Significance of PM_{10} regulations for the forest products industry

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To obtain construction and operating permits, facilities that emit significant amounts of particulates will need data on particle size distributions and emissions of particles with nominal diameters of 10 μm or less.

After many years of study and debate, the U. S. Environmental Protection Agency (EPA) issued revised ambient air quality standards for particulate matter in July 1987. The new standards are based on concentrations of particles with nominal diameters of 10 μm or less (PM_{10}). Previously, the ambient particulate standards were based on total suspended particulate (TSP) matter as measured by a high-volume sampler with specified design characteristics.

The shift from TSP to PM_{10} standards is a major one. In fact, EPA is essentially treating PM_{10} as a new criteria pollutant. New sampling methods have been specified for ambient monitoring. States have been given the task of identifying areas not meeting the new ambient standards and developing plans to reduce PM_{10} concentrations in these nonattainment areas. States are also charged with revising their air quality permitting procedures to ensure that new and existing emissions will not cause or contribute to violations of the ambient PM_{10} standards.

Nearly all pulp and paper mills and a considerable percentage of facilities that manufacture solid wood products have air quality permits that contain particulate matter emission limits. Emission sources include power boilers, recovery furnaces, smelt tanks, lime kilns, veneer dryers, chip dryers, press vents, and a number of miscellaneous sources such as slaker vents and starch handling systems. In addition to these stack and vent sources, there are a variety of fugitive emission sources associated with solid fuel handling, woodyard operations, and mill truck traffic.

For mills with particulate emission limits for such sources, the basic question is whether any changes in the limits will be necessary as a result of the new PM_{10} standards. For mills considering expansions that would result in increased particulate emissions, the concerns are about new permitting requirements such as ambient PM_{10} monitoring, estimation of PM_{10} emission rates, and determination of best available control technology for PM_{10} emissions.

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Here, we will look at available ambient PM_{10} concentration data gathered in the vicinity of forest products manufacturing facilities. We will compare these data with the PM_{10} standards and, where possible, to TSP data at the same location. We will also look at factors that affect ambient PM_{10} concentrations, information on EPA-approved ambient samplers, PM_{10} emission factors contained in EPA's AP-42 document (*1*) for boilers and kraft sources, and the effect on permitting of new and modified sources.

PM_{10} monitoring data

In late 1984, a review of available PM_{10} monitoring data indicated that there had been relatively little ambient monitoring done in the vicinity of forest products manufacturing facilities (*2*). The limited data suggested that the ratio of PM_{10} to TSP fell in the range of 0.4 to 0.6 and that PM_{10} concentrations would be less than 150 $\mu g/m^3$ (24 h average) and 50 $\mu g/m^3$ (annual average) at the vast majority of TSP monitoring sites located near these facilities.

Shortly after the final PM_{10} standards were published, EPA made a preliminary identification of areas having either a high (>95% probability) or medium (20–95% probability) likelihood of having PM_{10} concentrations in excess of the standards. These tentative nonattainment area designations were based largely on TSP monitoring data and an assumed relationship between TSP and PM_{10}, since most areas lacked sufficient PM_{10} data to determine whether or not the new standards were being met. The list of areas included several towns and counties in which forest products manufacturing facilities are located. **Table I** lists these areas and shows the types of facilities present.

Although these proposed nonattainment areas contain one or more forest product manufacturing facilities, particulate emissions from the facilities may or may not contribute to the elevated concentrations observed at monitoring sites. However, actual and permitted particulate emission rates of all sources in these areas are likely to be examined as part of the state's plans to reduce PM_{10} concentrations. Concentrations of PM_{10} are likely not homogeneous across an area, and the relative contribution

