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Effect of Coating Systems on the Vaporization of Pentachlorophenol from Treated Wood

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Specimens of southern pine treated with pentachlorophenol (penta) in mineral spirits (dip treatment), penta in P9 type A oil and penta in methylene chloride (pressure treatments) were used to evaluate the efficacy of different types of coatings in suppressing the vaporization of penta from treated wood. The clear film-forming coatings, such as polyurethane and alkyds, were typically greater than 90 percent effective for specimens dip treated with penta in mineral spirits. Two-component (epoxy type) pigmented coatings were effective on specimens treated with penta in P9 type A oil. Coatings that wre not compatable with P9 oil were the least effective in preventing penta vaporization. All coatings tested on specimens treated with penta in methylene chloride were greater than 90 percent effective in reducing vaporization.

Introduction

Possible health effects associated with the exposure of humans to air-borne pentachlorophenol (penta) have focused attention on the use of wood treated with this chemical inside homes. Similar concern has been expressed over the use of penta-treated wood in structures housing livestock or other animals.

The air-borne level of penta in an enclosed room freshly coated with 5-6 percent solution of penta was reported to range from 50 to 100 $\mu g/m^3$ (1). Six months later, the levels in the same room ranged from 0.6 to 1.7 $\mu g/m^3$.

Air levels of penta measured under actual field conditions by Saur *et al.* (2) were predominantly less than 1 $\mu g/m^3$ for enclosed barns and other structures containing penta-treated wood. However, in that same study, air levels of 8.8 and 38.0 $\mu g/m^3$ were reported for one building. Unsuccessful attempts to grow plants in some buildings and log houses have been associated with use of penta-treated wood in those structures.

In measurements of air levels of penta taken under controlled conditions, temperature was shown to affect the air levels by the following equation:

$$\ln(C) \simeq - \Delta H/I\ T + k$$

where C = concentration of penta in air, AH = heat of phase change, R = gas constant, T = temperature in degrees Kelvin and k = a constant (3). Changes in relative humidity had little effect on the observed air-borne levels of penta.

The use of cosolvents with commonly used penta-carrier systems was shown to reduce the amount of penta vaporization from treated specimens (4). Likewise, vaporization from specimens treated with penta in heavy oils, such as Bunker C, was less than that from specimens treated with penta in conventional solvents.

The objective of the study reported here was to determine the effectiveness of different coating systems in reducing the levels of air-borne penta vaporizing from specimens dip-treated with penta in mineral spirits and pressure-treated with penta in P9 type A oil or methylene chloride,

Experimental

Penta in volatile solvent carrier systems: mineral spirits and methylene chloride

One set of wood samples consisted of 11″ x 3″ x ¾″-thick specimens cut from southern pine boards selected for uniformity of growth and freedom from defects. These specimens were given a 60-second dip treatment in a commercial water-repellent preservative formulation containing approximately five percent penta in mineral spirits and polypropylene glycol cosolvent. The second set of samples was composed of specimens of the same approximate size as the first. These were flat sawn, with the treated surface exposed, from logs commercially diptreated with the same type of penta formulations. The exposed, treated surface area was approximately 530 cm^2 for the 11″ × 3″ × ¾″ specimens and 210 cm^2 for the log sections (5).

Clear wood finishes representing different commercial formulations were selected for testing on specimens treated with penta in mineral spirits (Table 1). All of these solvent-borne Coatings are suitable for interior use. Some are recommended by the manufacturer for exterior use as well. No water-borne varnishes were evaluated on specimens treated with penta in mineral spirits.

Inaddition to the clear finishes (Table 1), selected pigmented exterior coatings (Table 2) were also tested on 11″ × 3 × ¾″ specimens pressure-treated with penta in methylene chloride. These specimens were treated by the full-cell scale cylinder using a full-cell process (4). A retention of 0.35 to 0.45 pounds per cubic foot was obtained.

Penta in P9 type A carrier systems

Specimens treated with P9 type A oil (Chevron WT blend) carrier systems were also 11″ × 3″ × ¾″ to maintain consistency in sample size. These specimens were treated by a local treating plant using a full-cell process. The same retention level as that required for specimens in a previous study (3) was used (0.35 to 0.45 pounds per cubic foot).

Wood treated with penta in P9 type A oil is generally used in applications where exterior-type coat-

TABLE 1. Coatings Tested on Samples Dipped in Five Percent Penta Water-Repellent Preservative Formulation.

