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MOVES run documentation

Gary Dolce o Ron Myers

12/16/2010 05:52 PM

Ron,

Here is a documentation summary. Please let me know if you need more information or if you think it needs other editing.

Thanks,
Gary



Documentation of MOVES runs to support AP.docx

Documentation of MOVES runs to support AP-42 dust method

The particulate collectors in the studies used to derive the AP-42 dust equation include particulates from vehicle exhaust and from brake and tire wear as well as re-entrained road dust. In order to develop an equation for road dust alone, we had to estimate the fraction of particulates coming from vehicle exhaust and brake and tire wear. Previously, these fractions were estimated using MOBILE6.2, which was EPA's approved model for estimating on-road vehicle emissions until it was replaced by the MOVES model in 2010. MOVES includes significant new data about PM emissions from both light duty and heavy duty on-road vehicles which allow MOVES to account for the impacts of ambient temperature, vehicle speed, and vehicle deterioration on emissions. None of these factors were accounted for in MOBILE6.2. For this analysis, we used MOVES2010a, the most current approved version of MOVES.

The particulate studies used in this analysis included information on the date of the test (sometimes month and year, sometimes just year), vehicle speed, ambient temperature, and average vehicle weight. We ran MOVES2010a using inputs that approximated that information as closely as possible. MOVES2010a only provides output for calendar years 1990 and 1999-2050. For road dust data collected before 1990, or for 1991 to 1995, we ran MOVES2010a for calendar year 1990. For data collected from 1996 to 1998, we ran MOVES2010a for calendar year 1999. For data collected in other calendar years, we ran MOVES2010a at the National scale in Inventory mode for the actual calendar year the test was done. Results were specified for a single hour (11:00-11:59 am) of a weekday in July.

The speed distribution input in MOVES accounts for vehicle speed in 5 mph bins. For each one of the individual tests, we ran MOVES2010a allocating all of the vehicle activity to a single speed bin which includes the vehicle speed observed in the test. To reduce the number of number of total runs needed, temperatures for the individual tests were rounded to the nearest multiple of 5 degrees. In a small number of cases, vehicle speed or temperature data were not available for particular tests. In those cases, a vehicle speed of 25 mph or an ambient temperature of 75 degrees was used. All other inputs to MOVES were national defaults.

All vehicle and fuel type combinations (except for electric vehicles) were included. Emissions were generated only for the urban unrestricted road-type. Emissions were generated for all PM10 pollutants (primary exhaust PM10 total, primary PM10 brake wear, and primary PM10 tire wear. Only running exhaust and crankcase running exhaust processes were included in the exhaust emissions calculations as the test sites did not include any starting or idling activity. Inventory results generated by MOVES source type (vehicle type) were divided by VMT to get emission factors by source type for each speed and temperature bin in the original test data.



Fugitive dust analysis

Gary Dolce to: Ron Myers

Cc: David Brzezinski

11/08/2010 05:41 PM

Ron,

We completed the MOVES runs corresponding to each of the road dust test scenarios you provided. The results are in the attached spreadsheet. The columns in orange (Q and R) represent the MOVES data and the impact on the dust emission factor for that test. The final two columns (T and U) show the changes from the original numbers in the spreadsheet, which we understand were calculated with MOBILE. We are not sure how significant these differences are for the rest of your analysis. Note there are three cases where the final dust emission factor is calculated to be negative with the MOVES exhaust, brake, and tire factors subtracted out.

Give me call when you have had a chance to digest this so we can talk about next steps.

Thanks,

Gary

734-214-4414



Fugitive_Dust Final_Summary.xls

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind Concentration (mg/m3)	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)	RunID	LDgpm	HDgpm	Weighted gpm	Estimated PM10 Road Dust Emission Factor (g/VMT)	Vehicle Change Ratio	PM10 Change Ratio
USX 5/1990	AUC3	Nov-89	0.42	27	50	5.5	0.011	2.25	0.153	0.3014	1.949	AUC3	0.0607	1.8196	0.3298	1.9202	1.094	0.985
USX 5/1990	AUC4	Nov-89	0.52	25	63	6	0.04	16.1	0.173	0.3241	15.776	AUC4	0.0481	1.8148	0.3537	15.7463	1.091	0.998
USX 5/1990	AUC5	Nov-89	0.23	29	62	3.9	0.07	15.3	0.087	0.2287	15.071	AUC5	0.0444	1.7651	0.1941	15.1059	0.849	1.002
USX 5/1990	AUC6	Nov-89	0.23	27	39	6.2	0.03	3.7	0.182	0.3332	3.367	AUC6	0.0779	1.8261	0.3961	3.3039	1.189	0.981
USX 5/1990	AUC7	Nov-89	0.26	27	42	3	0.01	0.402	0.05	0.1878	0.214	AUC7	0.0779	1.8261	0.1653	0.2367	0.880	1.106
USX 5/1990	AUC8	Nov-89	0.15	27	40	2	0.03	7.88	0.009	0.1424	7.738	AUC8	0.0779	1.8261	0.0936	7.7864	0.658	1.006
USX 5/1990	AUE1	Nov-89	4	15	43	12	0.01	3.22	0.42	0.5967	2.623	AUE1	0.1013	2.0832	0.9337	2.2863	1.565	0.872
USX 5/1990	AUE2	Nov-89	4	16	44	5.1	0.6	10.6	0.136	0.2832	10.317	AUE2	0.1013	2.0832	0.3709	10.2291	1.310	0.991
USX 5/1990	AUE3	Nov-89	2.2	15	41	2.6	0.08	16.1	0.033	0.1696	15.93	AUE3	0.1153	2.0886	0.1804	15.9196	1.064	0.999
USX 5/1990	AUE4	Nov-89	1.3	15	41	2.6	0.06	9.01	0.033	0.1696	8.84	AUE4	0.1153	2.0886	0.1804	8.8296	1.064	0.999
EPA 7/1984	M-1	Feb-80	0.46	30	28	5.6	0.124	4.99	0.157	0.3059	4.684	M-1	0.0940	1.7944	0.3610	4.6290	1.180	0.988
EPA 7/1984	M-2	Feb-80	0.26	30	27	3.8	0.033	1.55	0.083	0.2242	1.326	M-2	0.1079	1.8026	0.2486	1.3014	1.109	0.981
EPA 7/1984	M-3	Feb-80	0.147	30	28	4.5	0.07	3.54	0.112	0.256	3.284	M-3	0.0940	1.7944	0.2845	3.2555	1.111	0.991
EPA 7/1984	M-4	Feb-80	0.432	35	38	2.1	0.03	0.177	0.013	0.1469	0.03	M-4	0.0744	1.4801	0.0927	0.0843	0.631	2.810
EPA 7/1984	M-5	Feb-80	1.01	35	53	2.2	0.09	0.692	0.017	0.1515	0.541	M-5	0.0510	1.4577	0.0749	0.6171	0.494	1.141
EPA 7/1984	M-6	Feb-80	0.716	30	35	2.1	0.063	1.38	0.013	0.1469	1.233	M-6	0.0822	1.7874	0.1043	1.2757	0.710	1.035
EPA 7/1984	M-7	Feb-80	0.59	35		2.3	0.13	4.22	0.021	0.156	4.064	M-7	0.0851	1.4902	0.1146	4.1054	0.734	1.010
EPA 7/1984	M-8	Feb-80	2.48	20	50	2.2	0.12	11.2	0.017	0.1515	11.049	M-8	0.0750	1.9180	0.1063	11.0937	0.702	1.004
EPA 7/1984	M-9	Feb-80	0.293	30	50	4.1	0.13	3.24	0.095	0.2378	3.002	M-9	0.0560	1.7719	0.2190	3.0210	0.921	1.006
EPA 7/1984	M-10	Feb-80	0.022	55	60	4.5	0.104	0.177	0.112	0.256	0.02	M-10	0.0507	1.2030	0.1798	-0.0028	0.702	-0.139
EPA 7/1984	M-11	Feb-80	0.022	55	56	4.8	0.08	0.322	0.124	0.2696	0.052	M-11	0.0574	1.2143	0.2009	0.1211	0.745	2.329
EPA 7/1984	M-12	Feb-80	0.022	55	65	3.8	0.08	0.084	0.083	0.2242	0.02	M-12	0.0450	1.1933	0.1403	-0.0563	0.626	-2.816
EPA 7/1984	M-13	Feb-80	0.11	35	60	2.7	0.065	0.306	0.038	0.1742	0.132	M-13	0.0454	1.4523	0.0988	0.2072	0.567	1.570
EPA 7/1984	M-14	Feb-80	0.079	35	55	2.7	0.03	1.37	0.038	0.1742	1.196	M-14	0.0510	1.4577	0.1044	1.2656	0.600	1.058
EPA 7/1984	M-15	Feb-80	0.049	35	77	2.7	0.09	1.47	0.038	0.1742	1.296	M-15	0.0351	1.4429	0.0886	1.3814	0.508	1.066
EPA 7/1984	M-16	Feb-80	0.022	55	70	4.3	0.06	0.241	0.103	0.2469	0.02	M-16	0.0402	1.1852	0.1581	0.0829	0.640	4.145
EPA 7/1984	M-17	Feb-80	0.809	30	75	2	0.056	2.64	0.009	0.1424	2.498	M-17	0.0346	1.7599	0.0501	2.5899	0.352	1.037
EPA 7/1984	M-18	Feb-80	0.731	30	75	2	0.08	0.37	0.009	0.1424	0.228	M-18	0.0346	1.7599	0.0501	0.3199	0.352	1.403
EPA 7/1984	M-19	Feb-80	0.929	30	70	2.4	0.05	0.177	0.025	0.1606	0.016	M-19	0.0359	1.7603	0.0791	0.0979	0.492	6.122
EPA 1/1983	Y1	1982	90.7	10	?	3.6	?	117	0.075	0.2151	116.785	Y-1	0.0690	2.1809	0.2274	116.7726	1.057	1.000
EPA 1/1983	Y2	1982	76.1	10	?	3.7	?	182	0.079	0.2196	181.78	Y-2	0.0690	2.1809	0.2359	181.7641	1.074	1.000
EPA 1/1983	Y3	1982	193	10	?	3.8	?	36.3	0.083	0.2242	36.076	Y-3	0.0690	2.1809	0.2443	36.0557	1.090	0.999
EPA 1/1983	Y4	1982	193	10	?	3.7	?	200	0.079	0.2196	199.78	Y-4	0.0690	2.1809	0.2359	199.7641	1.074	1.000
EPA 1/1983	Z1	1982	11.3	10	?	8	?	317	0.256	0.415	316.585	Z-1	0.0690	2.1809	0.6096	316.3904	1.469	0.999
EPA 1/1983	Z2	1982	12.4	15	?	8	?	740	0.256	0.415	739.585	Z-2	0.0547	2.0661	0.5697	739.4303	1.373	1.000
EPA 1/1983	Z3	1982	12.4	15	?	8	?	1820	0.256	0.415	1819.585	Z-3	0.0547	2.0661	0.5697	1819.4303	1.373	1.000
EPA 1/1983	AC4	1982	287	10	?	5.7	?	1750	0.161	0.3105	1749.69	AC-4	0.0690	2.1809	0.4090	1749.5910	1.317	1.000
EPA 1/1983	AC5	1982	188	15	?	7	?	1420	0.214	0.3695	1419.63	AC-5	0.0547	2.0661	0.4852	1419.5148	1.313	1.000
EPA 1/1983	AC6	1982	399	20	?	3.1	?	613	0.054	0.1924	612.808	AC-6	0.0460	1.9085	0.1466	612.8534	0.762	1.000
EPA 1/1983	AD1	1982	94.8	23	?	42	?	1480	1	2.1227	1477.877	AD-1	0.0375	1.8114	1.8114	1478.1886	0.853	1.000