I. Areas identified by EPA as having a high or medium probability of violating ambient PM10 standards

State	Area	Nonattainment probability	Sources
Idaho	Sandpoint	High	Sawmills
Ind.	Terre Haute	Medium	Pulp and paper mills
Mich.	Monroe	Medium	Pulp and paper mills
Mont.	Columbia Falls	Medium	Sawmills, wood products
Mont.	Eureka	Medium	Sawmills
Mont.	Kalispell	High	Sawmills, wood products
Mont.	Libby	High	Sawmills, wood products
Mont.	Missoula	High	Sawmills, wood products, pulp and paper mills
Mont.	Polson	High	Sawmills, wood products
Mont.	Thompson Falls	Medium	Sawmills
Ohio	Cincinnati	Medium	Pulp and paper mills
Ohio	Middletown	Medium	Pulp and paper mills
Ore.	Bend	Medium	Sawmills, wood products
Ore.	Eugene/Springfield	High	Sawmills, wood products, pulp and paper mills
Ore.	Grants Pass	High	Sawmills, wood products
Ore.	Klamath Falls	High	Sawmills, wood products
Ore.	La Grande	Medium	Sawmills, wood products
Ore.	Medford/White City	High	Sawmills, wood products
Ore.	Portland	Medium	Sawmills, wood products, pulp and paper mills
Pa.	Erie	Medium	Pulp and paper mills
Tex.	Harris County	Medium	Pulp and paper mills
Wash.	Lacey	High	Wood products
Wash.	Tacoma	High	Sawmills, wood products, pulp and paper mills
Wash.	Wallula	High	Pulp and paper mills
Wis.	DePere	Medium	Pulp and paper mills
Wis.	Superior	Medium	Wood products

of various sources such as wood stoves, industrial facilities, fugitive emissions, vegetative burning, and general background will vary depending on location. It may well turn out that most of the emission limits for the forest products facilities will remain unchanged.

PM_{10} monitoring data are available for many of the areas listed in Table I, but non-EPA-approved samplers were extensively used. Most of these samplers were the Sierra-Andersen Model 321-A High Volume Sampling System with size-selective inlet. It is not known if the use of recently upgraded and recently approved samplers would have any significant effect on the measured concentrations.

These PM_{10} monitoring data are summarized in **Table II**, along with any TSP measurements made at the site. Almost all data are for the western states of Montana, Oregon, and Washington. Many sites have annual average concentrations exceeding 50 $\mu g/m^3$, and both the highest and second highest 24-h average concentrations observed during a calendar year exceed 150 $\mu g/m^3$ at several locations. Sites showing elevated PM_{10} concentrations tended to have TSP concentrations that were above the previous TSP ambient air quality standards. Year-to-year variations are apparent, as is the spatial variability in concentrations in areas with more than one monitor.

Factors possibly contributing to the elevated PM_{10} levels observed at the western monitoring sites include:

- Windblown soil in relatively dry areas
- Restricted dispersion of emissions generated in towns located in deep mountain valleys
- Emissions from residential wood burning during periods with cold weather and limited dispersion
- Forest fires
- Prescribed agricultural and silvicultural burning.

Detailed analyses of source contributions will be needed to develop reasonable control strategies to reduce PM_{10} concentrations to acceptable levels. Whether emissions from any forest products facilities in these areas would need to be reduced remains to be determined.

In its 1986 air quality monitoring report (*3*), the Oregon Dept. of Environmental Quality noted that residential wood heating would be the focus of efforts to reduce PM_{10} concentrations in many of the state's nonattainment areas. Slash and controlled agricultural burning might be subject to increased restrictions, since these sources represent approximately 25% of the statewide total primary PM_{10} emissions. The possibility of additional controls for a few industrial sources was mentioned for areas with particularly high PM_{10} concentrations.

