

DIFFICULTIES OF MEASURING KILN EMISSIONS

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Trends in Southern Pine Drying

The approach used to investigate VOC emissions from southern pine kilns was influenced by previous research into superheated steam drying. Superheated steam drying is not new. A patent was issued for the process in 1867. Over 15 years ago an experimental kiln was built at the Mississippi Forest Products Laboratory to study superheated steam drying at atmospheric pressure. The kiln (Figure 1) dried 12 pieces of 2x6 dimension lumber. Results of the study¹ showed that drying rate increased as temperature increased and as the velocity of the superheated steam recirculating within the kiln was increased. Advantages discovered for superheated steam drying were: 1- fast drying rate (lumber dried in 17 hours at 245°F and in 11 hours at 260°F), 2- no energy is required for venting (the kiln was not vented), 3- Less energy is required to power the recirculating fans (pure steam is lower density than a steam-air mixture), and 4- the kiln exhausts steam that can be used as a heat source.

The southern pine industry has been slow to adopt the technology. However, newer kilns approach superheated steam drying by drying at higher temperatures with higher wet bulb temperatures. Some kiln operators keep vents closed and allow the wet-bulb temperature to reach 212°F until the last stages of the drying cycle. In Australia and New Zealand radiata pine is being dried at 300°F.

Superheated steam drying cannot be accomplished in direct fired kilns, because air is admitted to the kiln from the burner. There is, however, a trend to increasing drying temperature and reducing the amount of venting in direct fired kilns.

VOC Emissions from Pine Kilns

The clean air act and the associated regulation of air emissions from industrial processes has stimulated interest in chemical emissions from lumber drying kilns. Lumber companies do not know what their kilns are emitting or the quantities they are discharging. Likewise, regulating agencies have limited

¹ Taylor, F. W. 1984. Superheated steam drying in an experimental chamber. Proceedings, North American Wood Drying Symposium, Starkville, MS, Nov. 1984, pp. 97-101.

information about emissions. Both of these groups are requesting research data upon which to base economic and/or regulatory decisions.

In most states permits are required for new kilns. A permit allows legal discharge of a specified amount of VOC's. Discharges of more than the permitted amount may result in fines. It is the responsibility of the industry, seeking a permit, to choose the amount they wish to be permitted to discharge. Since there is little reliable data upon which to base a decision, and since permits are relatively inexpensive (compared to the cost of fines for discharging more than permitted) one option is to request a permit for much more discharge than is expected. This strategy can avoid fines, or avoid having production curtailed to prevent exceeding permitted emissions.

The strategy of seeking a permit that allows more discharge than is expected may have negative financial implications in the future, because the cost of permits (per unit of emissions) is expected to increase greatly in coming years. Some states have already announced schedules for increasing permit fees. Information is needed to make accurate decisions on regulation of emissions.

Monitoring emissions is difficult and expensive. Lumber manufacturers have spent large amounts of money to monitor emissions from existing kilns. The measurement techniques used are methods developed for monitoring emissions from other industries. These methods are technically sophisticated and accurate, but there are problems applying them to determining emissions from kilns. Kilns may emit different chemicals or different quantities of chemical compounds at different times during a drying cycle. Venting is intermittent and the rate of venting is different for different periods of the drying cycle. It is difficult to determine the flow of vent gasses from the vents of typical kilns. Also, most kilns are not sealed well enough to prevent fugitive emissions from places other than vents.

The cost of monitoring emissions is borne by the industry. Industries must contract with independent testing laboratories (approved by regulating agencies) to conduct tests that will verify compliance. Since emissions from lumber kilns are not subject to reduction by technology, the amount of emissions should be directly related to the amount of wood dried. If accurate information can be developed on the amount of emissions per unit of wood dried, monitoring could be accomplished by determining the number of units dried. Such an approach may save the cost of periodic monitoring to assure compliance.

Monitoring involves measuring the relative proportion of VOC's in the recirculating atmosphere in the kiln or in the vent stream being emitted from the kiln, analyzing the sample, and then calculating the total emissions discharged during a drying cycle. There are opportunities for error both in measuring the concentration of chemicals in the kiln atmosphere and in determining the volume of kiln atmosphere vented.

