Effective Management of Resin Exudation from Eastern White and Red Pine

Prepared by:
R. W. Rice, Ph.D
University of Maine
Orono, Maine

Prepared for:
The Northeastern Lumber
Manufacturers Institute (NELMI)
Cumberland Center, Maine, 04021

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Introduction

Resin exudation, often called pitch bleed, from Eastern white and red pine is an occasional problem for manufacturers and builders when the species are used for exterior trim and millwork. In addition, the problem extends to interior environments, such as bathrooms, in which the relative humidity rises and falls frequently.

The "extractives" that form the basis of the pitch bleed problem are resins or resin acids that are a natural development of the growing process. Within the trees, the extractives are contained in specialized cells called resin canals. Resin canals and the associated resin acids are found in both the heartwood and sapwood of all pine species, Douglas fir, larch and the spruces. When an injury or insult occurs, resin flows from the canals and concentrates in the area of the injury. Furthermore, the tissue growing in the area of the injury develops an abnormally large number of canals, termed traumatic resin canals. The result is a pitch pocket. The same effect occurs, routinely, in and around branches, leading to high levels of resin and the potential for resin exudation around knots when the wood is in service. However, normal resin canals are more abundant in the pine species than in the other three species.

The purpose of this study was to evaluate the effectiveness of a number of commercially available coatings that are used to prevent resin exudation. In addition to testing the effectiveness of the coating in blocking resin exudation, the tests also were intended to quantify the effect of drying schedule temperature on resin exudation. The testing regime was severe as discussed below.

Background for the study.

Little, if any, information is available that provides manufacturers of primed lumber or homeowners with information about resin exudation from pine lumber over an extended period. Although the manufacturers of resin blocking coatings provide application information, the effectiveness of the coating is generally a combination of how the wood is prepared, the method of application and the effectiveness of the coating.

The resins of pine can be removed or "extracted" using either water or chemicals such as ether, alcohol, and benzene. Approximately three percent of the dry weight of clear white or red pine consists of water soluble extractives that could result in resin exudation (Rowell, 1984). Although the water soluble fraction of extractives from knots in white and red pine is unknown, it is generally higher than in the clear wood. When ether was used as a solvent, the percentage of resin removed from red pine knots was 33 percent and from white pine knots it was about 18 percent according to Levitin (1962). The yield of extractives from clear samples of white and red pine extracted with ether was about 3-6.5 percent of the dry weight.

The coatings and finishes applied to wood are intended to limit the effects of moisture and weathering on the surfaces by restricting the amount of moisture that can pass through the coating from the outside. Although coatings are never completely impermeable to water, effective coatings protect surfaces during periods of rain, snow and high humidity for extended periods. If exposed to high humidities or water vapor for an extended period, or if the coating or finish is not effective, the moisture moving though the coating will interact with and solubilize the pitch. As the resin/water vapor mixture moves back through the coating in response to dry weather or high temperatures, the resin appears as a dark ring around knots or, in severe cases, as globules on the surface. Prolonged exposure to sunlight has the same affect on resin exudation. As sunlight strikes a surface, it warms the coating and the wood resulting in water vapor and pitch moving from the surface of the wood and through the coating.

The effect of wood drying temperature in reducing resin exudation is often mentioned but seldom quantified. The United States Department of Agriculture recommends that high temperatures be used to set the pitch at the beginning of the drying process (USDA, 1991). However, recognizing that brown stain may be a problem if high temperatures are used at the beginning of drying, the USDA recommends that an anti-brown stain (low temperature) schedule be used but that the final temperature step be at least 160F for 4/4 lumber and 170F for thicker lumber. The USDA does not specify how long the temperature should remain elevated in order to set the pitch.

Design of the Experiments.

The experiments were done in two phases. The first phase was designed to test all of the chosen coatings under similar conditions so that a broad determination of resin blocking effectiveness could be seen. The small sample testing resulted in two coatings being selected for full- sized lumber testing.

Phase II testing involved having the coatings professionally applied to full-sized white pine lumber which had been dried at three different maximum temperatures. After coating and subjecting the lumber to warm temperatures and high humidity for an extended period, they were visually evaluated for resin exudation as described below. The details of each phase follow.