In addition to PM_{10} monitoring data collected in potential nonattainment areas having forest products manufacturing facilities, ambient PM_{10} monitoring has been conducted near a number of pulp mills. **Table III**

II. Particulate monitoring data from areas with a medium or high PM_{10} nonattainment probability

			PM_{10}, $\mu g/m^3$				TSP, $\mu g/m^3$			
State	*Area*	*Year*	*No. of samples*	*Annual average*	*Highest*	*Second highest*	*No of samples*	*Annual geo. mean*	*Highest*	*Second highest*
Idaho	Sandpoint	86	?	41	168	133	...	...	...	...
Mont.	Columbia Falls	87	49	55	186	115	...	...	...	...
Mont.	Columbia Falls	86	56	52	146	115	...	...	...	...
Mont.	Columbia Falls	85	29	39	77	76	...	...	...	...
Mont.	Kalispell	87	47	47	119	105	...	...	...	...
Mont.	Kalispell	86	57	61	260	198	...	...	...	...
Mont.	Kalispell	85	20	48	77	68	51	79	441	432
Mont.	Libby	87	60	82	216	214	...	...	...	...
Mont.	Libby	86	54	86	322	214	...	...	...	...
Mont.	Libby	85	31	58	157	112	56	100	642	471
Mont.	Missoula-A	87	114	36	200	162	...	...	...	...
Mont.	Missoula-A	86	253	45	238	227	...	...	...	...
Mont.	Missoula-B	87	97	59	276	245	...	...	...	...
Mont.	Missoula-B	86	321	49	240	225	...	...	...	...
Mont.	Missoula-C	87	69	42	180	125	...	...	...	...
Mont.	Thompson Falls	87	42	49	128	105	...	...	...	...
Mont.	Thompson Falls	86	46	51	113	113	...	...	...	...
Mont.	Thompson Falls	85	26	49	89	85	48	81	604	362
Ore.	Bend	87	43	34	106	79	41	...	179	176
Ore.	Bend	86	61	31	138	94	59	49	198	135
Ore.	Bend	85	48	44	196	125	59	58	264	174
Ore.	Eugene-A	87	46	35	129	124	136	...	167	162
Ore.	Eugene-A	86	61	31	85	72	176	45	132	115
Ore.	Eugene-B	87	265	41	175	174	46	...	237	188
Ore.	Eugene-B	86	354	38	157	114	61	74	218	193
Ore.	Grants Pass	87	46	62	268	230	...	...	...	...
Ore.	Grants Pass	86	64	49	148	104	63	84	241	169
Ore.	Klamath Falls	87	39	67	330	289	43	...	395	394
Ore.	Klamath Falls	86	66	67	412	216	77	88	460	294
Ore.	LaGrande	87	39	53	137	123	35	...	307	240
Ore.	LaGrande	86	52	54	109	104	44	109	222	213
Ore.	Medford	87	45	61	249	207	67	...	322	293
Ore.	Medford	86	115	56	213	172	144	72	258	218
Ore.	Portland-A	87	42	31	68	66	44	...	139	135
Ore.	Portland-A	86	94	30	91	84	127	55	285	136
Ore.	Portland-A	85	85	42	106	98	81	67	176	175
Ore.	Portland-B	87	41	26	72	58	45	42	94	81
Ore.	Portland-B	86	51	26	77	71	67	37	264	102
Ore.	Portland-B	85	83	33	89	87	128	48	184	166
Ore.	Portland-C	87	42	48	123	117	44	...	341	235
Ore.	Portland-C	86	58	54	183	136	61	144	460	385
Ore.	White City	87	44	80	219	210	42	...	384	309
Ore.	White City	86	59	70	218	169	58	136	318	280
Pa.	Erie	86	115	31	140	80	48	45	112	111
Wash.	Lacey	86	146	39	193	179	61	37	231	173
Wash.	Lacey	85	39	91	254	249	53	45	255	166
Wash.	Tacoma-A	86	353	42	175	157	298	68	256	247
Wash.	Tacoma-A	85	130	59	211	206	165	79	335	273
Wash.	Tacoma-B	86	59	44	152	141	59	68	261	221
Wash.	Tacoma-B	85	65	57	162	152	66	83	207	206
Wash.	Tacoma-C	86	60	38	120	110	121	57	322	222
Wash.	Wallula	86	144	63	241	211	53	51	300	278

1987 data through September only.