Our research approach was to build a kiln that could be completely sealed, with the amount of venting carefully controlled and accurately monitored. This approach was suggested by the previous research on superheated steam drying in which the atmosphere vented from the sealed kiln was condensed. A new

sealed kiln was built with a method for introducing compressed air in measured quantities to control relative humidity (wet-bulb temperature). The atmosphere leaving the kiln passed through a large condenser cooled by tapwater, followed by a condenser cooled by ice, followed by a condenser cooled to minus 130°F. We analyzed the condensate (water and VOC's) by conventional analysis techniques. The volume of wood dried in the unit was small, but the precision with which emissions could be measured was great.

We planned to use the experimental kiln to evaluate the effect of several factors on the emission of VOC's. Factors to be considered were: drying temperature, species (there are four major species and several minor species of southern pine), season of harvest, geographic area where trees grow, and whether plantation wood is different from wood grown in natural stands. Before much progress was made a major obstacle was encountered. The basic assumption that VOC's would condense, along with the water, and could be analyzed was challenged.

Samples of green wood were analyzed for content of major VOC's. After the wood was dried, samples were again analyzed for the content of the same chemicals. Comparison of these results with the analysis of condensate showed that there was much less VOC's in the condensate than would be expected from the chemical analyses of the wood before and after drying. There are two possible explanations for this result. VOC's may not be condensing or they may be changing to other compounds. There is some evidence to suggest that major components such as alpha pinene can be changed in the presence of heat and oxygen. Also, compounds in small quantities may not readily condense and could be carried out with the air stream passing through the condensers. To evaluate the effectiveness of recovery, a test was devised to impregnate wood with a known quantity of water and alpha pinene and determine recovery. A liter of alpha pinene and a large volume of water were added to dry wood by a pressure treatment. When the wood (one kiln charge in volume) was re-dried only half the alpha pinene added to the wood was captured in the condenser.

To investigate the problem of why the expected volume of VOC's was not recovered in the condensate new equipment was needed. Sample trains to test in accordance with EPA standard tests were requisitioned. Securing funding (\$30,000) for this specialized equipment, waiting for delivery and becoming proficient in using the equipment has delayed the project for almost 12 months. Equipment for three test methods is now available. The methods are:

METHOD 25-A: This method involves passing a sample of gaseous emissions through an instrument that measures total hydrocarbons. It uses a flame ionization analyzer that can run continuously. Therefore, it is possible to determine changes in the concentration of hydrocarbon emissions at different times during the drying cycle. Also, the amounts can be totaled to be used in calculations of total emissions. The method only measures total hydrocarbons as volume concentration equivalents of the calibration gas or as carbon equivalents. It can not determine individual chemicals.

MODIFIED METHOD 5: This method involves the following steps: (1) a sample of emission gases is withdrawn through a heated tube, (2) particles are filtered out, (3) water and condensible chemicals are removed by a series of cold traps, (4) air and non-condensed gases pass through a porous filter that adsorbs VOC's, (5) chemicals adsorbed in the filter or condensed are analyzed. Sampling is usually conducted for a relatively short period of time (20 minutes). This method allows identification of the various chemicals collected and permits estimates of the quantities of each chemical. A disadvantage is that sample collection is for only discreet times (20 minute periods) during the drying cycle.

VOST - VOLATILE ORGANIC SAMPLING TRAIN: This method, similar to Modified Method 5, is used for collecting highly volatile compounds (boiling points less than 100 degrees C.). A sample of emission gasses is drawn through a glass lined probe. The gas train is cooled and volatile compounds are collected on a pair of sorbent resin traps. Liquid condensate is collected in an impinger placed between the two resin traps. The first resin trap contains Tenax and the second contains Tenax and petroleum based charcoal. Analysis of the traps is carried out by thermal desorption purge-and-trap by gas chromatography/mass spectrometry. Significant quantities of such compounds are not expected in the emission from pine kilns, but analysis is needed.

We plan to use these methods to determine emissions from our experimental kiln. They will also be used to determine if VOC's are contained in the air stream that passes through condensers.

Previous testing has revealed the monoterpenes contained in the gasses emitted from pine kilns. They are:

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| 1 - Alpha Pinene | 6 - Fenchyl Alcohol |
| 2 - Camphene | 7 - Borneol |
| 3 - Beta Pinene | 8 - Estragole |
| 4 - Beta Myrcene | 9 - Alpha Terpineol |
| 5 - Limonene | 10 - Methyleneugenol |

Our goal is to confirm the presence and proportions of these compounds and study the factors that affect variations in emissions.