Title III Implications of Drying Kiln Source Test Results

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Background Information:
Drying kilns are known to be sources of HAP emissions. Wood fired boilers are also known to be sources of HAP emissions. Initially, it was thought that methanol, formaldehyde, and phenol were the HAPs of concern from drying kilns with ~95% of the HAPs being methanol. While there was limited test data, based on the assumed emission rates for methanol, at least one facility concluded that they were a major source for HAP. In early 2007, test data became available indicating that significant quantities of acetaldehyde may be emitted from drying kilns in addition to the methanol and for some species the acetaldehyde emission rate appears to significantly exceed the methanol emission rate. Based on the new information, sources should re-evaluate their HAP emissions and their major source status. The following discussion is intended as an aid for sources in such a re-evaluation. Title III applicability is based on potential emissions. A source with potential HAP emissions greater than Title III thresholds need to obtain an Oregon Title V Operating Permit and need to satisfy applicable Maximum Achievable Control Technology standards. A source can take operational limitations to become a Synthetic Minor to avoid Title III and Title V requirements, but the window to do so is very short requiring immediate action.

Comments about the Testing:
- This is a draft document and may contain errors. The following observations, assumptions and calculations are for discussion purposes.
- There is limited test data for Douglas Fir and Hemlock, with even less for other species.
- Additional testing is needed and conclusions may need to be altered as additional test data becomes available.
- Care should be taken when choosing, handling, and preparing lumber to be tested. Great effort must be made to mimic realistic drying conditions as closely as possible to gain the most representative source test results.
- OSU is only going to be available for conduction source tests until about July 2007. Dr. Mike Milota will be on sabbatical for a year and they don't want to continue testing when he is gone. They may want to get away for testing altogether.
- The test data originally focused on methanol and formaldehyde. Recent tests suggest that there may be significant acetaldehyde emissions in some wood species.

Assumptions about the Results:
- Pine is not normally dried at temperatures > 200º F
- There is no data for Slash Pine dried < 200º F
- Methanol
    - Methanol emissions increase rapidly with kiln temperature starting at about 180º F
    - When there was no specific test data for kilns operating above 200º F, methanol emissions were assumed to increase by 50% over 200º F test results. In some cases, the rate of increase could be substantially greater.
- Acetaldehyde
    - Acetaldehyde emissions may not increase with kiln temperature, and it is possible that acetaldehyde emissions may go down as temperature increases above some point.
    - When there was no specific acetaldehyde test data for a given species, acetaldehyde emissions were assumed to be the same as for hemlock (the highest emitting wood species for acetaldehyde).

Determining Title III Applicability:
- Action Levels have been calculated based on 80% of the single HAP Title III threshold for facilities with no HFB and 75% of the threshold for facilities with a HFB.
- Action Level throughputs assume single worst case wood species dried.
- Sources in excess of the Action Levels need to review their potential and actual HAP emissions to determine Title III applicability and synthetic minor options, if any.
- Sources would likely need some guidance on how to make actual HAP calculations for their facility.

Summary of Drying Kiln HAP Source Test Results
(Table 1)

The following is a compilation of all source test data collected to this point:

