (g / hr)	8	8	73	81	177	304	452	248	255	296	329	
CO Emissions (g / lb)	2.37	2.37	2.01	1.79	1.87	3.19	5.23	2.02	1.46	1.02	1.01	
CO Emissions (g / hr)	50.0	50.0	198.5	198.8	408.9	1391	3254	1652	1492	1260	1500	
Weighted hp	3.0	3.0	25.6	18.6	37.4	63.1	75.1	86.8	118.4	111.5	712.6	1255
Weighted NO <sub>x</sub> Emissions (g/hr)	85.9	85.9	244.1	140.7	228.4	314.5	379.7	404.6	593.9	584.9	3580	6642
Weighted PM Emissions (g/hr)	1.5	1.5	9.1	5.3	11.5	15.8	19.9	9.4	9.9	8.9	53.2	145.9
Weighted CO Emissions (g/hr)	9.50	9.50	24.81	12.92	26.58	72.35	143.2	62.8	58.18	37.80	242.9	700

**FTP over the Duty Cycle (g / bhp hr):**     
**NO<sub>x</sub> (g / bhp hr)**     
**PM (g / bhp hr)**     
**CO (g / bhp hr)**  
5.292                                     
0.116                                     
0.558

Tier 2 Locomotive UP 5436  
**40 CFR Part 92**  
Line Haul Duty Cycle  
Second Test: January 29, 2008

Notch Setting:

	Idle	DB2	1	2	3	4	5	6	7	8	
Uncorrected NO <sub>x</sub> (g/gal):	150.1	131.2	137.1	117.3	94.4	97.6	91.1	104.6	107.6	106.4	
PM (g/gal):	3.4	5.1	4.8	5.7	4.6	5.1	2.1	1.7	1.6	1.6	
CO (g/gal):	17.1	13.6	12.5	13.3	23.9	36.7	14.6	10.0	7.4	6.8	
THC (g/gal):	9.1	4.9	4.4	4.3	2.5	1.6	2.2	2.3	2.9	3.0	
Notch Weighting Factor	0.38	0.125	0.065	0.065	0.052	0.044	0.038	0.039	0.03	0.162	
Gross hp	22	213	280	573	1196	1687	2273	3007	3699	4348	
Observed Fuel Rate (lb/hr)	21.2	85.4	108.0	213.7	452.2	622.6	818.4	1021.6	1232	1478	
NO <sub>x</sub> Emissions (g / lb)	21.4	18.7	19.6	16.7	13.5	13.9	13.0	14.9	15.4	15.2	
NO <sub>x</sub> Emissions (g / hr)	454	1598	2113	3575	6091	8665	10635	15249	18918	22421	
PM Emissions (g / lb)	0.49	0.73	0.68	0.81	0.66	0.73	0.30	0.24	0.23	0.24	
PM Emissions (g / hr)	10	63	74	173	300	454	245	245	288	348	Total:
CO Emissions (g / lb)	2.43	1.94	1.79	1.90	3.41	5.24	2.08	1.42	1.05	0.98	
CO Emissions (g / hr)	51.6	165.7	193.3	406.5	1541.1	3261	1701	1453	1300	1441	
Weighted hp	8.4	26.6	18.2	37.2	62.2	74.2	86.4	117.3	111.0	704.4	1246
Weighted NO <sub>x</sub> Emissions (g/hr)	172.4	199.8	137.3	232.3	316.7	381.3	404.1	594.7	567.5	3632	6638
Weighted PM Emissions (g/hr)	3.9	7.8	4.8	11.2	15.6	20.0	9.3	9.6	8.6	56.3	147.2
Weighted CO Emissions (g/hr)	19.61	20.71	12.56	26.42	80.14	143.5	64.63	56.67	38.99	233.5	696.7

<b>FTP over the Duty Cycle (g / bhp hr):</b>	<b>NO<sub>x</sub> (g / bhp hr)</b> 5.328	<b>PM (g / bhp hr)</b> 0.118	<b>CO (g / bhp hr)</b> 0.559
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Tier 2 Locomotive UP 5436  
**Indirect Remote Sensing Device**  
Line Haul Duty Cycle  
Second Test: January 29, 2008

Notch Setting:

		Idle	DB2	1	2	3	4	5	6	7	8	
NO <sub>x</sub> (g/gal):	Avg.	134.5	121.7	123.9	107.2	96.0	86.3	87.3	97.8	103.5	102.9	
	St. Dev.	23.3	5.4	5.4	8.9	5.5	6.0	4.7	5.2	3.9	3.1	
	Max.	205.8	134.5	138.9	149.5	116.6	115.0	98.9	112.7	116.0	115.6	
	Min.	59.1	111.4	106.2	83.0	75.6	72.3	71.6	72.1	89.9	91.9	
PM (g/gal):	Avg.	15.4	21.7	25.9	25.2	24.9	11.7	4.0	3.5	2.9	2.4	
	St. Dev.	10.6	17.2	17.9	29.9	22.1	12.2	1.1	0.6	0.3	0.2	
	Max.	45.7	65.6	77.0	177.7	90.9	100.6	13.9	9.1	4.7	3.5	
	Min.	2.7	5.9	6.6	5.6	5.1	5.2	3.0	2.6	2.2	2.0	
CO (g/gal):	Avg.	163.2	128.8	130.2	88.7	115.7	56.1	16.0	12.7	10.5	9.5	
THC (g/gal):	Avg.	-8.5	-9.6	-6.5	1.7	-5.0	5.2	3.4	2.9	2.5	2.8	
CO <sub>2</sub> (g/gal):	Avg.	9817	9873	9867	9924	9889	9972	10037	10042	10046	10048	
Notch Weighting Factor		0.38	0.125	0.065	0.065	0.052	0.044	0.038	0.039	0.03	0.162	
Gross hp		22	213	280	573	1196	1687	2273	3007	3699	4348	
Observed Fuel Rate (lb/hr)		21.2	85.4	108.0	213.7	452.2	622.6	818.4	1022	1232	1478	
NO <sub>x</sub> Emissions (g / lb)		19.2	17.4	17.7	15.3	13.7	12.3	12.4	13.9	14.8	14.7	
NO <sub>x</sub> Emissions (g / hr)		407	1483	1909	3269	6191	7667	10189	14249	18201	21700	
PM Emissions (g / lb)		2.19	3.10	3.69	3.59	3.55	1.66	0.57	0.50	0.41	0.35	
PM Emissions (g / hr)		46	265	399	768	1604	1036	466	509	505	514	Total:
CO Emissions (g / lb)		23.28	18.37	18.58	12.65	16.50	8.00	2.29	1.81	1.49	1.35	
CO Emissions (g / hr)		493.4	1569	2006	2704	7461	4979	1872	1847	1837	1993	
Weighted hp		8.4	26.6	18.2	37.2	62.2	74.2	86.4	117.3	111.0	704.4	1246
Weighted NO <sub>x</sub> Emissions (g/hr)		154.5	185.4	124.1	212.5	321.9	337.4	387.2	555.7	546.0	3515	6340
Weighted PM Emissions (g/hr)		17.7	33.1	25.9	49.9	83.4	45.6	17.7	19.9	15.2	83.2	391.4
Weighted CO Emissions (g/hr)		187.5	196.1	130.4	175.8	388.0	219.1	71.12	72.04	55.11	322.8	1818

	<b>NO<sub>x</sub> (g / bhp hr)</b>	<b>PM (g / bhp hr)</b>	<b>CO (g / bhp hr)</b>
<b>RSD over the Duty Cycle (g / bhp hr):</b>	<b>5.089</b>	<b>0.314</b>	<b>1.459</b>

Tier 2 Locomotive UP 5436  
**Indirect Remote Sensing Device**  
Line Haul Duty Cycle  
Third Test: January 30, 2008

Notch Setting:

		Idle	DB2	1	2	3	4	5	6	7	8	
NO <sub>x</sub> (g/gal):	Avg.	157.6	144.3	148.0	120.7	105.8	97.9	102.1	116.8	124.8	119.0	
	St. Dev.	39.0	10.0	8.6	10.9	8.1	5.0	6.9	6.7	5.4	3.9	
	Max.	229.1	181.5	180.1	171.5	142.9	111.7	125.8	138.3	145.4	130.9	
	Min.	112.2	128.5	131.9	101.5	89.3	81.6	85.3	93.0	110.9	108.4	
PM (g/gal):	Avg.	1.6	4.3	4.4	4.7	4.6	5.2	2.6	1.5	1.3	1.3	
	St. Dev.	1.1	0.6	0.6	0.8	0.6	1.0	1.1	0.3	0.3	0.2	
	Max.	5.1	6.6	6.2	8.9	8.0	11.8	8.0	3.4	2.3	2.0	
	Min.	-0.8	2.0	0.1	1.1	3.0	3.6	1.2	0.5	0.7	0.8	
CO (g/gal:)	Avg.	11.7	8.5	7.7	9.5	13.0	24.2	11.8	6.1	4.2	4.7	
THC (g/gal:)	Avg.	38.2	32.9	27.9	34.2	15.9	11.7	7.5	7.6	8.5	9.7	
CO <sub>2</sub> (g/gal):	Avg.	10009	10019	10025	10016	10029	10016	10039	10048	10050	10048	
Notch Weighting Factor		0.38	0.125	0.065	0.065	0.052	0.044	0.038	0.039	0.03	0.162	
Gross hp		22	210	280	573	1199	1692	2280	3010	3700	4363	
Observed Fuel Rate (lb/hr)		21.0	97.0	110.2	216.3	458.9	628.7	824.4	1037.3	1246.4	1488.8	
NO <sub>x</sub> Emissions (g / lb)		22.5	20.6	21.1	17.2	15.1	14.0	14.6	16.7	17.8	17.0	
NO <sub>x</sub> Emissions (g / hr)		472	1997	2327	3724	6929	8776	12007	17291	22183	25266	
PM Emissions (g / lb)		0.22	0.62	0.63	0.67	0.66	0.75	0.36	0.21	0.18	0.19	
PM Emissions (g / hr)		5	60	69	145	304	468	300	216	230	276	
CO Emissions (g / lb)		1.67	1.21	1.10	1.36	1.85	3.45	1.69	0.87	0.60	0.67	Total:
CO Emissions (g / hr)		35.0	117.2	121.2	294.5	847.8	2172.1	1390.6	907.2	751.4	995.3	
Weighted hp		8.4	26.3	18.2	37.2	62.3	74.4	86.6	117.4	111.0	706.8	1249
Weighted NO <sub>x</sub> Emissions (g/hr)		179.4	249.6	151.3	242.1	360.3	386.1	456.3	674.3	665.5	4093.1	7458
Weighted PM Emissions (g/hr)		1.8	7.5	4.5	9.4	15.8	20.6	11.4	8.4	6.9	44.7	131.1
Weighted CO Emissions (g/hr)		13.31	14.65	7.88	19.14	44.09	95.57	52.84	35.38	22.54	161.23	467

	<b>NO<sub>x</sub> (g / bhp hr)</b>	<b>PM (g / bhp hr)</b>	<b>CO (g / bhp hr)</b>
<b>RSD over the Duty Cycle (g / bhp hr):</b>	<b>5.973</b>	<b>0.105</b>	<b>0.374</b>