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind Concentration (mg/m3)	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)	RunID	LDgpm	HDgpm	Weighted gpm	Estimated PM10 Road Dust Emission Factor (g/VMT)	Vehicle Change Ratio	PM10 Change Ratio
EPA 1/1983	AD2	1982	63.6	23	?	39	?	342	1	2.1227	339.877	AD-2	0.0375	1.8114	1.8114	340.1886	0.853	1.001
EPA 1/1983	AD3	1982	52.9	23	?	40	?	233	1	2.1227	230.877	AD-3	0.0375	1.8114	1.8114	231.1886	0.853	1.001
EPA 8/1983	F34	1980-81	2.78	NR	90	28	0.552	188	0.789	1.7033	186.297	F34	0.0378	1.8134	1.4388	186.5612	0.845	1.001
EPA 8/1983	F35	1980-81	2.03	NR	90	25	0.057	298	0.699	1.5235	296.476	F35	0.0378	1.8134	1.2790	296.7210	0.839	1.001
EPA 8/1983	F36	1980-81	0.201	NR	50	8.3	0.134	54.7	0.268	0.4286	54.271	F36	0.0607	1.8196	0.5320	54.1680	1.241	0.998
EPA 8/1983	F37	1980-81	0.417	NR	50	17	0.163	77.2	0.626	0.8238	76.376	F37	0.0607	1.8196	1.1617	76.0383	1.410	0.996
EPA 8/1983	F38	1980-81	0.218	NR	50	18	0.301	167	0.667	0.8692	166.131	F38	0.0607	1.8196	1.2339	165.7661	1.420	0.998
EPA 8/1983	F39	1980-81	0.441	NR	50	18	0.177	253	0.667	0.8692	252.131	F39	0.0607	1.8196	1.2339	251.7661	1.420	0.999
EPA 8/1983	F27	1980-81	14.8	NR	100	14	0.531	130	0.502	0.6875	129.312	F27	0.0378	1.8135	0.9292	129.0708	1.352	0.998
EPA 8/1983	F32	1980-81	0.117	NR	90	14	0.138	53.1	0.502	0.6875	52.412	F32	0.0378	1.8134	0.9292	52.1708	1.352	0.995
EPA 8/1983	F61	1980-81	17.9	NR	40	40	0.327	463	1	2.1227	460.877	F61	0.0779	1.8261	1.8261	461.1739	0.860	1.001
EPA 8/1983	F45	1980-81	5.11	NR	50	16	0.744	212	0.585	0.7784	211.222	F45	0.0607	1.8196	1.0896	210.9104	1.400	0.999
EPA 8/1983	F62	1980-81	14.4	NR	45	36	0.294	317	1	2.1227	314.877	F62	0.0686	1.8226	1.8226	315.1774	0.859	1.001
EPA 8/1983	F74	1980-81	5.59	NR	50	29	0.114	545	0.819	1.7632	543.237	F74	0.0607	1.8196	1.5012	543.4988	0.851	1.000
EPA 8/1983	B52	1980-81	7.19	NR	90	12	0.102	35.4	0.42	0.5967	34.803	B52	0.0378	1.8134	0.7836	34.6164	1.313	0.995
EPA 8/1983	B50	1980-81	13.6	NR	90	9.4	0.225	82.1	0.313	0.4786	81.621	B50	0.0378	1.8134	0.5936	81.5064	1.240	0.999
EPA 8/1983	B51	1980-81	13.6	NR	90	11	0.41	140	0.379	0.5512	139.449	B51	0.0378	1.8134	0.7108	139.2892	1.289	0.999
EPA 8/1983	B54	1980-81	3.77	NR	90	10	0.187	93.3	0.338	0.5058	92.794	B54	0.0378	1.8134	0.6379	92.6621	1.261	0.999
EPA 8/1983	B55	1980-81	6.3	NR	90	11	0.295	183	0.379	0.5512	182.449	B55	0.0378	1.8134	0.7108	182.2892	1.289	0.999
EPA 8/1983	B56	1980-81	2.4	NR	90	9.2	0.229	126	0.305	0.4695	125.531	B56	0.0378	1.8134	0.5794	125.4206	1.234	0.999
EPA 8/1983	B58	1980-81	10.4	NR	90	18	0.19	368	0.667	0.8692	367.131	B58	0.0378	1.8134	1.2221	366.7779	1.406	0.999
EPA 8/1983	B57	1980-81	2.32	NR	90	12	0.358	195	0.42	0.5967	194.403	B57	0.0378	1.8134	0.7836	194.2164	1.313	0.999
EPA 8/1983	B59	1980-81	2.06	NR	90	11	0.149	348	0.379	0.5512	347.449	B59	0.0378	1.8134	0.7108	347.2892	1.289	1.000
EPA 8/1983	B60	1980-81	3.19	NR	90	12	0.339	439	0.42	0.5967	438.403	B60	0.0378	1.8134	0.7836	438.2164	1.313	1.000
EPA 4/1997	BH1	1996	0.184	55	?	2.2	0.233	1.08	0.017	0.1515	0.929	BH1	0.0199	0.6453	0.0306	1.0494	0.202	1.130
EPA 4/1997	BH2	1996	0.0127	55	?	2.2	0.03	0.102	0.017	0.1515	0.02	BH2	0.0199	0.6453	0.0306	0.0714	0.202	3.572
EPA 4/1997	BH6	1996	1.47	40	?	2.2	0.3	4.68	0.017	0.1515	4.529	BH6	0.0196	0.8810	0.0343	4.6457	0.226	1.026
EPA 4/1997	BJ6	1996	0.06	45	?	2.2	0.045	0.301	0.017	0.1515	0.15	BJ6	0.0196	0.8394	0.0336	0.2674	0.222	1.783
EPA 4/1997	BJ7	1996	0.06	45	?	2.2	0.13	1.94	0.017	0.1515	1.789	BJ7	0.0196	0.8394	0.0336	1.9064	0.222	1.066
EPA 4/1997	BK7	1996	0.082	45	?	2.2	0.033	0.57	0.017	0.1515	0.419	BK7	0.0196	0.8394	0.0336	0.5364	0.222	1.280
EPA 4/1997	BK8	1996	0.082	45	?	2.2	0.033	0.44	0.017	0.1515	0.289	BK8	0.0196	0.8394	0.0336	0.4064	0.222	1.406
CRA 5/2008	CE-1	Apr-01	1.16	1	54	36	0.05	27	1	11.06	15.94	CE-1	0.1119	4.8801	4.8801	22.1199	0.441	1.388
CRA 5/2008	CE-2	Apr-01	0.86	1	47	36	0.075	64	1	11.06	52.94	CE-2	0.1342	4.8934	4.8934	59.1066	0.442	1.116
CRA 5/2008	CE-11	Apr-01	1.34	5	46	12	0.2	154	0.42	2.212	151.788	CE-11	0.0836	2.4647	1.0837	152.9163	0.490	1.007
CRA 5/2008	CE-3	Apr-01	0.86	1	68	39	0.07	45	1	11.06	33.94	CE-3	0.0893	4.8694	4.8694	40.1306	0.440	1.182
CRA 5/2008	CE-15	Apr-01	1.91	5	67	40	0.065	63.5	1	2.212	61.288	CE-15	0.0576	2.4532	2.4532	61.0468	1.109	0.996
CRA 5/2008	CE-16	Apr-01	1.41	5	64	40	0.05	77.1	1	2.212	74.888	CE-16	0.0576	2.4532	2.4532	74.6468	1.109	0.997
CRA 5/2008	CE-17	Apr-01	2.93	5	64	40	0.04	41.3	1	2.212	39.088	CE-17	0.0576	2.4532	2.4532	38.8468	1.109	0.994
CRA 5/2008	CE-19	Apr-01	0.76	5	55	38	0.04	18.6	1	2.212	16.388	CE-19	0.0686	2.4580	2.4580	16.1420	1.111	0.985
CRA 5/2008	CE-12	Apr-01	1.34	5	66	13	0.085	23.1	0.461	2.212	20.888	CE-12	0.0576	2.4532	1.1620	21.9380	0.525	1.050