Species	Data Source	Max. Drying Temp ° F	Methanol lbs/MMBF	Formaldehyde lbs/MMBF	Acetaldehyde lbs/MMBF	Propionaldehyde lbs/MMBF	Acrolein lbs/MMBF
Hemlock	OSU Weyerhaeuser	200	98	1.5			
	OSU Weyerhaeuser	200	075				
	OSU Weyerhaeuser	200	154	1.8			
	OSU Hampton	180	31.2	0.82			
	OSU Hampton	180	30.4	0.82			
	OSU Hampton	200	57	1.4			
	OSU Rosboro	175	44	0.8	133	0.8	2.4
	OSU Rosboro	175	77	1.4	128	1	1.1
	OSU Hampton	200	75	1.37	78	2	1.2
	OSU Hampton	200	83				
	OSU Weyerhaeuser	225	189	3.5			
	OSU Weyerhaeuser	225	167	3.4			
	OSU Weyerhaeuser	225	250	4			
	OSU Hampton	215	138	4.3			
Inland Douglas Fir	OSU	160	25	1 ave			
	OSU	160	23				
	OSU	160	26				
	OSU	160	18				
Douglas Fir	OSU Rosboro	174	68		43	0.5	0.9
	OSU Rosboro	174	69		71	0.6	0.4
White Fir	OSU	< 200	122 ave	2.8 ave			
Ponderosa Pine	OSU	175	50	2.2			
		175	80	3.6			
Lodgepole Pine	Forintec QA #5	195	73		12		
	Forintec QA #1	195	92				
	Forintec QA #2	195	64				
	OSU QA #1	195	28				
	OSU QA #2	195	20				
	OSU	250	62	4 ave			
	OSU	250	63				
	OSU	250	56				
Slash Pine	GP Kiln	235	150				
	GP Kiln	235	270		39		
	MSU Pilot	235	170		30		
	MSU Pilot	235	170				
	OSU Pilot	235	180				
	OSU Pilot	235	270		65		
	MSU Pilot	235	100				
	MSU Pilot	235	110				
	OSU Pilot	235	142				
	OSU Pilot	235	89				
	GP Kiln	220	170				
	GP Kiln	220	150				

Assumed Drying Kiln HAP Emission Factors
(Table 2)

Using the source test results from the previous table, these are the calculated averages:

Species	Max. Kiln Temp. ºF	Total HAP lb/MMBF	Methanol lb/MMBF	Formaldehyde lb/MMBF	Acetaldehyde lb/MMBF	Propionaldehyde lb/MMBF	Acrolein lb/MMBF
Hemlock	< 200 º F	189	72	1.24	113	1	1.6
Hemlock	> 200 º F	305	186	3.8	113 (1)	1 (1)	1.6 (1)
Douglas Fir	< 200 º F	97	38	1	57	0.55	0.65
Douglas Fir	> 200 º F	116	57	1 (1)	57 (1)	0.55 (1)	0.65 (1)
White Fir	< 200 º F	240	122	2.8	113 (2)	1 (1)(2)	1.6 (1)(2)
White Fir	> 200 º F	301	183	2.8 (1)	113 (1)(2)	1 (1)(2)	1.6 (1)(2)
Ponderosa Pine (3)	< 200 º F	184	65	2.9	113 (1)(2)	1 (1)(2)	1.6 (1)(2)
Lodgepole Pine (3)	< 200 º F	73.6	55	04	12	1 (1)(2)	1.6 (1)(2)
Lodgepole Pine (3)	> 200 º F	78.6	60	4 (6)	12 (6)	1 (1)(2)	1.6 (1)(2)
Slash Pine (4)	> 200 º F	215	164	4 (5)	44.7	1 (1)(2)	1.6 (1)(2)

(1) Assumes emissions of this HAP not temperature dependent. There is insufficient data to know for sure.
(2) Assumes emissions are the same as hemlock
(3) Pine is not normally dried at temperatures > 200º F
(4) No data for Slash Pine dried < 200º F
(5) Assume to be the same as for Lodgepole Pine
(6) Assumes emissions the same as for Lodgepole Pine dried at < 200 º F

Assumed Hogged Fuel Boiler HAP Emission Factors
(Table 3)

Pollutant	Emission Factor lb/MMlbSteam(1)	Reference
Phenol	0.086	AP-42; 9/03
Acrolein	6.77	AP-42; 9/03
Formaldehyde	2.20	NCASI TB 858; 2/03
Acetaldehyde	1.40	AP-42; 9/03
Benzene	5.58	NCASI TB 858; 2/03
Naphthalene	0.164	AP-42; 9/03
Chromium	0.001	NCASI TB 858; 2/03
Chlorine	1.34	AP-42; 9/03
Cobalt	0.00032	NCASI TB 858
Arsenic	0.0017	NCASI TB 858; 2/03
Cadmium	0.0069	AP-42; 9/03
Manganese	0.254	NCASI TB 858; 2/03
Mercury	0.00168	NCASI TB 858; 2/03
Nickel	0.0558	AP-42; 9/03
Selenium	0.00508	NCASI TB 858; 2/03
Hydrogen Chloride	1.134	NCASI TB 858; 2/03
Styrene	3.22	AP-42; 9/03
Toluene	1.56	AP-42; 9/03
Xylenes (total)	0.042	AP-42; 9/03
Methanol	1.404	NCASI TB 858; 2/03
Lead compounds	0.00981	NCASI TB 858; 2/03
Total HAP	25.24	

