# COMMONWEALTH of VIRGINIA

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**MEMORANDUM**

**TO:** Regional Directors, Director – Air Permits, Director – Air Compliance, Director – Data Analysis and Planning, Director – Regulatory Affairs, Air Permit Managers, Air Compliance Managers

**CC:** Richard F. Weeks, Chief Deputy Director
James J. Golden, Deputy Director for Program Development

**FROM:** Michael G. Dowd – Director, Air Division

**SUBJECT:** APG-573: Lumber Kiln Emissions Calculations

**DATE:** September 30, 2010

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**Purpose:**

The purpose of this document is to provide guidance to air permitting staff for calculating uncontrolled emissions from lumber kilns for permitting applicability. This guidance is not intended to cover every situation but should be applicable in most scenarios. Check with the regional air permit manager and/or the central office staff if a deviation from the guidance is deemed necessary.

**Background:**

On February 16, 2006, the United States Environmental Protection Agency (EPA) promulgated National Emission Standards for Hazardous Air Pollutants for Plywood and Composite Wood Products (PCWP MACT) Manufacturing facilities. In this regulation, lumber kilns at PCWP manufacturing facilities and at any other kind of facility are included as an affected source. Although there are no specific requirements for lumber kilns (other than an initial notification requirement) contained in the PCWP MACT, emissions from the lumber kilns must be quantified and included toward determining major source applicability.

The PCWP MACT when originally promulgated in February 2006 contained an option that allowed facilities to submit a low-risk demonstration to EPA and if approved the facility would be exempt from the regulation.[1] As part of this low-risk demonstration (Table 2A to Appendix B of the PCWP MACT), EPA required testing of certain units to quantify emissions but for some hard-to-test units (including lumber kilns) emission factors were provided to quantify emissions. For lumber kilns Table 2A included emission factors for the following hazardous air pollutants (HAP[2]): acetaldehyde, acrolein, formaldehyde, and phenol. EPA notes that these were the most conservative factors available and were developed from drying southern pine.

In EPA's Response to Comments Document[i] a statement is made by EPA that volatile organic compound (VOC) emissions from hardwoods can be as high as those from softwoods. See excerpt below from page 26.

> 'Emission test data for HAP from hardwood lumber kilns were not available at the time Table 2A was developed, and to our knowledge, are not available today. Hardwood lumber is dried at a lower temperature for longer amounts of time than is softwood lumber. It has been documented that drying at higher temperatures results in increased HAP (methanol and formaldehyde) emissions from softwood lumber kilns. Therefore, one would expect that hardwood lumber kilns would have lower HAP emissions than softwood lumber kilns. However, this is not true for VOC. **Milota**[3] notes that VOC emissions from some hardwood lumber kilns can be significant (ranging from 0.3 to 4.3 pounds per thousand board feet [lb/MBF]), in some cases similar to emissions from softwood lumber kilns (ranging from 0.12 to 4.3 lb/MBF). Given that VOC emissions from hardwood lumber kilns can be significant and that HAP and VOC emissions profiles differ for softwood lumber kilns (as discussed elsewhere in this document), is unclear how HAP emissions may differ among softwood and hardwood lumber kilns in the absence of HAP emissions data from hardwood kilns.'

Because EPA concluded that VOC emissions from drying hardwood could be as high as those from softwood, confusion arose within regional offices as to what emission factor should be used. In an effort to substantiate EPA's conclusion that VOC emissions from hardwoods can be as high as softwoods, DEQ conducted a search to find hardwood lumber kiln drying test data to support EPA's claim. The most recent data found was in a study conducted by Beakler & Blankenhorn[ii] with results published in the November 2007 issue of the Forest Products Journal. Both red oak and white oak were tested. In this study, the highest VOC emission rate was for red oak at 0.358 lb/MBF.

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[1] On June 19, 2007, the United States Court of Appeals for the District of Columbia Circuit vacated EPA's provisions in the National Emission Standards for Hazardous Air Pollutants: Plywood and Composite Wood Products that allowed demonstration of a low risk subcategory. As a result Appendix B referenced in this document was removed from the regulation.

[2] HAP means hazardous air pollutant and relates only to federal programs.

[3] Michael R. Milota, Department of Wood Science and Engineering. Oregon State University

DEQ contacted Dr. Milota to find out what study or stack tests he was referencing in the EPA document. In an email, Dr. Milota stated that the EPA reference was from a presentation that he made for the Forest Products Society in Montreal in 2002 where he cited a Rice[4] study that showed VOC emissions from red oak as high as 14 lb/MBF. He also included a more recent paper by R. W. Rice of the University of Maine which showed VOC emissions as high as 22 lb/MBF for red oak. However, Dr. Milota cautioned against using the results from this study as EPA protocol were not followed. Therefore, the results of these studies were not used in determining VOC emission factors.