III. Particulate monitoring data from sites located in the vicinity of forest products manufacturing facilities

State	Distance,* km	Year	PM_{10}, $\mu g/m^3$				TSP, $\mu g/m^3$			
			No. of samples	Annual average	Highest	Second highest	No. of samples	Annual geo. mean	Highest	Second highest
Maine	1.3	85	86	19	63	61	348	25	106	105
		86	117	21	76	57	351	25	119	84
	0.2	85	116	35	70	69	358	41	195	157
		86	169	30	78	77	357	35	142	133
	0.6	86	104	22	134	77	231	27	260	176
	0.5	85	98	32	135	73	191	63	147	145
		86	77	24	79	56	196	57	157	153
	1.0	85	58	33	76	74	107	47	155	127
		86	104	36	115	99	110	45	190	158
N.H.	0.2	85	211	36	109	93	120	65	174	172
		86	330	39	150	115	113	72	270	224
		87	325	37	99	85	113	74	195	186
	0.4	86	172	32	95	73	117	59	202	197
		87	171	32	94	86	113	50	167	152
Wash.	3.0	86	102	37	107	91	60	54	246	145
	1.5, 3.0	85	54	35	80	77	61	46	98	86
		86	57	28	73	68	58	39	96	94
	1.5	86	44	52	101	101	62	65	150	150
	5.5	86	38	62	396	146	42	80	618	304
Idaho	3.0	86	...	41	93	81	...	63	148	123
Ala.	0.8	85	45	21	45	43	45	51	181	104
Ohio	1.5	85	46	32	87	60	57	37	90	72
		86	51	28	101	98	58	35	107	95

*Distance between mills and monitor.

lists the data from these sites and shows the approximate distance between the mill and monitor. The vast majority of these sites appear to have PM_{10} concentrations lower than the PM_{10} standards. Interestingly, some of the TSP measurements exceed the previous secondary TSP ambient air quality standards but do not exceed the new PM_{10} standards. For these locations, the change from TSP to PM_{10} standards is beneficial.

Ambient sampling devices

When EPA sets ambient air quality standards for a particular pollutant, it generally specifies a reference method to measure the pollutant in the ambient air. For PM_{10}, EPA issued a set of performance criteria for ambient sampling devices rather than detailed specifications for a particular reference method. It is the responsibility of equipment manufacturers to demonstrate that their sampling device satisfies all of the performance criteria to be designated as a reference method.

EPA published the final performance criteria on July 1, 1987. As of December 1987, four sampling devices have been designated as EPA-approved reference methods. These are the Wedding & Associates PM_{10} Critical Flow High-Volume Sampler and the Sierra-Andersen or General Metal Works PM_{10} High-Volume Air Sampler System Models 1200, 321-B, and 321-C. These samplers are all upgraded models of earlier sampling systems, which were modified to overcome some minor problems identified during field testing programs.

Although other types of sampling devices, including dichotomous and medium-flow rate samplers, are commercially available and have been used for PM_{10} measurements in the past, the use of high-volume PM_{10} samplers now dominates. The high-volume systems have the advantages of low cost and ease of operation compared to the other systems. Also, existing TSP high-volume sampler systems can be modified to measure PM_{10}, which is another cost advantage. Thus it appears the high-volume systems will be the principal type of sampler used for ambient PM_{10} measurements in the foreseeable future.

PM_{10} emissions

A major impetus for the control of particulate emissions from industrial facilities was EPA's promulgation of ambient air quality standards for TSP in 1971. Since the high-volume sampler was specified as the method for measuring ambient TSP, emphasis was placed on the measurement and control of total particulate emissions from industrial sources. Particulate emission regulations issued by states and New Source Performance Standards issued by EPA were based on stack sampling procedures that measured total particulates, such as EPA Method 5.