(1) Assumes 1100 Btu per pound of steam and 65% boiler efficiency

Drying Kiln Throughput Action Levels (12-month basis)

Action Levels were developed to give a source some guideline to whether or not they are at risk for being a major source of HAPs from their drying kilns and/or hogged fuel boilers. The Action Levels are specific to wood species, maximum drying kiln temperatures, and whether or not a hogged fuel boiler is the source of steam. The Department would not require HAP emission factor verification for sources operating below the Action Levels set forth in this table; these Action Levels are estimates only. It is solely the source's responsibility to determine HAP major source applicability.

Action Level Calculations:

1. Calculate maximum kiln throughput @ 80% of single HAP Title III threshold w/o a HFB

   (Maximum throughput in MMBF) x (single HAP EF in lb/MMBF) = 20,000 (lbs) x (0.8)

   Example: Hemlock dried ≤ 200 ºF
   (Maximum throughput in MMBF) x (113 lb/MMBF) = 16,000 lbs
   (Maximum throughput in MMBF) = 142 MMBF

   Conclusion: If the source has the potential to dry more than 142 MMBF of wood, and hemlock is the highest-emitting wood species they typically process, and their drying kiln temperatures are less than or equal to 200 ºF, then they would need a closer look at whether they would trigger Title III.

2. Calculate maximum kiln throughput @ 75% of Single HAP Title III threshold w/ a HFB (Assume HFB adds 5% to kiln HAPs)

   (Maximum throughput in MMBF) x (single HAP EF in lb/MMBF) = 20,000 (lbs) x (0.75)

   Example: Hemlock dried ≤ 200 ºF
   (Maximum throughput in MMBF) x (113 lb/MMBF) = 15,000 lbs
   (Maximum throughput in MMBF) = 133 MMBF

   Conclusion: If the source has the potential to dry more than 133 MMBF of wood, and hemlock is the highest-emitting wood species they typically process, and their drying kiln temperatures are less than or equal to 200 ºF, and they operate a hogged fuel boiler, then they would need a closer look at whether they would trigger Title III.

Estimated Action Levels (by wood species) (Table 4)

Species	Max. Kiln Temp. ºF	Drying Kiln Action Level (in MMBF)	
		w/ HFB	w/o HFB
Hemlock	< 200º F	142	133
Hemlock	> 200º F	86	80
Douglas Fir	< 200º F	281	263
Douglas Fir	> 200º F	280	188
White Fir	< 200º F	131	123
White Fir	> 200º F	87	82
Ponderosa Pine	< 200º F	142	133
Lodgepole Pine	< 200º F	290	272
Lodgepole Pine	> 200º F	267	249
Slash Pine	> 200º F	98	91

Actual Emission Calculations

This calculation needs to be done for each wood species and then summed to compile actual emissions for the source.

a. To calculate actual emissions for a single HAP w/o HFB:

Actual single HAP emissions = Σ[(actual kiln throughput by species in MMBF) x (single HAP EF by species in lb/MMBF)]

b. To calculate actual emissions for total HAPs w/o HFB:

Actual total HAP emissions = Σ(single HAP emissions)

c. To calculate actual emissions for a single HAP w/ HFB

Actual single HAP emissions = Σ[(actual kiln throughput by species in MMBF) x (single HAP EF by species in lb/MMBF)] + [(actual MMlbSteam) x (single HAP EF in lb/MMlbSteam)]

d. To calculate actual emissions for total HAPs w/ HFB:

Actual total HAP emissions = Σ(single HAP emissions)