Name	Type of Formation
Fixall 409 Satin Finish	Vinyltoluene coplymer with linoleic, linolenic and oleic acid
Deft-ClearWoodFinish	Nitrocellulose, coconut oil alkyd, stearates
Minwax 209 Wood Finish	Notprovided
Mautz-Polyurethane Clear	Oil-modified urethane resins
Fixall Exterior Spar Varnish	Linseed oil, tung oil, modified phenolic resin
DanishWoodFinish	Not provided
Olympic Stain 718	Linseed oil semi-transparent
Fixall 405 Clear Varnish	Tung oil, linseed oil, ester gum

TABLE 2. Summary of Coatings and Combinations of Coatings Tested on Penta/Oil-Treated and Penta/Methylene Chloride-Treated Samples..

1. Water-Borne Coating Systems
   - A. 1 coat DuPont Lucite Latex Wood Primer, 51c
     1 coat DuPont Lucite house paint, 50C
   - B. 1 and 2 coats Glidden Durkee Insul-Aid
     1 coat Glidden Durkee Insul-Aid plus 1 coat of Mautz Deluxe Enamel E-725
   - C. 1 and 2 coats Koppers 600 acrylic emulsion
2. Solvent-Borne Coating Systems
   - A. 1 coat Mautx Deluxe Enamel E-725
   - B. 1 and 2 coats Mautz Epoxy Enamel, 920 with Mautz Enamel Catalyst, C-920
   - C. 1 and 2 coats Fuller O'Brien Pigmented Shellac, 2-7870
   - D. 1 and 2 coats of Koppers Rustarmor 500
   - E. 1 coat of Koppers Bitumastic 300M
3. Clear Water-Borne Coatings
   - A. 1 coat Varathane Super 100
   - B. 1 coat Varathane Super 102
4. Aluminum Pigmented Varnish (2 lbs. Alcoa Aluminum Paste to 1 gal. Mautz V-200)
   - A. 1 and 2 coats of Aluminum Pigmented Varnish
   - B. 1 coat Aluminum Pigmented Varnish plus 1 coat Mautz Deluxe Enamel E-725
5. Other
   - A. Paraffin Wax
   - B. PermatoxPentits

[a]Coating Formations:

DuPont Lucite Latex Wood Primer

Pigment 20% Titanium dioxide (IV) 16% Silica 4%	Vehicle 80% Acrylic resins 27% Additives 3% Water 46% ethylene glycol 4%

DuPont Lucite House Paint

Pigment 29% Titanium dioxide (IV) 14% Titanium diocide (I) 3% Silicates 7% Mica 5%	Vehicle 71% Acrylic Resin 19% Additives 2% Water 48% Ethylene glycol 2%

Glidden Durkee Insul-Aid

Pigment 31.9% titanium dioxide (III) 8.8% Barium sulfate 4.6% Silica and silicates 18.5%	Vehicle 68.1% Butadiene styrene resin 23.1% Additives 2% Water 43%

Mautz Deluxe Enamel E-725

Pigment 52.2% Titanium dioxide 51.7% Zinc oxide 0.9% Calcium dioxide 30.2% Magnesium silicate 17.2%	Vehicle 47.8% Alkyd 45.1% Alphatic hydrocarbons and driers 54.9%

Mautz Epoxy Enamel 920

Pigment 48.1% Titanium dioxide 100%	Vehicle 51.9% Polyamide catalyst 43.1% Butyl alcohol 14.1% aromatic hydrocarbons 28.7% Aliphatic hydrocarbons 14.1%

Mautz Catalyst for 920 (C-920)

Pigment - none	Epoxy resin 46% Aromatic hydrocarbons 15.5% Alcohols 12% Glycol ethers 26.5%

TABLE 2. (Cont'd.)

Fuller O'Brien Pigmented Shellac	
Pigment 31.7%	Vehicle 68.3%
Titanium pigments 79%	Non-volatile 31.5%
Inert pigments 21%	Volatile 68.5%
Koppers Rustarrest 500 Ext. [illegible] Green 369	
Pigment 26%	Vehicle 74%
Titanium dioxide 85%	Oil modified alkyd resin 55%
Chromium oxide green 15%	Aliphatic and aromatic hydrocarbon solvents 41%
Phthalocyanine Blue - trace	Additives (dryers and thickeners) 3%
Koppers 400 Acrylic Emulsion Ext. [illegible] Green 369	
Pigment 33%	Vehicle 67%
Extender pigment 55%	Acrylic emulsion 56%
Titanium dioxide 40%	Water 36%
Chromium oxide green 5%	Coupling solvents 7%
Phthalocyanine blue - trace	Additives (preservatives and stabilizers) 1%
Koppers Bitumastic 300M	
Pigment 25%	Vehicle 75%
Silicates 100%	Coal tar pitch 37%
	Epoxy resin 27%
	Polyamide resin 12%
	Aromatic hydrocarbon solvents 20%
	Additives (catalyst, thickeners) 4%
Varathane Super 100	Not Available
Varathane Super 102	Not available
Aluminum Pigmented Varnish (Moore V-200)	
Polyurethane 49.0%	
Benzophenone 0.5%	
Aromatic hydrocarbons 11.5%	
Aliphatic hydrocarbons and driers 39.0%	