Emissions from the lumber kiln drying of softwoods, particularly southern yellow pine are well documented in a National Council for Air and Stream Improvement (NCASI) Technical Information Document, Special Report 08-01.

The emission factors that were selected are provided in Table 1 along with the reference for each factor.

**Applicability:**

This guidance is applicable only to drying lumber in lumber kilns. This guidance is not applicable to veneer drying operations, rotary dryers or any other drying operation other than lumber kilns. For information regarding veneer drying operations or any other wood drying operation, please contact OAPP.

**HAPs, PCWP MACT Applicability, and State Toxics**

If the new lumber kiln is located at a major source of HAPs or if the addition of the new lumber kiln increases the HAP emissions such that the facility becomes major for HAP (Potential to Emit of 10 tons/year for an individual HAP and/or 25 tons/year for all HAPs at the facility), then the lumber kiln is subject to the PCWP MACT. The PCWP MACT does not impose any control or work practice requirements for lumber kilns.

The EPA rule writer told DEQ staff that there are no plans for a PCWP NESHAP for area sources. Therefore, state toxics do apply to lumber kilns located at area sources and toxic emissions must be quantified for permit applicability. Lumber kilns with toxic emissions that exceed the corresponding exemption level trigger minor NSR permitting and emission limits need to be included in the State Only Enforceable section of the permit unless operating restrictions are imposed such that the toxic emissions are reduced to below the exemption level. However, because the PCWP MACT floor indicates no controls for lumber kilns at major sources of HAP, it is unlikely an area source could feasibly control emissions. Also there would be inequity in requiring more rigorous control at an area source than at a major source. Therefore, in accordance with this policy, area source lumber kilns should be treated similarly to those located at a major

[4] R.W. Rice, University of Maine, School of Forest Resources

source. Presumptive BACT for area source lumber kilns is operation of the lumber kiln in accordance with the manufacturer's recommendations and no add-on control. Given the modeling characteristics of wood kilns and other factors discussed in this document, DEQ has determined that toxic modeling (Rule 6-5) is not required for lumber kilns unless facility wide modeling for a particular toxic pollutant(s) is triggered by another emission unit at the facility. However, facility wide HAP emissions need to be quantified for major source applicability determination. If at some point in the future a technology for controlling emissions from lumber kilns is developed, this guidance will be re-evaluated and adjusted if necessary.

**Permitting Applicability Emissions Calculations:**

**1. New Lumber Kiln at Existing Facility**

**VOC and VOC Toxics:** Uncontrolled emissions are calculated based on the lumber kiln operating at its maximum design capacity for 8760 hours per year. Since lumber kilns are typically batch operations, the maximum load or charge that the lumber kiln can dry and the minimum drying time must be known (provided by the applicant). Most often the wood is measured in thousand board feet (MBF). For permitting applicability, drying times should not include the time required to move the wood product in and out of the lumber kiln. However, loading and unloading times are built-in if a permit is required and the applicant requests a limit on lumber throughput. Drying times can vary widely (several hours to weeks) depending on the type of wood and moisture content (initial and desired) of the wood. Drying times used in the examples in this document are not intended to be used as default values.

Although other variables may affect emissions (for example heartwood versus sapwood, season that the wood was harvested and length of time between harvesting and drying) for the purposes of this document these variables will not be considered.

If the application indicates that the lumber kiln will only be used for drying hardwood, then the emission factors for hardwood drying[5] may be used. If the lumber kiln is exempt from permitting, the permit exemption letter should state that only hardwood can be dried in the lumber kiln and that records must be kept for verification. If a permit is required, then a condition limiting the lumber kiln to drying hardwoods should be included.

If a mixture of hardwoods and softwoods or all softwoods will be dried in the lumber kiln, then the emission factors for softwoods must be used.

Five toxic pollutants should be evaluated for minor NSR permitting applicability: acetaldehyde, acrolein, formaldehyde, methanol, and phenol. Facility wide potential

[5] For a more conservative emissions estimate, softwood factors could be used.

HAP emissions should also be calculated to determine if the facility is a major source of HAP.

Unless source specific testing data is available, the following emission factors are provided for calculating permitting and/or major source applicability. Deviations from using the provided emission factors must be justified and well documented in the engineering analysis.