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind Concentration (mg/m3)	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)		RunID	LDgpm	HDgpm	Weighted gpm	Estimated PM10 Road Dust Emission Factor (g/VMT)		Vehicle Change Ratio	PM10 Change Ratio
CRA 5/2008	CF-1N	Jun-01	0.97	5	76	40	0.035	4.99	1	2.212	2.778		CF-1N	0.0519	2.4546	2.4546	2.5354		1.110	0.913
CRA 5/2008	CF-1/South	Jun-01	0.97	1	81	40	0.04	19.5	1	11.06	8.44		CF-1S	0.0873	4.8809	4.8809	14.6191		0.441	1.732
CRA 5/2008	CF-2N	Jun-01	0.81	5.3	92	41	0.044	16.3	1	2.0868	14.213		CF-2N	0.0522	2.4663	2.4663	13.8337		1.182	0.973
CRA 5/2008	CF-2/South	Jun-01	0.81	1	92	41	0.08	63.5	1	11.06	52.44		CF-2S	0.0877	4.8964	4.8964	58.6036		0.443	1.118
CRA 5/2008	CF-3N	Jun-01	0.63	5.1	63	41	0.015	1.09	1	2.1686	0.02		CF-3N	0.0576	2.4532	2.4532	-1.3632		1.131	-68.158
CRA 5/2008	CF-3/South	Jun-01	0.63	1	68	41	0.025	23.1	1	11.06	12.04		CF-3S	0.0893	4.8694	4.8694	18.2306		0.440	1.514
CRA 5/2008	CF-4N	Jun-01	1.1	4.7	82	41	0.019	3.08	1	2.3532	0.727		CF-4N	0.0520	2.4585	2.4585	0.6215		1.045	0.855
CRA 5/2008	CF-5	Jun-01	1.4	1	76	41	0.03	16.3	1	11.06	5.24		CF-5	0.0871	4.8733	4.8733	11.4267		0.441	2.181
CRA 5/2008	CI-7	Aug-02	0.05	15.3	70	27	0.03	1.63	0.759	1.6434	0.02		CI-7	0.0275	1.3626	1.0409	0.5891		0.633	29.457
CRA 5/2008	CI-8	Aug-02	0.05	15.3	70	27	0.03	2.99	0.759	1.6434	1.347		CI-8	0.0275	1.3626	1.0409	1.9491		0.633	1.447
CRA 5/2008	CM-1	Sep-03	0.72	5	63	39.8	0.035	6.35	1	2.212	4.138		CM-1	0.0511	2.3617	2.3617	3.9883		1.068	0.964
CRA 5/2008	CM-2	Sep-03	0.72	1	75	39.6	0.05	63.5	1	11.06	52.44		CM-2	0.0778	4.6956	4.6956	58.8044		0.425	1.121
CRA 5/2008	CM-4	Sep-03	0.7	5	65	39.5	0.035	7.26	1	2.212	5.048		CM-4	0.0511	2.3617	2.3617	4.8983		1.068	0.970



Paved Roads data - Test locations
Ron Myers to: Gary Dolce

11/02/2010 04:45 PM

Gary:

Some additional information on the county where the tests were conducted: See attached file



Paved_Road_Data_Table-4-17_mod.docx

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Table 4-17. Final Paved Roads Emissions Factor Data Set

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind Concentration (mg/m ³)	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
USX 5/1990 Fairless Hills, PA	AUC3	11/1989	0.42	27	50	5.5	0.011	2.25	0.153	0.3014	1.949
	AUC4	11/1989	0.52	25	63	6	0.04	16.1	0.173	0.3241	15.776
	AUC5	11/1989	0.23	29	62	3.9	0.07	15.3	0.087	0.2287	15.071
	AUC6	11/1989	0.23	27	39	6.2	0.03	3.7	0.182	0.3332	3.367
	AUC7	11/1989	0.26	27	42	3	0.01	0.402	0.050	0.1878	0.214
	AUC8	11/1989	0.15	27	40	2	0.03	7.88	0.009	0.1424	7.738
	AUE1	11/1989	4	15	43	12	0.01	3.22	0.420	0.5967	2.623
	AUE2	11/1989	4	16	44	5.1	0.6	10.6	0.136	0.2832	10.317
	AUE3	11/1989	2.2	15	41	2.6	0.08	16.1	0.033	0.1696	15.930
	AUE4	11/1989	1.3	15	41	2.6	0.06	9.01	0.033	0.1696	8.840
	M-1 7 th Street, Kansas City	2/1980	0.46	30	28	5.6	0.124	4.99	0.157	0.3059	4.684
	M-2 7 th Street, Kansas City	2/1980	0.26	30	27	3.8	0.033	1.55	0.083	0.2242	1.326