With the shift to PM_{10} ambient standards, regulatory agencies will be focusing on the contribution of industrial sources to ambient PM_{10} concentrations. Sources contribute to ambient PM_{10} levels in two ways:

1. Direct emission of particulates with aerodynamic diameters of 10 μm or less (primary particulate)
2. Emission of gases that may eventually form particles with diameters less than 10 μm in the atmosphere (secondary particulate).

IV. Percent of particulate mass emissions with diameters of 10 μm or less (AP-42)

Source	Uncontrolled	Mechanical collector	Wet scrubber	ESP[a]	Fabric filter
Kraft recovery furnace					
Direct contact evaporator	94	...	...	...	...
Noncontact evaporator	...	...	...	75	...
Smelt tank	89	...	90	...	...
Lime kiln	17	...	98	89	...
Boilers					
Bark	35	79/36[b]	87	...	...
Wood and bark	90	91/32[b]	98	...	...
Coal					
Pulverized, dry bottom	23	29	71	67	92
Pulverized, wet bottom	37	93	...	75	...
Cyclone	13	...	94	68	...
Spreader-stoker	20	73/65[b]	...	90	60
Oil residual	86	95	...	...	...
Oil distillate	50	...	...	...	...

[a]Electrostatic precipitator.
[b]With and without fly ash reinjection.

An example of secondary particulate would be sulfates formed from gaseous sulfur dioxide emissions.

Primary particulate

Major emission sources of primary particulate include power boilers, recovery furnaces, lime kilns, smelt dissolving tanks, material handling operations, and fugitive emissions such as dust generated by mill truck traffic. Combustion sources are generally controlled for particulate emissions, as are smelt dissolving tanks and many material handling systems. The fraction of particles that have aerodynamic diameters of 10 μm or less depends on the size distribution of the particles in the gas stream entering the control device and the efficiency of the device for collecting particles of different sizes.

Particle size distributions in exhaust gas streams have been measured with cascade impactors and cyclone sampling systems. Particle size sampling is difficult, and there is considerable uncertainty in the results because of possible measurement errors, potential particle stratification inside stacks, and variations in source and control device operation among different sampling runs. EPA has not yet developed a standard sampling method for making particle size measurements, and one is not expected in the near future. Thus, considerable variability can be expected among reported particle size distributions for similar sources with similar control devices.

In its most recent revision to the AP-42 Emission Factors document (*1*), EPA included summaries of particle size data for a number of source types. **Table IV** gives the percentage of the mass emissions that had aerodynamic diameters of 10 μm or less, as reported by EPA, for sources of interest to the forest products industry. Unfortunately, the database for many of these sources and control device types is limited to one or two measurements. Furthermore, EPA did not indicate the overall efficiency of the control devices sampled nor the total mass emission rates. Therefore, the reported size distributions should not be viewed as representing a broad cross section of similar sources. Many of the results are contrary to intuitive expectations. For example, Table IV shows that a greater fraction of the particulate emissions have diameters over 10 μm for fabric filters as compared to electrostatic precipitators installed on coal-fired spreader-stoker boilers.

Regarding noncombustion sources other than smelt dissolving tanks, virtually no particle size data are available. Particle size distributions for slaker vents, lime and starch handling systems, coal unloading and handling, woodyard operations, and other miscellaneous sources have not been measured.

Considering the limited database on particle size distributions and the source-to-source variability in the measurements, it might be expected that state and local regulatory agencies will request mills to generate source-specific particle size data for permitting purposes, especially if the mill is located in a probable PM_{10} nonattainment area.

Secondary particulate

In some areas, secondary particulates represent a significant fraction of ambient PM_{10} concentrations. Sulfates and nitrates, along with the associated cations, can be important in locales affected by region-wide

emissions of SO_2 and NO_x. Considerable amounts of condensed organic particulates have been measured in locations with a high density of residential wood burning.