**Table 1: Emission Factors for wood drying in lumber kilns**

| Pollutant | Softwood (lb/MBF) | Reference | Hardwood (lb/MBF) | Reference |
|---|---|---|---|---|
| VOC * | 4.09 | (1) | 0.358 | (4) |
| Acetaldehyde | 0.03 | (1) | 0.00032[6] | (5) |
| Acrolein | 0.006 | (2) | - | |
| Formaldehyde | 0.04 | (1) | - | |
| Methanol | 0.24 | (1) | - | |
| Phenol | 0.01 | (3) | - | |

* VOC as pinene for softwood and as propane for hardwood

**References**

(1) NCASI Special Report 08-01, May 2008
(2) NCASI Technical Bulletin 845 Appendix BB
(3) Table 2A to Appendix B Emission factors for Plywood and Composite Wood Product MACT (Subpart DDDD)
(4) Beakler & Blankenhorn, Forest Products Journal, November 2007
(5) Solliday et al., Forest Products Journal, July/August 1999

**Sample Calculation for a Hardwood Lumber Kiln**

Maximum load: 63 MBF
Minimum drying time: 40 hours
Maximum number of loads per year: 219 (8760 hr/yr/ 40 hr/load)
VOC emission factor for hardwood: 0.358 lb VOC /MBF
Acetaldehyde emission factor for hardwood: 0.00032 lb Acetaldehyde/MBF

63MBF x 0.358 lb VOC/MBF x 219 loads/year x ton/2000lb = 2.47 tons VOC /yr

63MBF x 0.00032 lb VOC/MBF x 219 loads/year x ton/2000lb = 0.0022 tons VOC /yr

[6] Reference ii refers to a study by Solliday et al. (1999) that showed the primary VHAP component of the non-condensable portion of VOC from drying of red oak is acetaldehyde. However, the non-condensable portion compared to the total VOC (mainly acetic acid) is only about 0.0009 percent or 0.00032 lb/MBF.

**Table 2: Emissions Summary Table: New Hardwood Lumber Kiln**

| Pollutant | CAS | Uncontrolled Emissions | | Exemption rate* | | Exempt? |
|---|---|---|---|---|---|---|
| | | Lbs/hr** | Tons/yr | Lbs/hr | Tons/yr | |
| VOC | N/A | N/A | 2.47 | N/A | 10 | Yes |
| Acetaldehyde | 75070 | 0.000504 | 0.0022 | 8.91 | 26.1 | Yes |

*Exemption level for VOC comes from 9 VAC 5-80-1320 D; exemption level for acetaldehyde is from 9 VAC 5-80-1320 E.1.
** lbs/hr numbers are dependent on both batch size and hours of drying time. Hourly emissions are averaged over the entire drying time. (63 MBF/40 hours * toxic EF)

In this example, the addition of one lumber kiln drying only hardwood is exempt from minor New Source Review permitting. Keep in mind that HAPs from all emission units (boilers, generators, etc.) at the facility must be totaled for assessing major source HAP status for the facility.

Since the annual exemption rate for acetaldehyde is greater than the HAP major source threshold of 10 tons per year, a facility would become a major HAP source with a total hardwood lumber kiln throughput of 62,500,000 MBF per year.

**Sample Calculation for a Softwood Lumber Kiln**

Maximum load: 63 MBF
Minimum drying time: 24 hours
Maximum number of loads per year: 365
VOC emission factor for softwood: 4.09 lb VOC /MBF

63MBF x 4.09 lb VOC/MBF x 365 loads/year x ton/2000lb = 47.02 tons/yr

**Table 3: Emissions Summary Table: New Softwood Lumber Kiln**

| Pollutant | CAS | Uncontrolled Emissions | | Exemption rate* | | Exempt? |
|---|---|---|---|---|---|---|
| | | Lbs/hr** | Tons/yr | Lbs/hr | Tons/yr | |
| VOC | N/A | N/A | 47.02 | N/A | 10 | No |
| Acetaldehyde | 75070 | 0.079 | 0.345 | 8.91 | 26.1 | Yes |
| Acrolein | 107028 | 0.0158 | 0.069 | 0.02277 | 0.03335 | No |
| Formaldehyde | 50000 | 0.105 | 0.50 | 0.0825 | 0.174 | No |
| Methanol | 67561 | 0.63 | 2.76 | 10.824 | 37.99 | Yes |
| Phenol | 108952 | 0.026 | 0.115 | 1.254 | 2.755 | Yes |

*Exemption level for VOC is from 9 VAC 5-80-1320 D; exemption levels for each HAP is from 9 VAC 5-80-1320 E.1.
** lbs/hr numbers are dependent on both batch size and hours of drying time. Hourly emissions are averaged over the entire drying time. (63 MBF/24 hours * toxic EF)

The new lumber kiln is subject to minor New Source Review (Article 6) permitting. Emission limits need to be included in the State Only Enforceable section of the permit for acrolein and formaldehyde unless operating restrictions are imposed such that the toxic emissions are reduced to below the corresponding exemption level. BACT is operating the lumber kiln in accordance with the manufacturer's recommendations and no add-on control. Acrolein and formaldehyde emissions do not need to be modeled. However, facility wide HAP emissions need to be quantified for major source applicability determination.