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m³)				
EPA 7/1984	M-3 7 th Street, Kansas City	2/1980	0.147	30	28	4.5	0.070	3.54	0.112	0.2560	3.284
	M-4 Volker Blvd, Kansas City	2/1980	0.432	35	38	2.1	0.030	0.177	0.013	0.1469	0.030
	M-5 Volker Blvd, Kansas City	2/1980	1.01	35	53	2.2	0.090	0.692	0.017	0.1515	0.541
	M-6 Rockhill Road, Kansas City	2/1980	0.716	30	35	2.1	0.063	1.38	0.013	0.1469	1.233
	M-7 Volker Blvd, Kansas City	2/1980	0.59	35		2.3	0.130	4.22	0.021	0.1560	4.064
	M-8 Tonganoxie, KS,	2/1980	2.48	20	50	2.2	0.120	11.2	0.017	0.1515	11.049
	M-9 7 th Street, Kansas City, KS	2/1980	0.293	30	50	4.1	0.130	3.24	0.095	0.2378	3.002
	M-10 I-44,	2/1980	0.022	55	60	4.5	0.104	0.177	0.112	0.2560	0.020

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m ³)				
	Hampton by Sublette, St. Louis MO										
	M-11 I-44, Hampton by Sublette, St. Louis MO	2/1980	0.022	55	56	4.8	0.080	0.322	0.124	0.2696	0.052
	M-12 I-44, Hampton by Sublette, St. Louis MO	2/1980	0.022	55	65	3.8	0.080	0.084	0.083	0.2242	0.020
	M-13 Kings Highway and Penrose Park, St. Louis, MO	2/1980	0.11	35	60	2.7	0.065	0.306	0.038	0.1742	0.132
	M-14 Kings Highway and Penrose Park, St. Louis, MO	2/1980	0.079	35	55	2.7	0.030	1.37	0.038	0.1742	1.196
	M-15 Kings Highway	2/1980	0.049	35	77	2.7	0.090	1.47	0.038	0.1742	1.296

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m ³)				
	and Penrose Park, St. Louis, MO										
	M-16 I-44, Hampton by Sublette, St. Louis MO	2/1980	0.022	55	70	4.3	0.060	0.241	0.103	0.2469	0.020
	M-17 24 th and Madison, Granite City, IL	2/1980	0.809	30	75	2	0.056	2.64	0.009	0.1424	2.498
	M-18 24 th and Madison, Granite City, IL	2/1980	0.731	30	75	2	0.080	0.37	0.009	0.1424	0.228
	M-19 Benton Road and Oregon, Granite City, IL	2/1980	0.929	30	70	2.4	0.050	0.177	0.025	0.1606	0.016
	Y1 Missouri	1982	90.7	10	?	3.6		117	0.075	0.2151	116.785
	Y2 Missouri	1982	76.1	10	?	3.7		182	0.079	0.2196	181.780

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m ³)				
EPA 1/1983	Y3 Missouri	1982	193	10	?	3.8		36.3	0.083	0.2242	36.076
	Y4 Missouri	1982	193	10	?	3.7		200	0.079	0.2196	199.780
	Z1 Missouri	1982	11.3	10	?	8		317	0.256	0.4150	316.585
	Z2 Missouri	1982	12.4	15	?	8		740	0.256	0.4150	739.585
	Z3 Missouri	1982	12.4	15	?	8		1820	0.256	0.4150	1819.585
	AC4 Arizona	1982	287	10	?	5.7		1750	0.161	0.3105	1749.690
	AC5 Arizona	1982	188	15	?	7		1420	0.214	0.3695	1419.630
	AC6 Arizona	1982	399	20	?	3.1		613	0.054	0.1924	612.808
	AD1 Kansas	1982	94.8	23	?	42		1480	1.000	2.1227	1477.877
	AD2 Kansas	1982	63.6	23	?	39		342	1.000	2.1227	339.877
	AD3 Kansas	1982	52.9	23	?	40		233	1.000	2.1227	230.877
	F34 Middletown , OH	1980-81	2.78	NR	90	28	0.552	188	0.789	1.7033	186.297
	F35 Middletown	1980-81	2.03	NR	90	25	0.057	298	0.699	1.5235	296.476

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m ³)				
EPA 8/1983	, OH										
	F36 Middletown, OH	1980-81	0.201	NR	50	8.3	0.134	54.7	0.268	0.4286	54.271
	F37 Middletown, OH	1980-81	0.417	NR	50	17	0.163	77.2	0.626	0.8238	76.376
	F38 Middletown, OH	1980-81	0.218	NR	50	18	0.301	167	0.667	0.8692	166.131
	F39 Middletown, OH	1980-81	0.441	NR	50	18	0.177	253	0.667	0.8692	252.131
	F27 Middletown, OH	1980-81	14.8	NR	100	14	0.531	130	0.502	0.6875	129.312
	F32 Middletown, OH	1980-81	0.117	NR	90	14	0.138	53.1	0.502	0.6875	52.412
	F61 Middletown, OH	1980-81	17.9	NR	40	40	0.327	463	1.000	2.1227	460.877
	F45 Middletown, OH	1980-81	5.11	NR	50	16	0.744	212	0.585	0.7784	211.222
	F62 Middletown, OH	1980-81	14.4	NR	45	36	0.294	317	1.000	2.1227	314.877

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m³)				
	F74 Middletown , OH	1980-81	5.59	NR	50	29	0.114	545	0.819	1.7632	543.237
	B52 Houston, TX	1980-81	7.19	NR	90	12	0.102	35.4	0.420	0.5967	34.803
	B50 Houston, TX	1980-81	13.6	NR	90	9.4	0.225	82.1	0.313	0.4786	81.621
	B51 Houston, TX	1980-81	13.6	NR	90	11	0.410	140	0.379	0.5512	139.449
	B54 Houston, TX	1980-81	3.77	NR	90	10	0.187	93.3	0.338	0.5058	92.794
	B55 Houston, TX	1980-81	6.3	NR	90	11	0.295	183	0.379	0.5512	182.449
	B56 Houston, TX	1980-81	2.4	NR	90	9.2	0.229	126	0.305	0.4695	125.531
	B58 Houston, TX	1980-81	10.4	NR	90	18	0.190	368	0.667	0.8692	367.131
	B57 Houston, TX	1980-81	2.32	NR	90	12	0.358	195	0.420	0.5967	194.403

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m³)				
	B59 Houston, TX	1980-81	2.06	NR	90	11	0.149	348	0.379	0.5512	347.449
	B60 Houston, TX	1980-81	3.19	NR	90	12	0.339	439	0.420	0.5967	438.403
EPA 4/1997	BH1 Denver, CO	1996	0.184	55		2.2	0.233	1.08	0.017	0.1515	0.929
	BH2 Denver, CO	1996	0.0127	55		2.2	0.030	0.102	0.017	0.1515	0.020
	BH6 Denver, CO	1996	1.47	40		2.2	0.300	4.68	0.017	0.1515	4.529
	BJ6 Raleigh, NC	1996	0.06	45		2.2	0.045	0.301	0.017	0.1515	0.150
	BJ7 Raleigh, NC	1996	0.06	45		2.2	0.130	1.94	0.017	0.1515	1.789
	BK7 Reno, NV	1996	0.082	45		2.2	0.033	0.57	0.017	0.1515	0.419
	BK8 Reno, NV	1996	0.082	45		2.2	0.033	0.44	0.017	0.1515	0.289
	CE-1 Marshall, Minnesota	4/2001	1.16	1	54	36	0.050	27	1.000	11.06	15.940
	CE-2 Marshall, Minnesota	4/2001	0.86	1	47	36	0.075	64	1.000	11.06	52.940
	CE-11	4/2001	1.34	5	46	12	0.200	154	0.420	2.212	151.788

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m ³)				
CRA 5/2008	Marshall, Minnesota										
	CE-3 Marshall, Minnesota	4/2001	0.86	1	68	39	0.070	45	1.000	11.06	33.940
	CE-15 Marshall, Minnesota	4/2001	1.91	5	67	40	0.065	63.5	1.000	2.212	61.288
	CE-16 Marshall, Minnesota	4/2001	1.41	5	64	40	0.050	77.1	1.000	2.212	74.888
	CE-17 Marshall, Minnesota	4/2001	2.93	5	64	40	0.040	41.3	1.000	2.212	39.088
	CE-19 Marshall, Minnesota	4/2001	0.76	5	55	38	0.040	18.6	1.000	2.212	16.388
	CE-12 Marshall, Minnesota	4/2001	1.34	5	66	13	0.085	23.1	0.461	2.212	20.888
	CF-1N Columbus, Nebraska	6/2001	0.97	5	76	40	0.035	4.99	1.000	2.212	2.778
	CF-1/South Columbus, Nebraska	6/2001	0.97	1	81	40	0.040	19.5	1.000	11.06	8.440
	CF-2N Columbus,	6/2001	0.81	5.3	92	41	0.044	16.3	1.000	2.0868	14.213

