

APPENDIX B

Diesel Particulate Matter Emission Factors and Stack Parameters for Locomotives

Appendix B provides the diesel PM emissions factors and stack parameters for locomotive models observed on trains entering and leaving J.R. Davis Yard in Roseville, California. As discussed in Chapter 4 and Appendix C, 11 different locomotive model classifications were identified based on the diesel engines they used.

The Electro-Motive Division (EMD) of General Motors provided the locomotive engine exhaust gas parameters for the locomotive models. This information was used as inputs for air dispersion modeling, e.g., a g/hr emission factor, stack exit velocities, stack dimensions, stack heights, and stack temperatures.

The following is a brief description of the data presented in the tables contained in Appendix B.

Table B-1: This table presents diesel PM emission factors (EFs) for locomotives and the source of the data. This data was compiled from all available emissions data for locomotives with the majority of the data obtained from U.S. EPA's Locomotive Emission Standards Regulatory Support Document, April 1998. It also identifies additional locomotive model groups that were included in the 11 different locomotive model groups based on similar engine configurations.

Tables B-2 through B-8: These tables contain stack parameters by notch setting for specific EMD locomotive models that were considered in UPRR's locomotive fleet. Approximately 66 percent of UPRR's locomotive fleet are comprised of locomotives manufactured by EMD.

Table B-1: Diesel PM Emission Factors for Locomotives

Model Number	Engine Type	Idle	Dynamic Brake*	Throttle Notches								DATA REFERENCES
				1	2	3	4	5	6	7	8	
Switchers (1)	EMD 12-645E	g/bhp/hr	0.80	0.32	0.33	0.31	0.24	0.23	0.28	0.25	0.28	EPA RSD, APPENDIX B, 12/17/97
		hp	15	72	233	440	669	885	1109	1372	1586	
GP-60	EMD 16-710G3A	g/hr	31	56	76	138	159	201	308	345	448	SWITCHERS
		g/bhp/hr	3.18	4.09	0.25	0.31	0.23	0.21	0.25	0.21	0.23	EPA Locomotive Emissions Regulation
SD-70	EMD 16-710G3B	hp	5.00	23.00	430.00	975.00	1351.00	1817.00	2637.00	3496.00	4036.00	RSD, Appendix B, 12/17/97
		g/hr	15.90	94.07	133.30	292.50	310.73	381.57	659.25	734.16	928.05	LINE-HAUL LOCOMOTIVE
Table 14, BN#9457, avg Part #8 (SD70MAC)	EMD 16-710G3B	g/bhp/hr	1.67	2.41	0.26	0.23	0.20	0.19	0.21	0.24	0.25	EMISSIONS MEASUREMENTS -
		hp	10.80	13.90	202.00	435.00	1514.00	2003.00	2876.00	3640.00	4187.00	LOCOMOTIVES BY STEVEN G. FRITZ
GP-40 (3)	EMD 16-645-E3	g/hr	18.00	33.50	52.12	99.62	229.83	298.26	388.58	603.96	880.88	FINAL REPORT, AUGUST, 1995
		g/bhp/hr	2.82	1.16	0.34	0.33	0.25	0.23	0.28	0.24	0.26	EPA RSD, APPENDIX B
GP-50	EMD 16-645F3B	hp	17	69	105	396	686	1034	1461	1971	2661	LINE-HAUL LOCOMOTIVE
		g/hr	47.94	80.04	35.7	134.3	226.38	258.5	336.03	551.88	638.64	EMD 16-645-E3
GP-38 (4)	EMD 16-645E	g/bhp/hr	2.89	1.78	0.25	0.30	0.23	0.21	0.24	0.21	0.24	EPA RSD, APPENDIX B
		hp	9	36	205	475	1005	1353	1876	2786	3454	LINE-HAUL LOCOMOTIVE
GE Dash 9	GE 7 FDL, 16 cylinde	g/hr	26.01	64.06	51.25	142.5	301.5	311.19	393.96	663.84	725.34	
		g/bhp/hr	2.53	0.88	0.32	0.32	0.24	0.23	0.28	0.26	0.29	EPA RSD, APPENDIX B
GE Dash 8	GE 7 FDL, 12 or 16 cylinder	hp	15	82	98	333	589	871	1161	1465	1810	LINE-HAUL LOCOMOTIVE
		g/hr	38.00	72.00	110.00	186.00	212.00	267.00	417.00	463.00	608.00	
GE Dash 7	GE HDL	g/bhp/hr										RECEIVED FROM GENERAL
		hp	45.872	47.641	59.3804	115.0184	232.4322	253.4752	430.6692	596.216	671.6898	643.2664
C60-A	EMD 16V265H	g/hr	2.48	1.63	0.45	0.32	0.31	0.21	0.16	0.14	0.15	Tier 0 DASH 9 (BNSF 5419) & AC 4400
		g/bhp/hr	14.9	90.5	191.2	416.2	940.2	1396	2048.4	2668	3352.9	4100.6
SD-90MACH	EMD 16V265H	hp	36.952	147.515	86.04	133.184	291.462	293.16	327.744	373.52	489.406	ELECTRIC (Cert data)
		g/hr	9.12	5.32	0.67	0.35	0.45	0.24	0.18	0.18	0.18	DASH 8 MFT TIER 0
Locomotives Groups	(1) Includes GP15-1, SW1500, MP15, MP15-AC	g/bhp/hr	25.00	117.00	300.00	700.00	1050.00	1550.00	2050.00	2600.00	3000.00	EPA RSD, APPENDIX B
		hp	228.00	622.44	100.50	201.00	245.00	372.00	369.00	468.00	540.00	LINE-HAUL LOCOMOTIVE
Locomotives Groups	(2) Includes SD70, SD75, SD70M & SD70MAC	g/hr										RECEIVED FROM GENERAL
		hp	67.8019	147.869	108.765	168.545	337.9375	305.4352	500.4864	604.6515	713.461	1063.981
Locomotives Groups	(3) Includes GP40, GP40-2, SD40-2, SD45-2, GP45, P420C, F40PH	g/bhp/hr										Tier 0 AC6000, UP 7555
		hp	61.05	108.50	50.10	99.06	255.85	423.70	561.60	329.28	258.15	933.60
Locomotives Groups	(4) Includes GP38-2, GP38-2L, GP39-2, GP39-2L, GP38-3L, SD38-2	g/hr										Emissions test data
		hp										EMD
Locomotives Groups	(5) Includes C44-9, C44-9W, C44-AC, C44AC/60AC	g/hr										
		hp										
Locomotives Groups	(6) Includes B32-8, C39-8, B39-8, B40-8, C40-8, C41-8	g/hr										
		hp										
Locomotives Groups	(7) Includes B23-7, C30-7, C36-7, B30-7, B36-7, U36B	g/hr										
		hp										