ings would be desirable. Because of the need to find a coating system compatible with oil retained in the treated wood, a wide variety of formulations and combinations of coatings were selected for testing based on information from manufacturers and the literature (Table 2). They were of four basic types:

1) Waterborne (latex) coating systems
2) Solvent-borne coating systems
3) Waterborne varnishes (clear)
4) Aluminum pigmented varnish

Permatox Pentite is a waterborne formulation designed primarily for use on logs or other wood treated with penta in a volatile carrier system. It is not a film-forming agent but inhibits vaporization of penta by formation of a chemical complex.

Evaluation of penta vaporization rates

Prior to the application of any coatings, the ends of the specimens were coated with paraffin wax and the amount of penta vaporization from each specimen determined. Each specimen was placed in a 4.1" × 19"-long glass tube housed in an environmental chamber (Figure 1). Air, conditioned to 31°C and 50 percent relative humidity, was pumped at a rate of 1.0 liter per minute across the samples. Air-borne penta was collected by a gas-scrubbing apparatus for interior coatings tests or by silica gel sorption tubes for exterior coatings tests. The gas-scrubbing apparatus and mass spectral analysis techniques used in this study have been described previously (3,4).

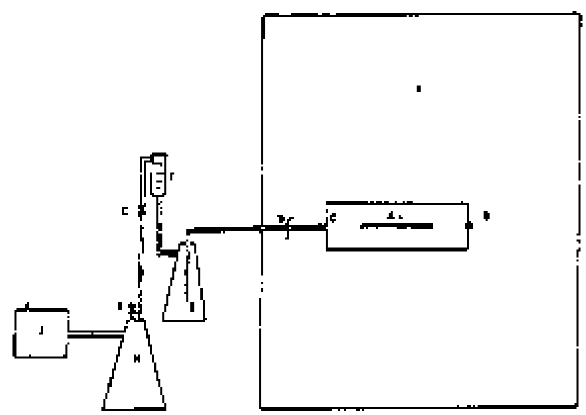
The technique for using silica gel sorption tubes was adopted mid-way through this project because of its simplicity and shorter analytical time. Air was pumped at 1.0 liter per minute through a 0.6 cm × 15 cm tube containing 0.6 to 0.7 g of silica gel (Figure 1). The penta was desorbed with 10 ml of benzene and analyzed by electron-capture gas chromatography.

A direct comparison of the two different methods was made prior to the adoption of this technique. No signifiant difference in the measured air levels of penta was observed. The levels of tetrachlorophenol were not determined.

Coating and testing procedure

The specimens treated with the commercial water-repellent preservative formulation of penta in mineral spirits were given one and two coats of the selected finish (Table 1). The level of air-borne penta was determined approximately two weeks after the application of each coat.

The specimens treated with penta in P9 type A oil were given a single coat of an exterior finish (Table 2) and the level of airborne penta measured two and



Key to Figure 1

A. 11" × 3" × ¾" treated sample.
B. Air inlet from Aminco unit to sample chamber.
C. Air outlet for 48 cm × 10.4 cm (id) glass test cylinder.
D. Sample collection tube containing 0.6 g of silica gel or gas sparger.
E. Water entrainment trap.
F. Flowmeter 0-1 L/min.
G. Air flow control valve.
H. Ballast volume to pump.
I. Air flow to ballast volume control valve.
J. Vacuum pump—Neptune Dyna Pump, Model 4K.
K. Aminco Air unit controlled chamber.

four weeks after the coating application. The specified second coating was applied and the specimens were retested for penta vaporization. One coat each of paraffin wax and Permatox Pentite was also applied to specimens treated with the penta in P9 type A oil. Coatings that were 80 percent efficient in reducing penta vaporization from specimens treated with penta in mineral spirits were retested on specimens treated with penta in P9 type A oil and specimens treated with penta in methylene chloride.

To determine the weight of each coating applied, the initial weights of the container, 30–40g of coating, the brush and aluminum foil (12″ × 12″) were recorded. The specimen was coated, allowed to drip onto the aluminum foil and all materials reweighed, The weight of the coating was recorded as the difference.