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m ³)				
	Nebraska										
	CF-2/South Columbus, Nebraska	6/2001	0.81	1	92	41	0.080	63.5	1.000	11.06	52.440
	CF-3N Columbus, Nebraska	6/2001	0.63	5.1	63	41	0.015	1.09	1.000	2.1686	0.020
	CF-3/South Columbus, Nebraska	6/2001	0.63	1	68	41	0.025	23.1	1.000	11.06	12.040
	CF-4N Columbus, Nebraska	6/2001	1.1	4.7	82	41	0.019	3.08	1.000	2.3532	0.727
	CF-5 Columbus, Nebraska	6/2001	1.4	1	76	41	0.030	16.3	1.000	11.06	5.240
	CI-7 Blair, Nebraska	8/2002	0.05	15.3	70	27	0.030	1.63	0.759	1.6434	0.020
	CI-8 Blair, Nebraska	8/2002	0.05	15.3	70	27	0.030	2.99	0.759	1.6434	1.347
	CM-1 Marshall, Minnesota	9/2003	0.72	5	63	39.8	0.035	6.35	1.000	2.212	4.138
	CM-2 Marshall, Minnesota	9/2003	0.72	1	75	39.6	0.050	63.5	1.000	11.06	52.44

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind Concentration (mg/m³)	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
	CM-4 Marshall, Minnesota	9/2003	0.7	5	65	39.5	0.035	7.26	1.000	2.212	5.048



Paved Road Test Data

Ron Myers to: Gary Dolce, Rudolph Kapichak
Cc: Schell.Bob

10/12/2010 12:22 PM

Gary:

Per our telephone discussion, I am sending you two files.

One is the technical memorandum that was developed by PECHAN to estimate the vehicle exhaust, tire wear and brake wear emissions for the 2003 revision of the AP-42 Paved Road section. In this revision, a decision was made by EPA (PECHAN?) to use the predictive equation that included road emissions, exhaust emissions, brake emissions and tire wear emissions and subtract the national fleet average emissions of exhaust emissions, brake emissions and tire wear emissions. As I discussed with you, this was a simplistic approach which did not recognize that the underlying tests had a broad range of vehicle classes (spark ignition and compression ignition) with a broad range of vehicle emissions. In the most recent proposed revision, I used the individual vehicle classes to estimate the vehicle emissions associated with each emissions test using the average vehicle weight as the indicator of mix of vehicle class in the test.



Pechan_Tech_Memo_1980_Mobile6_EF's_8-21-03.pdf

The next is the data base of all the individual test data runs with the date or approximate date of the tests, the average speed recorded during the tests, the ambient temperature, the average vehicle weight, my estimate of the fraction of heavy duty vehicles in the test (based upon the average vehicle weight recorded and the typical fleet weights in the PECHAN memorandum) and my estimate of the vehicle emissions derived from the Mobile 6.2 estimates provided by PECHAN.



Paved_Road_Data_Table-4-17.doc

As we discussed, we may wish to use MOVES to provide an update emissions estimate for these tests since that provides EPA's best estimate of emissions. As you indicated, the use of the Mobile 6.2 data does not provide the best estimate of vehicle emissions as this model does not reflect all the aspects which may influence spark ignition and diesel ignition emissions. As you will notice in the data table, some of the test data have a significant contribution of vehicle emissions. For your information, all of the vehicle emissions for the CRA 5/2008 data were developed by Prashanth using MOVES.

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Final Draft - Paved Roads
August 22, 2003

The EPA's Emission Factor and Inventory Group announce the availability of a draft section on Paved Roads to Chapter 13, Miscellaneous Sources of the document *Compilation of Air Pollutant Emission Factors, Volume I, AP-42*.

The new draft section and the technical memorandum used to develop the emission factors are available on the AP-42 Chapter 13 web site at <http://www.epa.gov/ttn/chief/ap42/ch13/>. The draft section is available in WordPerfect or Acrobat PDF formats.

The draft section was developed to make the AP-42 section complimentary to EPA's MOBILE6 emission factor model. MOBILE6 now calculates particulate matter emissions from the vehicle exhaust, brake wear and tire wear. Previous versions of the Paved Road section produced emission estimates that included these vehicle emission components plus resuspended road dust. The new draft Paved Road section has been revised so that only resuspended road dust is estimated.

Comments are due not later than **September 22, 2003** and should be addressed to Bill Kuykendal of the Emission Factor and Inventory Group in writing. The address is D205-01, US EPA, Research Triangle Park, NC 27711 or by email to kuykendal.bill@epa.gov. His phone number is (919)541-5372.

**Recommendations for
Emission Factor
Equations in AP-42
Paved Roads Section:**

**TECHNICAL
MEMORANDUM**

PECHAN

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August, 21 2003

I. INTRODUCTION

Section 13.2.1 of AP-42 presents emission factor equations for fugitive dust emissions from paved roads. The current equations estimate PM emissions from reentrained road dust, and vehicle exhaust, brakewear and tirewear emissions. EPA is separating the component of emissions due to exhaust, brakewear and tirewear from the composite fugitive dust emission factor equation in AP-42 for two reasons. The first reason is to eliminate the possibility of double counting emissions. EPA's Mobile6.2 model estimates PM emissions from exhaust, brakewear and tirewear. Double counting results when employing both the fugitive dust emission factors from AP-42 and Mobile6.2 to estimate emissions from vehicle traffic on paved roads. The second reason is to incorporate the decrease in emissions from newer vehicle models and fuel sources. The paved road emission factor equation was developed for vehicles in the 1980 calendar year fleet. Since 1980, improvements in vehicles and fuel have decreased the amount of PM released from exhaust.

The equation in AP-42 was developed from regression analysis of numerous emission tests on paved roads. The tests could not distinguish between emissions from reentrained road dust, exhaust, brakewear and tirewear. Therefore, EPA developed an equation that included all four sources. The PM emission factor equation in AP-42 for the Final Section 13.2.1 Paved Roads dated October 2002 is:

$$E = k \left(\frac{sL}{2} \right)^{0.65} \left(\frac{W}{3} \right)^{1.5}$$

where E = emission factor, in grams per vehicle mile traveled (g/VMT),
 k = particle size factor,
 sL = average silt loading of the road, in grams per square meter (g/m²),
 W = average weight of the vehicle fleet, in tons, and

and 0.65 and 1.5 are curve fitting coefficients. Table 1 gives the particle size factor, k .

Table 1: Particle Size Factor for Paved Road Emission Factor Equation

Particle Size Range	Particle Size Factor, k		
	g/VMT	g/VKT	lb/VMT
PM _{2.5}	1.8	1.1	0.0040
PM ₁₀	7.3	4.6	0.016
PM ₁₅	9.0	5.5	0.020
PM ₃₀	38	24	0.082

The equation is valid for silt loading, mean vehicle weight and mean vehicle speed in the following ranges:

Silt loading:	0.02 - 400 grams per square meter (g/m ²) 0.03 - 570 grains per square foot (gr/ft ²)
Mean vehicle weight:	1.8 - 38 megagrams (Mg) 2.0 - 42 tons
Mean vehicle speed:	16 - 88 kilometers per hour (kph) 10 - 55 miles per hour (mph)

II. DEVELOPMENT OF NEW EMISSION FACTOR EQUATION

The emission factor equation given above must be altered to separate the reentrained road dust component from the mobile source component. In order to accomplish this, the mobile source component of the emission factor must be calculated. The vehicle exhaust, brakewear and tirewear emission factors were obtained from the MOBILE6.2 model. A typical vehicle fleet and fuel source from 1980 was utilized for the model runs. Pechan ran the model for eight different speeds; 25, 30, 35, 40, 45, 50, 55, and 60 mph. The model runs for each speed were executed for a particle size cutoff of 10 microns and 2.5 microns. Tables 2 and 3 present the assumptions used for the model runs.