Phase I

Potential resin blocking coatings were chosen in consultation with representatives from coating manufacturers and coating specialists. As a result, eight coatings were chosen as shown in Table 1. Neither the USDA developed mixture nor the Cabot Tannin-Bloc were intended to be applied to Eastern white pine for the purpose of stain blocking. The USDA mixture was used on the advice of the chemist who developed the mixture and the Cabot Tannin-Bloc was tried at the request of a NELMA member.

Table 1. Coatings chosen for testing and their characteristics.

Product Manufacturer	Description	Consituents	VOC level (g/L)
Benjamin Moore Co. White 340	SPS Stain Killer	Ti. Dioxide, Solvents	500
Benjamin Moore Co. QD 30	Stain Killer/Primer	Ti. Dioxide, Vinyl Toluene	500
Pittsburg Paint 17-21	Seal Grip Stain Blocker	Acrylic resin, Ti. dioxide	264
Pittsburg Paint 6-9	Oil Based Wood Primer	Alkyd Resin, Ti. Dioxide	350
Cabot	Tannin-Bloc	Unknown	VOC Free
USDA Mix	None	Resorcinol/Formaldehyde	Unknown
X-I-M Products	UMA (Urethane Modified Acrylic)	Acrylic resin, Urethane resin, Ti. dioxide	240
William Zinsser Co.	BIN	Ti. dioxide, solvents.	550

Table 3. Results of the small sample testing and comments.

Product Manufacturer	Designator	Resin Blocking	Comments
X-I-M Products	UMA (Urethane Modified Acrylic)	Good Blocker	Fair-Poor Hide; General primer, durable
USDA Mix	None	Good Blocker	No Hide
William Zinsser Co.	BIN	Good blocker	Fair -Good Hide; Durability questionable; spot priming only suggested
Benjamin Moore Co White 340	SPS Stain Killer	Fair/good blocking	Fair Hide; Durability questionable
Benjamin Moore Co. M202- QD 30	Stain Killer/Primer	Fair/good blocking	Fair Hide; Durability questionable
Cabot	Tannin-Bloc	Fair	No Hide
Pittsburg Paint 17-21	Seal Grip Stain Blocker	Less Effective	Poor Hide
Pittsburg Paint 6-9	Oil Based Wood Primer	Less Effective	Poor Hide

Phase II.

Phase two of the testing consisted of full sized lumber studies which combined the affects of temperature and the ability of the coatings to prevent resin exudation.

Three thousand board feet of lumber Premium Eastern white pine were dried in batches following normal drying schedules for Eastern white pine except that the final temperature was either 140F or 160F. At the end of the drying process, the lumber was equalized for extended periods at the highest temperature to "set" the pitch. The experimental design is shown in Table 4 and a flow diagram is shown as Figure 3.

Table 4. Volume and temperature conditions for Phase II of the experiments.

Volume (Bd ft)	Final Temperature (F)	Time held at final temperature (hours)
500	140	12
500	140	24
500	140	36
500	160	12
500	160	24
500	160	36

After drying the wood, each batch of 500 board feet was divided into two samples, planed, labeled carefully and sent to a professional coating company[2] for coating.

Six, 250 board feet batches received a single coating of BIN applied to the knots followed by a coating of non-resin blocking primer. The remaining six 250 board foot batches received a single coating of X-I-M, applied over the knots followed by a single coating of X-I-M to the surfaces. After drying, the batches were returned to the University of Maine for further treatment.

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[2] Appreciation is expressed to Mr. Ed Hawley of HBH coatings in Arlington VT who applied the resin blockers/primers to the wood.