EMD Engine Exhaust Gas Information

Air intake Temp 90 °F Barometer 29.4 In Hg

Table B-2

Switcher, Engine: 12-645E, Stack Diameter: 12", 2 Stacks.						
T/N	Exhaust Flow (cfm)	Exhaust (m ³ /s)	Diameter (m)	Exhaust Velocity (m/s)	Exhaust Temp (°F)	Exhaust Temp (°K)
8	12225	5.7696	0.3048	39.54	830	716
7	10697	5.0484	0.3048	34.59	747	670
6	8735	4.1225	0.3048	28.25	655	619
5	7293	3.4419	0.3048	23.59	577	576
4	5909	2.7887	0.3048	19.11	499	532
3	4673	2.2054	0.3048	15.11	421	489
2	3353	1.5824	0.3048	10.84	325	436
1	2423	1.1435	0.3048	7.84	222	379
Idle	1742	0.8221	0.3048	5.63	156	342
DB-1	4261	2.0110	0.3048	13.78	214	374

Table B-3

GP-3X, Engine:16-645E, Stack Diameter: 12", 2 Stacks.						
T/N	Exhaust Flow (cfm)	Exhaust (m ³ /s)	Diameter (m)	Exhaust Velocity (m/s)	Exhaust Temp (°F)	Exhaust Temp (°K)
8	16580	7.82	0.3048	53.62	820	711
7	14262	6.73	0.3048	46.12	747	670
6	11647	5.50	0.3048	37.67	655	619
5	9724	4.59	0.3048	31.45	577	576
4	7879	3.72	0.3048	25.48	499	532
3	6230	2.94	0.3048	20.15	421	489
2	4470	2.11	0.3048	14.46	325	436
1	3231	1.52	0.3048	10.45	222	379
Idle	2323	1.10	0.3048	7.51	156	342
DB-1	5681	2.68	0.3048	18.37	214	374