Table 2: Assumptions Used in MOBILE6.2 Model

Parameter	Value in MOBILE6.2
Calendar Year:	1980
Month:	July
Gasoline Fuel Sulfur Content:	300 ppm
Diesel Fuel Sulfur Content:	500 ppm
Reformulated Gas:	No

Table 3: Vehicle Fleet Assumptions Used in MOBILE6.2 Model

Vehicle Type	LDGV	LDGT12	LDGT34	HDGV	LDDV	LDDT	HDDV	MC
GVWR	3,075	4,105	7,000	35,000	3,705	6,000	70,000	550
VMT Distribution	0.6748	0.1477	0.0758	0.0365	0.0088	0.0118	0.0352	0.0094

The PM₁₀ and PM_{2.5} emission factors in g/VMT were obtained for each vehicle class at the eight different speeds. Table 4 presents the total PM₁₀ and PM_{2.5} emission factors for exhaust, brakewear and tirewear at all 8 speeds. The standard deviation was less than or equal to 0.000223 g/VMT. Based on this

analysis, it is assumed that the vehicle speed was not a factor in exhaust, brakewear and tirewear PM emissions.

**Table 4: Mobile 6.2 Emission Factors for Total PM Emissions
from Exhaust, Brakewear and Tirewear**

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
Total PM10 from Exhaust, Brakewear and Tirewear										
25 mph	0.1053	0.106	0.2748	0.1633	0.383	0.7206	0.7206	2.1227	0.0926	0.2119
30 mph	0.1053	0.106	0.2747	0.1632	0.3827	0.7206	0.7206	2.1227	0.0923	0.2119
35 mph	0.1053	0.1061	0.2746	0.1632	0.3824	0.7206	0.7206	2.1227	0.0921	0.2119
40 mph	0.1053	0.1061	0.2746	0.1632	0.3824	0.7206	0.7206	2.1227	0.0921	0.2119
45 mph	0.1053	0.1061	0.2746	0.1632	0.3824	0.7206	0.7206	2.1227	0.0921	0.2119
50 mph	0.1053	0.1061	0.2746	0.1632	0.3824	0.7206	0.7206	2.1227	0.0921	0.2119
55 mph	0.1053	0.1061	0.2746	0.1632	0.3824	0.7206	0.7206	2.1227	0.0921	0.2119
60 mph	0.1053	0.1061	0.2746	0.1632	0.3824	0.7206	0.7206	2.1227	0.0921	0.2119
Average	0.1053	0.1061	0.2746	0.1632	0.3825	0.7206	0.7206	2.1227	0.0922	0.2119
Std Dev	2.82E-09	4.63E-05	7.44E-05	3.54E-05	2.23E-04	1.13E-08	1.13E-08	0.00E+00	1.81E-04	0.00E+00
Total PM2.5 from Exhaust, Brakewear and Tirewear										
25 mph	0.0686	0.069	0.1853	0.1084	0.2581	0.6519	0.6521	1.9272	0.0595	0.1617
30 mph	0.0686	0.069	0.1852	0.1084	0.2578	0.6519	0.6521	1.9272	0.0592	0.1617
35 mph	0.0686	0.069	0.1851	0.1084	0.2575	0.6519	0.6521	1.9272	0.0589	0.1617
40 mph	0.0686	0.069	0.1851	0.1084	0.2575	0.6519	0.6521	1.9272	0.0589	0.1617
45 mph	0.0686	0.069	0.1851	0.1084	0.2575	0.6519	0.6521	1.9272	0.0589	0.1617
50 mph	0.0686	0.069	0.1851	0.1084	0.2575	0.6519	0.6521	1.9272	0.0589	0.1617
55 mph	0.0686	0.069	0.1851	0.1084	0.2575	0.6519	0.6521	1.9272	0.0589	0.1617
60 mph	0.0686	0.069	0.1851	0.1084	0.2575	0.6519	0.6521	1.9272	0.0589	0.1617
Average	0.0686	0.0690	0.1851	0.1084	0.2576	0.6519	0.6521	1.9272	0.0590	0.1617
Std Dev	0.00E+00	0.00E+00	7.44E-05	0.00E+00	2.23E-04	0.00E+00	0.00E+00	3.90E-08	2.23E-04	2.82E-09

Pechan developed PM_{10} and $PM_{2.5}$ emission factors using the AP-42 paved roads emission factor equation given above. The mean vehicle weight was set at a value for a typical vehicle fleet on paved roads from year 1980, 3.74 tons (EPA, 2001 and EPA, 2003). Pechan calculated emission factors for silt loadings ranging from 0.02 to 400 g/m². The resulting emission factors are given in Table 5 as “AP-42 Composite”.

Pechan then subtracted the value of the average emission factor for exhaust, brakewear and tirewear developed from Mobile 6.2. From Table 4, this value is 0.2119 for PM_{10} and 0.1617 for $PM_{2.5}$. This produced an emission factor for only the reentrained road dust component. Table 5 presents the results of subtracting the mobile source component for PM_{10} and $PM_{2.5}$. According to Section 13.2.1 of AP-42, the paved road emission factor equation is applicable for silt loadings ranging from 0.02 to 400 g/m². The PM_{10} emission factor is not affected in this range, however, the $PM_{2.5}$ emission factor becomes negative at silt loadings less than 0.029 g/m². Since negative emissions are not physically possible, the equation is now only valid for silt loading ranging from 0.03 to 400 g/m².

Table 5: PM₁₀ and PM_{2.5} Emission Factors for Combined Paved Road Emissions (AP-42) Mobile Source Emissions, and Reentrained Road Dust

Silt Loading	PM ₁₀ Emission Factors			PM _{2.5} Emission Factors		
	AP-42 Composite	Exhaust, Brake wear and Tire wear	Reentrained Road Dust	AP-42 Composite	Exhaust, Brake wear and Tire wear	Reentrained Road Dust
g/m ²	g/VMT	g/VMT	g/VMT	g/VMT	g/VMT	g/VMT
0.02	0.5093	0.2119	0.2974	0.1256	0.1617	-0.0361
0.05	0.9239	0.2119	0.7120	0.2278	0.1617	0.0661
0.075	1.2025	0.2119	0.9906	0.2965	0.1617	0.1348
0.1	1.4497	0.2119	1.2378	0.3575	0.1617	0.1958
0.25	2.6299	0.2119	2.4180	0.6485	0.1617	0.4868
0.5	4.1268	0.2119	3.9149	1.0176	0.1617	0.8559
0.75	5.3712	0.2119	5.1593	1.3244	0.1617	1.1627
1.0	6.4756	0.2119	6.2637	1.5967	0.1617	1.4350
2.0	10.1613	0.2119	9.9494	2.5055	0.1617	2.3438
3.0	13.2254	0.2119	13.0135	3.2610	0.1617	3.0993
4.0	15.9448	0.2119	15.7329	3.9316	0.1617	3.7699
5.0	18.4336	0.2119	18.2217	4.5453	0.1617	4.3836
7.0	22.9400	0.2119	22.7281	5.6564	0.1617	5.4947
10.0	28.9254	0.2119	28.7135	7.1323	0.1617	6.9706
25.0	52.4735	0.2119	52.2616	12.9387	0.1617	12.7770
100.0	129.2049	0.2119	128.9930	31.8587	0.1617	31.6970
400.0	318.1397	0.2119	317.9278	78.4454	0.1617	78.2837

Pechan recommends the emission factor equations for PM_{2.5}, PM₁₀, PM₁₅ and PM₃₀ given below.

$$E = k \left(\frac{sL}{2} \right)^{0.65} \left(\frac{W}{3} \right)^{1.5} - C$$

where E = emission factor, in grams per vehicle mile traveled (g/VMT),
 k = particle size factor,
 sL = average silt loading of the road, in grams per square meter (g/m²),
 W = average weight of the vehicle fleet, in tons,
 C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear,

and Table 7 gives the value of C and k .