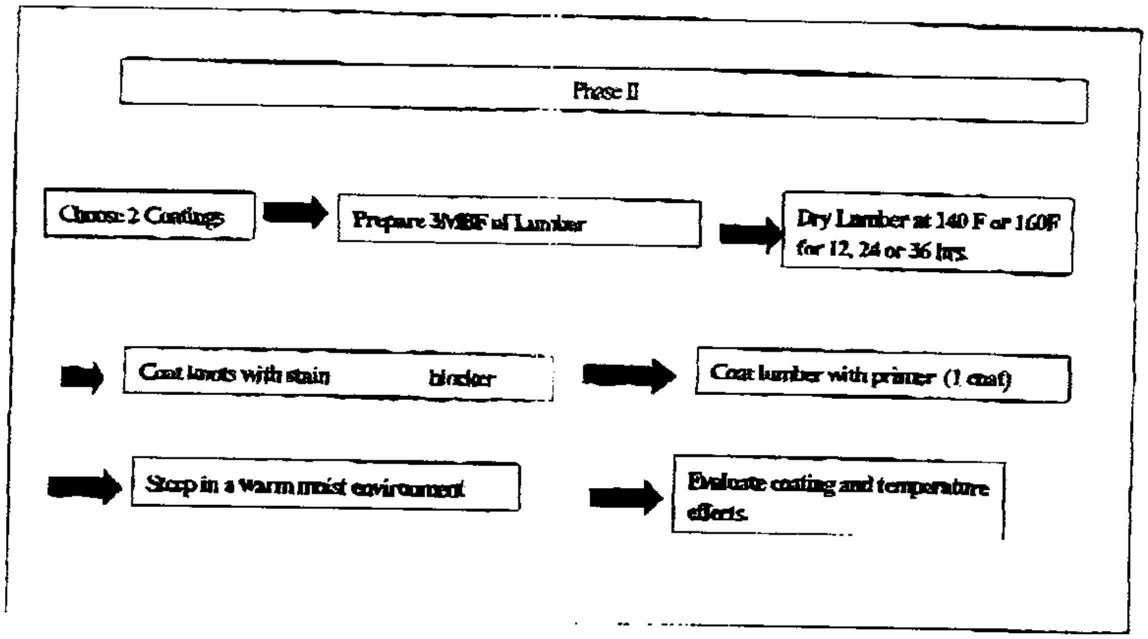


Figure 3. Flow diagram for the experiments of Phase II.

The coated lumber from each batch was returned to the dry kiln for at least seven days at 105-110F and 85-90 percent relative humidity. The conditions were designed to soften and re-solubilize the resins which would promote exudation. After the high humidity treatment, the lumber was visually evaluated.

Results from Phase II

Both of the tested coatings were effective in blocking resin exudation after drying for 36 hours at 160F. On average, the X-1-M appeared to be more effective than the BIN and has the added convenience of being both a resin blocker and a primer. However, typical coating equipment requires some modification before it can be used to apply the urethane modified acrylics. Urethane modified acrylics are also more expensive that stain blockers like BIN and have less hiding power.

Knot size and heartwood content varied within the samples tested. Neither the elevated drying temperatures nor the coatings were able to prevent resin exudation from those knots. The resins from smaller (1 ½ inch or less) diameter knots were effectively blocked from exuding under the severe testing conditions. An example is shown in Figure 2a.

The final drying temperature has an effect on the potential resin exudation. The lumber dried at 160F for a 36 hour period was much less likely to have problems with resin exudation over a prolonged period of high humidity and elevated temperature than other samples. The lumber dried at 140F was variable with some samples showing resin exudation and others showing none. In addition, for the samples dried at 140F, the time held at the temperature did not seem to make much difference in the amount of resin exudation. Overall, the best samples were those dried for 36 hours at 160F.

Recommendations.

Among the coatings tested, the most effective were the urethane modified acrylic and the BIN. When combined with a final drying temperature of 160F for a period of 36 hours, the resin exudation from nearly all samples was blocked. None of the coatings or drying schedule/coating combinations effectively blocked resin exudation from large knots that appeared heavily resinated.

In general, coated or primed lumber forms a small percentage of the production of most mills. It is recommended that the lumber used for priming be chosen such that the knots are less than 1 ½ inches in diameter and that the lumber be held at a temperature of 160F for approximately 36 hours before priming. In the Northeast, brown stain can be a problem when kiln temperatures exceed 140F. Therefore, lumber to be primed should be dried in the normal way along with lumber that will not be primed. After conventional drying, the lumber to be primed should be separated, returned to the kiln, and redried for 36 hours at 160F or higher. The temperature and relative humidity in the kiln should be maintained such that the desired final moisture content will be achieved.