Table B-4

GP-4X, Engine: 16-645E3B, Stack Diameter:36" X 15", 1 Stack.						
T/N	Exhaust Flow (cfm)	Exhaust (m ³ /s)	Diameter (m)	Exhaust Velocity (m/s)	Exhaust Temp (°F)	Exhaust Temp (°K)
8	19850	9.37	0.666	26.89	730	661
7	16604	7.84	0.666	22.49	728	660
6	13363	6.31	0.666	18.10	650	616
5	11143	5.26	0.666	15.10	592	584
4	8926	4.21	0.666	12.09	522	545
3	7160	3.38	0.666	9.70	448	504
2	5057	2.39	0.666	6.85	353	451
1	3543	1.67	0.666	4.80	233	385
Idle	2752	1.30	0.666	3.73	173	351
DB-1	6985	3.30	0.666	9.46	237	387

EMD Engine Exhaust Gas Information

Air intake Temp 90 °F Barometer 29.4 In Hg

Table B-5

GP-5X, Engine: 16-645F3B, Stack Diameter: 36" X 15", 1 Stack.						
T/N	Exhaust Flow (cfm)	Exhaust (m ³ /s)	Diameter (m)	Exhaust Velocity (m/s)	Exhaust Temp (°F)	Exhaust Temp (°K)
8	23851	11.26	0.666	32.31	634	607
7	20977	9.90	0.666	28.42	759	677
6	15293	7.22	0.666	20.72	767	681
5	12520	5.91	0.666	16.96	641	611
4	9306	4.39	0.666	12.61	552	562
3	6998	3.30	0.666	9.48	450	505
2	5110	2.41	0.666	6.92	382	467
1	3716	1.75	0.666	5.03	317	431
Idle	2446	1.15	0.666	3.31	174	352
DB-1	5517	2.60	0.666	7.47	197	365

Table B-6

GP-6X, Engine: 16-710G3A, Stack Diameter: 34" X 14", 1 Stack.						
T/N	Exhaust Flow (cfm)	Exhaust (m ³ /s)	Diameter (m)	Exhaust Velocity (m/s)	Exhaust Temp (°F)	Exhaust Temp (°K)
8	22867	10.79	0.6253	35.14	645	614
7	19818	9.35	0.6253	30.46	678	632
6	16212	7.65	0.6253	24.91	740	666
5	11442	5.40	0.6253	17.58	650	616
4	11206	5.29	0.6253	17.22	565	569
3	8501	4.01	0.6253	13.06	495	530
2	6498	3.07	0.6253	9.99	348	449
1	5165	2.44	0.6253	7.94	275	408
Idle	2036	0.96	0.6253	3.13	192	362
DB-1	2281	1.08	0.6253	3.51	204	369

Table B-7

SD-70, Engine: 16-710G3B, Stack Diameter: 34" X 14", 1 Stack.						
T/N	Exhaust Flow (cfm)	Exhaust (m ³ /s)	Diameter (m)	Exhaust Velocity (m/s)	Exhaust Temp (°F)	Exhaust Temp (°K)
8	23807	11.24	0.6253	36.59	600	589
7	21525	10.16	0.6253	33.08	670	627
6	16565	7.82	0.6253	25.46	710	650
5	14822	7.00	0.6253	22.78	695	641
4	11726	5.53	0.6253	18.02	630	605
3	8838	4.17	0.6253	13.58	550	561
2	6647	3.14	0.6253	10.22	371	461
1	5171	2.44	0.6253	7.95	296	420
Idle	1995	0.94	0.6253	3.07	195	364
DB-1	2224	1.05	0.6253	3.42	205	369

EMD Engine Exhaust Gas Information

Air intake Temp 90 °F Barometer 29.4 In Hg

Table B-8

SD-90, Engine: 16V265H, Stack Diameter: 36" X 15", 2 Stack.						
	Exhaust	Exhaust	Diameter	Exhaust Velocity	Exhaust	Exhaust Temp
T/N	Flow (cfm)	(m³/s)	(m)	(m/s)	Temp (°F)	(°K)
8	35511	16.76	0.666	24.05	840	722
7	29605	13.97	0.666	20.05	900	755
6	23710	11.19	0.666	16.06	1054	841
5	19049	8.99	0.666	12.90	1050	839
4	12705	6.00	0.666	8.61	1050	839
3	9523	4.49	0.666	6.45	840	722
2	5337	2.52	0.666	3.62	760	677
1	3538	1.67	0.666	2.40	670	627
Idle	2441	1.15	0.666	1.65	530	550
DB-1					620	600