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The Nuts and Bolts of Restoration

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RE RESTORATION: ESIVES – PART 2

By Ralph E. Moon, Ph.D. CHMM, CIAQP

Editor's Note: This is the second installment of a three-part series on Thermal Treatment, the use of High Temperature Restoration Techniques.

The restoration industry encounters a wide variety of wood products during drying following water losses. As the price of high quality lumber has outpaced the budget of most construction projects, composite wood products have replaced solid wood applications. In 2004, the production of particleboard (PB), medium density fiberboard (MDF) and hardboard (HB) totaled more than 10 billion square feet in the U.S. and Canada (Composite Panel Association, 2006). Increases in the residential housing market may increase the use of composite materials even more.

When high temperature heat is used, understanding the structural performance of wood and the release of volatile organic chemicals (VOCs) are important because they pose safety issues and possible claims of negligence. In the 1980s, concerns of formaldehyde emissions prompted research to improve adhesives because the bond used for particleboard and plywood emitted formaldehyde. Though improvements in adhesive technology and manufacturing techniques have diminished concerns about formaldehyde, owners and designers require that building materials and furnishings meet indoor air quality criteria. Research conducted to evaluate VOC emissions from particleboard and MDF helps us understand how composite wood responds to the early stages of high temperature heating.

Emissions from Composite Wood Products

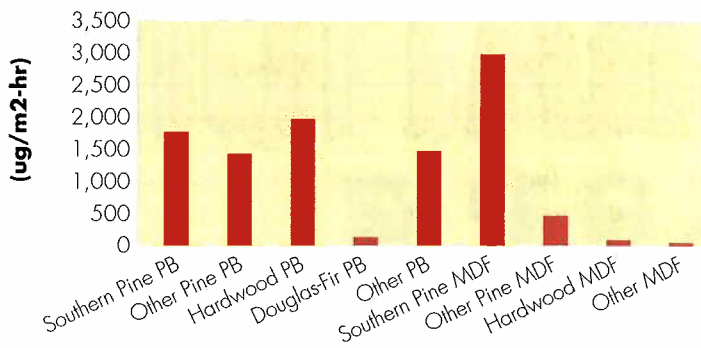
The VOCs released from wood composites provide insight into the types of chemicals released during the early stages of high temperature heating. Research was conducted at the Forest Products Laboratory to identify the compounds emitted from wood products during man-

ufacture and use (Bauman *et al.*, 1990). The research was conducted at room temperature. Wood specimens were placed in stainless steel chambers and clean air was passed through for a four-day period.

The primary compounds emitted were a-pinene and b-pinene (terpentine) and wood degradation products such as alcohols and aldehydes. The types of compounds emitted depended on the wood species or whether the wood panel was PB or MDF. Particleboard had the highest emission rates with the largest contribution from terpenoids. MDF had the lowest emission rates. Some volatiles, including pentanal, hexanal and nonanal, were also emitted even though they are not components of either the wood or the adhesives, but are a result of the oxidation of fats and fatty acids in wood (Svedberg *et al.*, 2004). The most predominant VOC emitted from soft woods was terpenes; however, when compared to all products, alcohols and aldehydes were present at elevated concentrations (Table 1).



Table 1
Total Aldehyde Emissions in 24 hours



Recognizing that emissions occur during the early stages of high temperature heating is important because many VOCs pose potential risks via inhalation. Pinene, for example, is a strong oxidizing agent that attacks rubber and has been cited as reasonably anticipated to be carcinogenic (Young, 2001)

High Temperature Effects on Building Materials

Wood

The behavior of drying wood in commercial kiln operations underscores the importance of slow and consistent drying efforts at high temperatures. Structural wood, exposed to elevated temperatures, experiences the same potential damage as wood in a kiln (Simpson, 1983).

Water is present in three forms in wood cells: 1) liquid or free water, 2) water vapor, and 3) chemically bound or hygroscopic water. When wood dries, free (cellular) water is the first to leave the cell. When the cell is dry, the cell walls still contain chemically bound (hygroscopic) water. This stage of drying is termed the fiber saturation point

(fsp). Wood cells will not shrink (distort) until bound water is extracted from the cell wall. The fsp is a critical milestone in the drying process because wood strength and shape will not change until the moisture content falls below the fsp.

When lumber is dried too quickly, drying stresses and damage can affect the strength of structural members in the home (USDA, 1957). Damage is caused by two kinds of stress, hydrostatic tension and differential shrinkage. Hydrostatic tension is created where high drying temperatures build up the hydrostatic tension in a cell. As a result, the interior cells collapse and there is an appearance of excessive shrinkage and a washboard effect in lumber.

Differential shrinkage occurs between the shell and center of the lumber when the outer wood fibers dry and shrink before the inner wood cells have begun to dry and shrink. This condition is termed, "case hardening." When this occurs, the core moisture cannot pass through to the surface. This prevents proper "wicking" to the surface of the board and evaporating. Lumber that is dried too quickly will degrade during the initial stages and will slow the overall drying process.

Wood dries the fastest at the beginning because the moisture differential is at its highest. This is when wood and a home are most susceptible to damage. During the early stages of drying, low temperatures and high humidity are necessary for many species of wood. As drying progresses, the temperature is slowly raised and the humidity lowered to maintain a steady drying rate

Wood: High Temperature Research

Research revealed that wood roofing systems (beams and sheathing) performed well when exposed to temperatures up to 150 F. Roof systems experience elevated temperatures *via* solar radiation [American Forest and Paper Association (AFPA), Inc., 1999].

Temperature measurements of roof systems vary depending on the orientation, hour of the day, season, color, ventilation rate and insulation thickness. Seasonal measurements showed that roof systems reached 150°F for short durations; the hottest members were limited to roof sheathing.

Under the severest conditions, the temperature of the structural beams, rafters and truss members in wood roofs generally do not reach 140°F. However, when these conditions do occur, the loss of strength associated with increased temperature is compensated by the increase in strength associated with lower moisture content.

Research results conducted during short-term, high temperature exposures has shown an increase in wood





strength properties when cooled below normal temperatures and a decrease in properties when heated above 150 F (AWC, 2005). When the wood returned to a normal temperature, it recovered its original properties.

Researchers who examined wood exposure at temperatures above 150 F showed a permanent loss in strength when cooled and tested at normal temperatures. These permanent effects were additive to those that occurred at the exposure temperature. Permanent strength losses occurred following exposure to temperatures >212 F; the damage was greater when wood was heated in water rather than in dry air.

Based on this research, temperatures of 150 F represent a threshold for the beginning of permanent loss of strength. This interpretation was substantiated by test data that showed an approximate 10 percent loss in bending strength for materials exposed for 300 days in water at 150 F and then tested at room temperature. The use of lumber or glued-laminated timber members that experience long-term exposure to temperatures over 150 F, should be avoided as shown in Table 2.

Table 2

Heating Duration	AWC Design Specifications
Short term heating up to 150°F	No design strength reduction required
Sustained temperatures 100°F	No design strength reduction required
Sustained temperatures 100°F to 125°F	10% to 30% design strength reduction, depending on the moisture content.
Sustained temperatures 125°F to 150°F	10% to 50% design strength reduction, depending on the moisture content and specific property.

Source: AWC, 2005

Wood: Adhesives

The vulnerability of adhesives to elevated temperature regimes (130-160 F) depends on the chemical structure of the adhesive used (Conner, 2001). Wood adhesives are generally classified as either synthetic or natural (Table 3). Synthetic adhesives are derived from petroleum products and are