After drying at 160F or greater, the knots should be coated with primer. After the primer dries, the entire board should be coated with primer, dried and one or two coats of a high hide coating should be applied to the surfaces.

During the first phase of testing, the coatings were applied to six and eight inch wide Premium grade (graded green) white pine measuring approximately two feet long[1]. The rough, green samples of lumber were dried using a conventional schedule with a maximum temperature of 140F and then subdivided into three batches. The first batch received no additional treatment prior to coating. Batch 2 was re-dried for 12-15 hours at 150F and batch 3 was re-dried for the same amount of time at 160F. The final moisture content of all samples was between 10-12 percent in accord with normal industry practices for Eastern white pine.

Samples from each batch were then coated with a single or a double coat of each coating type. The coatings were applied using a brush by non-professionals in accord with manufacturers recommendations. After coating, the samples were allowed to dry for at least 24 hours. Clear coatings (USDA mix and Cabot Tannin Bloc) were then coated with a single coating of white latex paint.

To force potential resin exudation, the samples were exposed to sunlight during the summer and early fall on a test fence or they were exposed to temperatures of 110F at high relative humidity (85-90 percent) in an environmental chamber for approximately 3 weeks. A least five replicates were used to evaluate each coating type, number of coats and maximum drying temperature. Approximately 350 samples were used for the tests. The experimental design is shown in Table 2 and a flow diagram depicting the major processing steps is shown in Figure 1.

Table 2. Design of the Phase I experiments

Number of Coatings	Maximum temperatures	Number of coats applied*	Minimum number of replicates	Approximate number of samples tested
8	3	2	5	350

* Boards were tested with both a single and a double coating of finish.

[1]All of the lumber for testing was supplied by Old Town Lumber Company to whom appreciation is expressed.

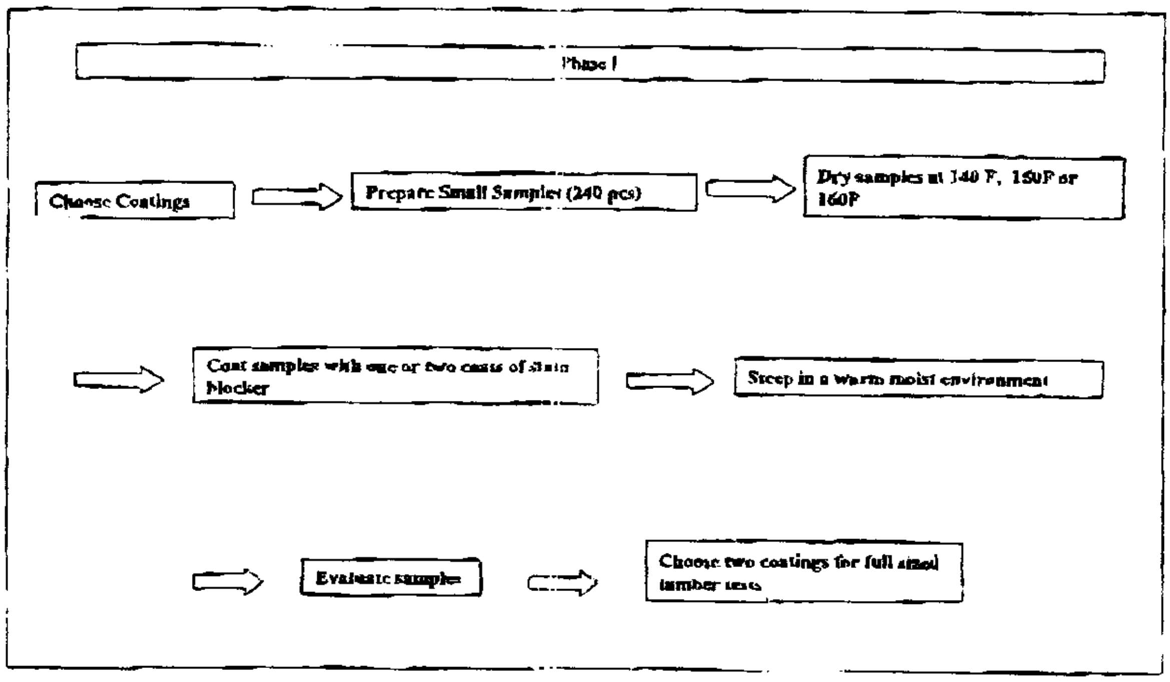


Figure 1. Flow diagram for Phase I.