If the permittee plans to install three lumber kilns of this size, the facility would be major for VOC (141.06 tons VOC/yr) and subject to Title V permitting unless operating restrictions are imposed. Although this lumber kiln by itself is not a major source of HAPs, if the permittee wanted to install four lumber kilns this size, the facility would be major for HAPs unless operating restrictions were imposed. As stated before, HAPs from all emission units (boilers, generators, etc.) at the facility must be totaled for assessing major source HAP status for the facility.

## 2. Throughput Increase for Permitted Lumber Kiln

**VOC:** If a lumber kiln was previously permitted and the permit contains a throughput limit, a net emission increase calculation must be made. Current uncontrolled emissions are based on the permitted throughput. The new uncontrolled emissions are based on the uncontrolled emissions calculated with the lumber kiln operating at its maximum design capacity. The permittee does not want to restrict throughput.

**Sample Calculation for Softwood**

Current uncontrolled VOC emissions

Maximum load: 63 MBF
Minimum drying time: 24 hours
Permitted throughput limit: 12,600 MBF/year
Maximum number of loads per year: 200
VOC Emission factor for softwood: 4.09 lb VOC /MBF

12, 600 MBF/year x 4.09 lb VOC/MBF x ton/2000lb = 25.77 tons VOC/yr

New uncontrolled VOC emissions

Maximum load: 63 MBF
Minimum drying time: 24 hours
Maximum number of loads per year: 365
VOC Emission factor for softwood: 4.09 lb VOC /MBF

63MBF x 4.09 lb VOC/MBF x 365 loads/year x ton/2000lb = 47.02 tons VOC/yr

NEI = 47.02 tons/yr – 25.77 tons/yr = 21.25 tons/yr

There is no NEI calculation for state toxics. Toxics emissions are always based on potential to emit. Since the permittee does not want a throughput limit, the potential to emit is equal to uncontrolled emissions.

**Table 4: State Toxics Emissions Summary Table: Modified Lumber Kiln**

| Pollutant | CAS | Potential Emissions | | Exemption rate* | | Exempt? |
|---|---|---|---|---|---|---|
| | | Lbs/hr** | Tons/yr | Lbs/hr | Tons/yr | |
| Acetaldehyde | 75070 | 0.07875 | 0.344925 | 8.91 | 26.1 | Yes |
| Acrolein | 107028 | 0.1575 | 0.068985 | 0.02277 | 0.03335 | No |
| Formaldehyde | 50000 | 0.105 | 0.4599 | 0.0825 | 0.174 | No |
| Methanol | 67561 | 0.63 | 2.7594 | 10.824 | 37.99 | Yes |
| Phenol | 108952 | 0.02625 | 0.114975 | 1.254 | 2.755 | Yes |

* exemption levels for each HAP is from 9 VAC 5-80-1320 E.1.
** lbs/hr numbers are dependent on both batch size and hours of drying time. Hourly emissions are averaged over the entire drying time. (63 MBF/24 hours * toxic EF)

As shown above, the NEI exceeds the modification threshold level of 10 tons/yr for VOC and the potential to emit for both acrolein and formaldehyde exceed their respective exemption levels. Therefore this is a modification subject to minor NSR permitting. Emission limits need to be included in the State Only Enforceable section of the permit for acrolein and formaldehyde unless operating restrictions are imposed such that the toxic emissions are reduced to below the corresponding exemption level. BACT is operating the lumber kiln in accordance with the manufacturer's recommendations and no add-on control. Acrolein and formaldehyde emissions do not need to be modeled. However, facility wide HAP emissions need to be quantified for major source applicability determination.

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[i] National Emission Standards for Hazardous Air Pollutants for Plywood and Composite Wood Products Background Information for Amendments to Final Standards, Summary of Public Comments and Responses, dated January 2006

[ii] Quantification of the VOCs released during kiln-drying red oak and white oak lumber.(volatile organic compounds), By Brian W. Beakler & Paul R. Blankenhorn & Nicole R. Brown & Matthew S. Scholl & Lee R. Stover, Forest Products Journal, November 2007