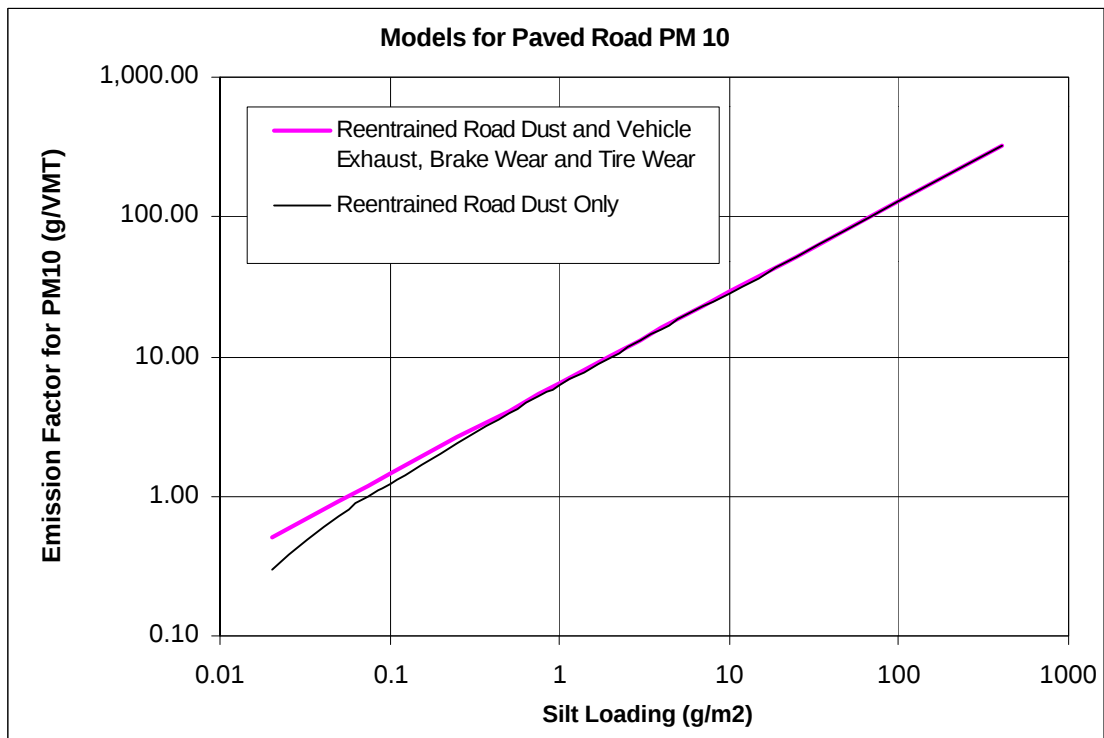
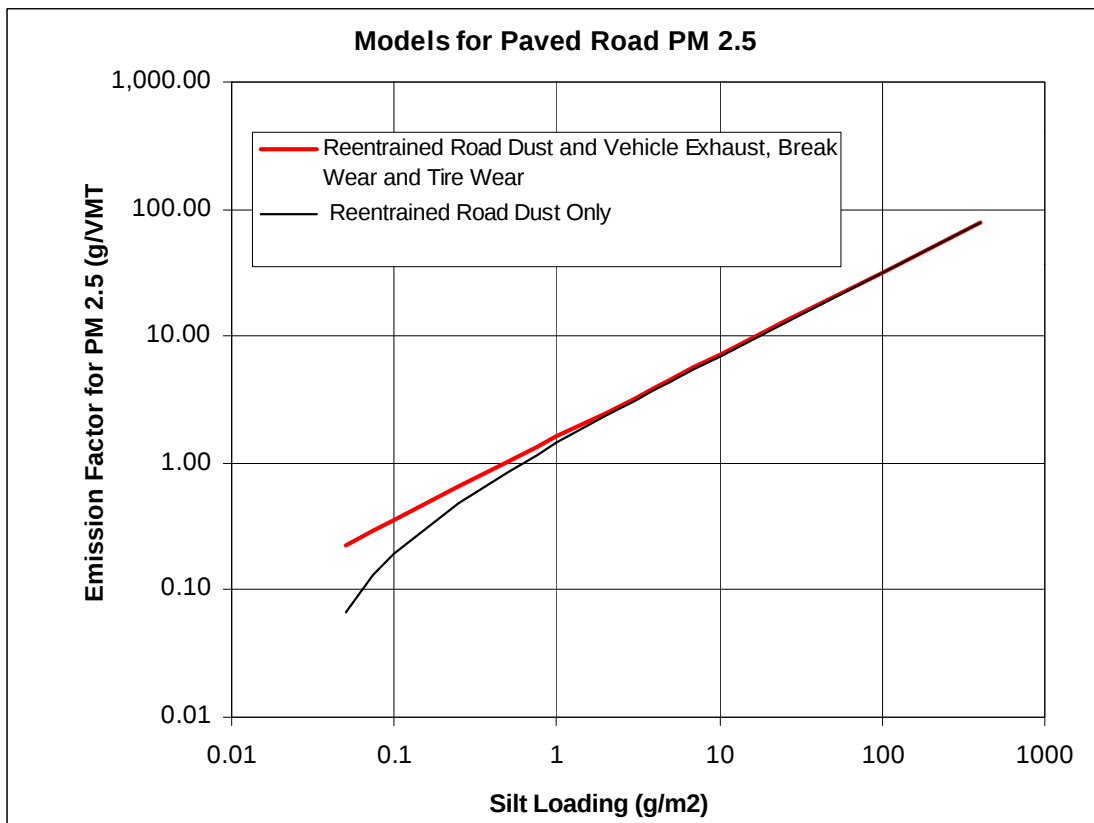
Table 7: Particle Size Factor for Paved Road Emission Factor Equation

Particle Size Range	Emission Factor for Exhaust, Brake Wear and Tire Wear, C			Particle Size Factor, k		
	g/VMT	g/VKT	lb/VMT	g/VMT	g/VKT	lb/VMT
PM _{2.5}	0.1617	0.1005	0.00036	1.8	1.1	0.0040
PM ₁₀	0.2119	0.1317	0.00047	7.3	4.6	0.016
PM ₁₅	0.2119	0.1317	0.00047	9.0	5.5	0.020
PM ₃₀	0.2119	0.1317	0.00047	38	24	0.082

The equation is valid for silt loading, mean vehicle weight and mean vehicle speed in the following ranges:

Silt loading:	0.03 - 400 grams per square meter (g/m ²) 0.04 - 570 grains per square foot (gr/ft ²)
Mean vehicle weight:	1.8 - 38 megagrams (Mg) 2.0 - 42 tons
Mean vehicle speed:	16 - 88 kilometers per hour (kph) 10 - 55 miles per hour (mph)

Figure 1.0 and Figure 2.0 present plots for PM₁₀ and PM_{2.5} of the original emission factor equation with both the reentrained road dust and the vehicle exhaust, brake wear and tire wear components and the modified emission factor with only the reentrained road dust component.

Figure 1.0 Models for PM₁₀ Emission Factor**Figure 2.0 Models for PM_{2.5} Emission Factor**

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Table 4-17. Final Paved Roads Emissions Factor Data Set

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind Concentration (mg/m ³)	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
USX 5/1990	AUC3	11/1989	0.42	27	50	5.5	0.011	2.25	0.153	0.3014	1.949
	AUC4	11/1989	0.52	25	63	6	0.04	16.1	0.173	0.3241	15.776
	AUC5	11/1989	0.23	29	62	3.9	0.07	15.3	0.087	0.2287	15.071
	AUC6	11/1989	0.23	27	39	6.2	0.03	3.7	0.182	0.3332	3.367
	AUC7	11/1989	0.26	27	42	3	0.01	0.402	0.050	0.1878	0.214
	AUC8	11/1989	0.15	27	40	2	0.03	7.88	0.009	0.1424	7.738
	AUE1	11/1989	4	15	43	12	0.01	3.22	0.420	0.5967	2.623
	AUE2	11/1989	4	16	44	5.1	0.6	10.6	0.136	0.2832	10.317
	AUE3	11/1989	2.2	15	41	2.6	0.08	16.1	0.033	0.1696	15.930
	AUE4	11/1989	1.3	15	41	2.6	0.06	9.01	0.033	0.1696	8.840
	M-1	2/1980	0.46	30	28	5.6	0.124	4.99	0.157	0.3059	4.684
	M-2	2/1980	0.26	30	27	3.8	0.033	1.55	0.083	0.2242	1.326
	M-3	2/1980	0.147	30	28	4.5	0.070	3.54	0.112	0.2560	3.284