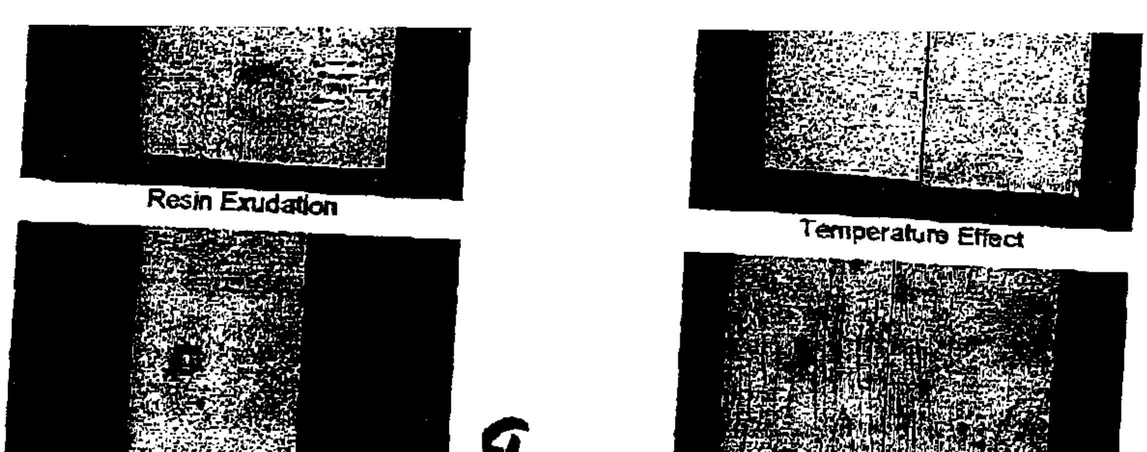
Results from Phase I testing.

Resin exudation through the coatings was evaluated visually to determine the effectiveness of the coatings using four criteria, they were as follows:

Exudation: The primary criteria for evaluation was the ability of the coating to prevent resin exudation. Complete failures blistered the coatings in and around knots. Moderate failures produced very dark colors around knots that indicated that extractives were on the exterior surface of the coatings. Mild failures produced some yellow discoloration around the knots. Examples of severe resin exudation are shown in Figure 2C.

Hide: Hide is the ability to hide a surface or a previous coating. Generally, coatings that have high pigment levels have hiding power with regard to knots, heartwood/ sapwood color differences and stains. Although highly pigmented coatings will hide knots, they do not necessarily block resin exudation because they may not form films that impede the exudation of resins. An example of hiding versus resin blocking is shown in Figure 2B. Heartwood telegraphing can often be prevented using high-hide coatings. Figure 2E shows an example of telegraphing.

Streaking. The addition of coatings and finishes over areas of high resin concentration re-solubilize's the resins and causes streaking. The streaks tend to darken with time.



Durability: After the initial three week period during which the samples were placed in the sun on a fence or in an environmental chamber at under humid conditions, samples of each coating type were returned to the test fence and allowed to "weather" for approximately five months during the winter. Coatings were then evaluated for durability. An example of two samples with non-durable coatings are shown in Figure 2F.

Temperature Effect: The samples were dried at three different temperatures to crystallize or "set" the resin. Once set, the resin should not easily solubilize in the presence of water vapor. Since knots have differing levels of resin, it is difficult to clearly evaluate the affect of temperature. However, as multiple samples from each temperature level were reviewed, it became clear that an affect existed and that samples dried at higher levels (160F) tended to exude much less that those dried at the two lower temperature levels (140F and 150F) when exposed to the fence or to the high humidity of the environmental chamber. An example of the temperature affect is shown in Figure 2D.

The results of the Phase I testing are summarized in Table 3. Based on the results of the Phase I studies, the two coatings chosen for further study were the X-I-M urethane modified acrylic and BIN (William Zinsser and Company).