A study of PM_{10} concentrations by the California Air Resources Board (4) indicated that approximately 20–40% of the monitored PM_{10} in nonattainment areas was secondary particulate. In the Los Angeles basin, nitrates in combination with associated ammonium ions and water molecules accounted for about one-third of the annual average PM_{10} concentration and up to two-thirds of the 24-h average concentration on days when PM_{10} concentrations exceeded 150 $\mu g/m^3$. Secondary organic particulates represented a significant fraction of wintertime PM_{10} levels in communities with substantial amounts of residential wood burning. The Board concluded that reducing ambient PM_{10} concentrations to meet the ambient air quality standards would require both further control of precursor SO_2, NO_x, and organic emissions and reductions in primary PM_{10} particulate emissions.

Whether SO_2, NO_x, or volatile organic compound emissions from forest products manufacturing facilities will need to be reduced to reduce ambient PM_{10} concentrations in potential nonattainment areas remains to be determined. The limited amount of PM_{10} monitoring data suggest that most mills are in attainment areas, so there seems to be little prospect for further emissions controls to reduce the formation of secondary particulates.

Effect on new source permitting

Air quality permits are normally required for constructing a new source or modifying an existing source. Particulate matter is one of the regulated pollutants that must be addressed in permit applications. The shift from TSP to PM_{10} standards means PM_{10} emissions and their effect on ambient air quality now need to be considered.

Determining PM_{10} emissions from a new source requires a knowledge of the expected mass emission rate and particle size distribution in the exiting exhaust gas stream. Equipment manufacturers will likely be expected to provide this information to prospective purchasers. If particulate control devices are to be installed, permit applicants may need to show that the control device selected represents "best available control technology" (BACT) or "lowest achievable emission rate" (LAER) for PM_{10}. Decisions on BACT and LAER determinations are made on a case-by-case basis, and there is little experience to draw upon at this time.

In situations where an existing mill is to be modified and the modification involves both installation of new sources and retirement of old sources, the net change in PM_{10} emissions has to be calculated. In addition to estimating PM_{10} emissions for the new sources, the emissions from the sources to be retired need to be determined. Depending on the accuracy required, either AP-42 PM_{10} emission factors could be used, or particle size measurements could be made.

Because the PM_{10} standards are relatively new, there is little experience to report concerning actual emission limits for PM_{10} in construction and operating permits. Existing EPA-approved stack sampling methods for particulate matter (i.e., Methods 5, 5B, and 17) measure total particulate emissions. There are no EPA-approved stack sampling methods for obtaining particle size distributions or PM_{10} emissions. If a regulatory agency specifies a PM_{10} emission limit in a source's permit, there would be uncertainty regarding determination of compliance with the limit unless a specific stack sampling method or procedure was identified. Until EPA approves PM_{10} stack sampling procedures, it seems likely that emission limits based on total particulates will continue to be specified in construction and operating permits.

New and modified sources subject to the prevention of significant deterioration (PSD) permitting requirements for particulates will need to perform air quality modeling for both PM_{10} and TSP. The purpose of the PM_{10} modeling is to determine the source's contribution to ambient PM_{10} concentrations. TSP modeling is needed to calculate PSD increment consumption. EPA has indicated that it hopes to establish PSD increments within the next two years for PM_{10}; so TSP modeling may not be required in the future.

Depending on the magnitude of the modeled ground level concentrations, sources subject to PSD requlation may also need ambient PM_{10} monitoring data. Unless the state is already monitoring PM_{10} in the vicinity of the source with an EPA-approved sampler, sources will need to carry out their own monitoring program to satisfy PSD requirements.

Summary

The shift from TSP to PM_{10} ambient air quality standards will not have a major impact on forest products manufacturing facilities. It appears most facilities will be located in PM_{10} attainment areas. In fact, TSP concentrations in some of these attainment areas had been exceeding the former secondary TSP standards.

Although the basic permitting requirements for new and modified sources did not change with the introduction of PM_{10} standards, there will be an increased need for particle size data for making PM_{10} emission estimates for a variety of source types. The emission estimates are required for determining the contribution of sources to ambient PM_{10} concentrations, for evaluating control technology capabilities with respect to primary PM_{10} emissions, and for obtaining air quality permits.

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