All specimens were stored at 22°C and 50 to 65 percent relative humidity. The specimens treated with P9 type A oil prior to coating were evaluated for tackiness and oil stain.

The percent effectiveness (E) of all the coatings overthe various penta treatments was calculated by the following equation:

$$E = \frac{C_1 - C_2}{C_1} \times 100$$

where C_1 = penta level before coating and C_2 = penta level after coating.

TABLE 3. Concentrations of Penta in Airfor specimens Dip Treated with Penta in Mineral Spirits for 60 Seconds in the Laboratory and Exposed at 31°C.

Coatings	Penta in Air Conc. (µg/m³) Uncoated	1 coat	2 coats	Percent[a] Effectiveness
Fixall 409 Satin Finish	145	31	21	81
Deft-Clear wood Finish	160	19	10	91
Minwax No. 209 Wood Finish	140	73	nill	74
Mautz-Polyurethane Clear Finish	111	10	8.7	92
Fixall Exterior Spar Finish	198	11	14	94
Danish Wood Finish	118	.9	8	96
Olympic Stain 718	91	32	39	61
Fixall 405 Clear Varnish	157	nil	21	91
AVERAGE	140	22	16	85

[a]Average values after 1st and 2nd coat were used to calculate percent effectiveness.

TABLE 4. Concentration of Penta in Air from Log Sections Commercially Treated with Penta in Mineral Spirits and Exposed at 31°C.

Coatings	Penta in Air Conc. (µg/m³) Uncoated	1 Coat	2 Coats	Percent[a] Effectiveness
Fixall 409 Satin Finish	20	0.7	7	81
Deft-Clear Wood Finish	18	nil	1	90
Minwax No. 209 Wood Finish	43	-	0.4	99
Mautz-Polyurethane Clear	7.3	-	0.5	93
Fixall Exterior Spar Finish	11	0.9	2	87
Danish Wood Finish	18	3	nil	92
Olympic Stain 718	19	1	0.3	91
Fixall 405 Clear Varnish	19	8	6	63
Linseed Oil	32	5	-	84
Tung Oil	16	7	7	56
AVERAGE	20.4	3.5	2.9	84

[a]Average values after 1st and 2nd coat were used to calculate percent effectiveness.

Results

Volatile solvent systems: mineral spirits and methylene chloride

The air concentration of penta from uncoated specimens (11″ × 3″ × ¾″) dipped in penta/mineral spirits solution ranged from 91 to 198 µg/m³ and averaged 140 µg/m³ (Table 3). The average penta level after application of the first coat of finish was 22 µg/m³, corresponding to an efficacy of 84 percent. The five best finishes had an average efficacy of 93 percent. The addition of a second coat of finish reduced the level of penta evolving from these specimens by an average of only four percent.

The air levels of penta observed for tests of treated log section ranged from 7.3 to 43 µg/m³ and averaged 20.4 µg/m³ (Table 4). These levels were substantially lower than the values obtained for the 11″ × 3″ × ¾″ specimens. The exposed treated area of the specimens cut from logs was approximately 50 percent as large as that for specimens cut from lumber. This factor accounts for only part of the observed difference in penta vaporization. Another contributing factor may have been a lower retention of penta by the specimens cut from logs—this caused, perhaps, by a shorter dip time, less penetration by the carrier solvent or depletion of penta because of aging.

The effects of the first and second applications of coatings to treated log sections were similar to those

TABLE 5. Effect of Selected Coatings on the Vaporization of Penta from Specimens Pressure Treated with Penta in Methylene Chloride.

Type of Coating	Wt. of Coating	Penta in Air Conc. (µg/m³) Uncoated	Coated	% Effectiveness
DuPont Lucite Latex Primer	7.75	290	3.2	99
Mautz Deluxe Enamel E-725	7.9	140	7.6	95
Koppers Bitumastic 300M	18.75	180	3.0	98
Varathane Super 100	8.45	160	6.3	96
Varathane Super 102	6.65	180	13	93
Aluminum Pigmented Varnish	6.75	140	4.7	97
Aluminum Pigmented Varnish	6.05	150	3.6	98
Permatox Pentite	dipped	180	6.9	96
Permatox Pentite	dipped	160	1.2	99
	AVERAGE	175		

observed with the 11″ × 3″ × ¾″ specimens. Five of the clear finishes tested on log sections were greater than 90 percent effective in reducing penta vaporization (Table 4). Three of these coatings (Deft-Clear Wood Finish, Mautz-Polyurethane and Fixall Exterior Spar Varnish) were also greater than 90 percent effective on 11″ × 3″ × ¾″ specimens (Tables 3 and 4).