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m ³)				
EPA 7/1984	M-4	2/1980	0.432	35	38	2.1	0.030	0.177	0.013	0.1469	0.030
	M-5	2/1980	1.01	35	53	2.2	0.090	0.692	0.017	0.1515	0.541
	M-6	2/1980	0.716	30	35	2.1	0.063	1.38	0.013	0.1469	1.233
	M-7	2/1980	0.59	35		2.3	0.130	4.22	0.021	0.1560	4.064
	M-8	2/1980	2.48	20	50	2.2	0.120	11.2	0.017	0.1515	11.049
	M-9	2/1980	0.293	30	50	4.1	0.130	3.24	0.095	0.2378	3.002
	M-10	2/1980	0.022	55	60	4.5	0.104	0.177	0.112	0.2560	0.020
	M-11	2/1980	0.022	55	56	4.8	0.080	0.322	0.124	0.2696	0.052
	M-12	2/1980	0.022	55	65	3.8	0.080	0.084	0.083	0.2242	0.020
	M-13	2/1980	0.11	35	60	2.7	0.065	0.306	0.038	0.1742	0.132
	M-14	2/1980	0.079	35	55	2.7	0.030	1.37	0.038	0.1742	1.196
	M-15	2/1980	0.049	35	77	2.7	0.090	1.47	0.038	0.1742	1.296
	M-16	2/1980	0.022	55	70	4.3	0.060	0.241	0.103	0.2469	0.020
	M-17	2/1980	0.809	30	75	2	0.056	2.64	0.009	0.1424	2.498

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m³)				
	M-18	2/1980	0.731	30	75	2	0.080	0.37	0.009	0.1424	0.228
	M-19	2/1980	0.929	30	70	2.4	0.050	0.177	0.025	0.1606	0.016
EPA 1/1983	Y1	1982	90.7	10	?	3.6		117	0.075	0.2151	116.785
	Y2	1982	76.1	10	?	3.7		182	0.079	0.2196	181.780
	Y3	1982	193	10	?	3.8		36.3	0.083	0.2242	36.076
	Y4	1982	193	10	?	3.7		200	0.079	0.2196	199.780
	Z1	1982	11.3	10	?	8		317	0.256	0.4150	316.585
	Z2	1982	12.4	15	?	8		740	0.256	0.4150	739.585
	Z3	1982	12.4	15	?	8		1820	0.256	0.4150	1819.585
	AC4	1982	287	10	?	5.7		1750	0.161	0.3105	1749.690
	AC5	1982	188	15	?	7		1420	0.214	0.3695	1419.630
	AC6	1982	399	20	?	3.1		613	0.054	0.1924	612.808
	AD1	1982	94.8	23	?	42		1480	1.000	2.1227	1477.877
	AD2	1982	63.6	23	?	39		342	1.000	2.1227	339.877

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m ³)				
	AD3	1982	52.9	23	?	40		233	1.000	2.1227	230.877
EPA 8/1983	F34	1980-81	2.78	NR	90	28	0.552	188	0.789	1.7033	186.297
	F35	1980-81	2.03	NR	90	25	0.057	298	0.699	1.5235	296.476
	F36	1980-81	0.201	NR	50	8.3	0.134	54.7	0.268	0.4286	54.271
	F37	1980-81	0.417	NR	50	17	0.163	77.2	0.626	0.8238	76.376
	F38	1980-81	0.218	NR	50	18	0.301	167	0.667	0.8692	166.131
	F39	1980-81	0.441	NR	50	18	0.177	253	0.667	0.8692	252.131
	F27	1980-81	14.8	NR	100	14	0.531	130	0.502	0.6875	129.312
	F32	1980-81	0.117	NR	90	14	0.138	53.1	0.502	0.6875	52.412
	F61	1980-81	17.9	NR	40	40	0.327	463	1.000	2.1227	460.877
	F45	1980-81	5.11	NR	50	16	0.744	212	0.585	0.7784	211.222
	F62	1980-81	14.4	NR	45	36	0.294	317	1.000	2.1227	314.877
	F74	1980-81	5.59	NR	50	29	0.114	545	0.819	1.7632	543.237
	B52	1980-81	7.19	NR	90	12	0.102	35.4	0.420	0.5967	34.803

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m ³)				
	B50	1980-81	13.6	NR	90	9.4	0.225	82.1	0.313	0.4786	81.621
	B51	1980-81	13.6	NR	90	11	0.410	140	0.379	0.5512	139.449
	B54	1980-81	3.77	NR	90	10	0.187	93.3	0.338	0.5058	92.794
	B55	1980-81	6.3	NR	90	11	0.295	183	0.379	0.5512	182.449
	B56	1980-81	2.4	NR	90	9.2	0.229	126	0.305	0.4695	125.531
	B58	1980-81	10.4	NR	90	18	0.190	368	0.667	0.8692	367.131
	B57	1980-81	2.32	NR	90	12	0.358	195	0.420	0.5967	194.403
	B59	1980-81	2.06	NR	90	11	0.149	348	0.379	0.5512	347.449
	B60	1980-81	3.19	NR	90	12	0.339	439	0.420	0.5967	438.403
EPA 4/1997	BH1	1996	0.184	55		2.2	0.233	1.08	0.017	0.1515	0.929
	BH2	1996	0.0127	55		2.2	0.030	0.102	0.017	0.1515	0.020
	BH6	1996	1.47	40		2.2	0.300	4.68	0.017	0.1515	4.529
	BJ6	1996	0.06	45		2.2	0.045	0.301	0.017	0.1515	0.150
	BJ7	1996	0.06	45		2.2	0.130	1.94	0.017	0.1515	1.789

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m ³)				
	BK7	1996	0.082	45		2.2	0.033	0.57	0.017	0.1515	0.419
	BK8	1996	0.082	45		2.2	0.033	0.44	0.017	0.1515	0.289
CRA 5/2008	CE-1	4/2001	1.16	1	54	36	0.050	27	1.000	11.06	15.940
	CE-2	4/2001	0.86	1	47	36	0.075	64	1.000	11.06	52.940
	CE-11	4/2001	1.34	5	46	12	0.200	154	0.420	2.212	151.788
	CE-3	4/2001	0.86	1	68	39	0.070	45	1.000	11.06	33.940
	CE-15	4/2001	1.91	5	67	40	0.065	63.5	1.000	2.212	61.288
	CE-16	4/2001	1.41	5	64	40	0.050	77.1	1.000	2.212	74.888
	CE-17	4/2001	2.93	5	64	40	0.040	41.3	1.000	2.212	39.088
	CE-19	4/2001	0.76	5	55	38	0.040	18.6	1.000	2.212	16.388
	CE-12	4/2001	1.34	5	66	13	0.085	23.1	0.461	2.212	20.888
	CF-1N	6/2001	0.97	5	76	40	0.035	4.99	1.000	2.212	2.778
	CF-1/South	6/2001	0.97	1	81	40	0.040	19.5	1.000	11.06	8.440
	CF-2N	6/2001	0.81	5.3	92	41	0.044	16.3	1.000	2.0868	14.213

Reference	Run ID	Date of Test	Silt loading (g/m2)	Speed (mph)	Temp (°F)	Weight (tons)	Downwind	Measured PM-10 Emission factor (g/VMT)	Estimated Fraction Heavy Duty Vehicles	Estimated Engine, brake, tire emission factor (g/VMT)	Estimated PM-10 Road Dust Emission factor (g/VMT)
							Concentration (mg/m³)				
	CF-2/South	6/2001	0.81	1	92	41	0.080	63.5	1.000	11.06	52.440
	CF-3N	6/2001	0.63	5.1	63	41	0.015	1.09	1.000	2.1686	0.020
	CF-3/South	6/2001	0.63	1	68	41	0.025	23.1	1.000	11.06	12.040
	CF-4N	6/2001	1.1	4.7	82	41	0.019	3.08	1.000	2.3532	0.727
	CF-5	6/2001	1.4	1	76	41	0.030	16.3	1.000	11.06	5.240
	CI-7	8/2002	0.05	15.3	70	27	0.030	1.63	0.759	1.6434	0.020
	CI-8	8/2002	0.05	15.3	70	27	0.030	2.99	0.759	1.6434	1.347
	CM-1	9/2003	0.72	5	63	39.8	0.035	6.35	1.000	2.212	4.138
	CM-2	9/2003	0.72	1	75	39.6	0.050	63.5	1.000	11.06	52.44
	CM-4	9/2003	0.7	5	65	39.5	0.035	7.26	1.000	2.212	5.048