Many of the measurements made in this part of the study were on quantities of penta that were near the detection limit of the mass spectrometric analytical method. These low levels contributed to the randomness of the data and no attempt was made to arrange the coatings in order of effectiveness. However, the three coatings mentioned above proved to be effective throughout the tests.

The average concentration of penta in air (Table 5) for methylene chloride-treated specimens was 176 µg/m³; that for specimens treated with penta-oil was 237 µg/m³. Previous tests of specimens pressure-treated with penta in oil and methylene chloride gave typical values of 170 and 240 µg/m³, respectively (3). Assay of penta retained by the specimens did not account for the difference in air levels observed with specimens in this study. Aging, sample history, wood extractives. wood density or other uncontrolled variables may have contributed to these differences.

P9 type A solvent systems

The variation in levels of penta among wood specimens treated with penta in P9 type A oil was similar to that previously described for other preservative systems. For the first 16 specimens tested, the measured levels of penta ranged from 124 to 416 µg/m³. The arithmetic mean was 237 µg/m³, with a coefficient of variation of 41 percent. One cause for this relatively large variation has been attributed to differences in the wood substrate. The average coefficient of variation for measurements taken on the same specimen was 11 percent and is a result of normal experimental errors of all types. Some variation in values is attributed to non-uniform, or random fluctuation in, air flow around the sample. This variation is similar in magnitude to the variations observed in previous penta vaporization studies (3.4).

The most effective coatings in reducing penta vaporization after the application of the first coat were Koppers Bitumastic 300M and Mautz Epoxy Enamel 920, both of which were more than 90 percent effective (Table 6). The Mautz coating is a two-component, epoxy-type material and the Koppers 300M is also a two-part reactive coating. DuPont Lucite Wood Primer. a single-component acrylic latex finish, was 83 percent effective. Paraffin wax was the least effective coating (Table 6). The penta and P9 type A oil appeared to transport readily through the wax coating. The use of paraffin as an end-coating material was discontinued part way through the study, and a fast-curing epoxy resin used instead.

An aluminum-pigmented varnish reduced penta levels in air by 67, 50 and 48 percent in triplicate tests. Duplicate tests with Fuller O'Brien Pig-

TABLE 6. Summary of the Effectiveness of Single Coats of Selected Finishing Materials on the vaporization of Pentachlorophenol from Wood Pressure Treated with Penta in P9 Type A Oil.[a]

		Penta in Air Conc. ($\mu g/m^3$)			
			Coated		Average[b]
Type of Coating	Wt. of Coating	Uncoated	Run 1	Run 2[c]	% Effectiveness
DuPont Lucite Latex Wood Primer	9.81	130	17	27	83
Glidden Durkee Insul-Aid	4.92	170	56	70	63
Glidden Durkee Insul-Aid	6.38	120	70	60	46
Koppers 600 Acrylic Emulsion	7.12	190	69	93	57
Mautz Deluxe Enamel E-725	9.50	170	45	18	81
Mautz Epoxy Enamel 920	9.69	140	10	15	91
Fuller O'Brien Pigmented Shellac	3.98	330	80	90	74
Fuller O'Brien Pigmented Shellac	3.63	390	76	81	80
Koppers Rustarmor 500	6.87	290	130	110	59
Koppers Bitumastic 300 El	12.6	250	5.5	4.6	98
Varathane Ultra Plastic Super 102	6.05	200	61	61	70
Aluminum Pigmented Varnish	3.78	180	52	66	67
Aluminum Pigmented Varnish	3.86	150	65	85	50
Aluminum Pigmented Varnish	3.79	290	140	160	48
Paraffin wax, brushed	10.08	370	370	350	3
Paraffin wax, dipped	9.92	180	190	130	11
Permatox Pentite (applied by brush)	3.94	410	260	280	34

[a]Values are not corrected for a "background" contribution of 1.1 $\mu g/m^3$.

[b]Percent effectiveness was calculated from the averages of values obtained from Run 1 and Run 2.

[c]Run 2 was made two weeks after Run 1.

TABLE 7. Summary of the Effect of a Second Coating on the Vaporization of Pentachlorophenol from Wood Pressure Treated with Penta in P9 Type A Oil.[a]

Type of Coating	Wt. of coating	Penta in Air conc (μg/m³)	% Effectiveness[b]
DuPont Lucite Latex Top Coat over DuPont Lucite Latex Wood Primer	4.24	14	63
Glidden Durkee Insul-Aid over itself	4.79	30	82
Mautz Deluxe Enamel E-725 over Glidden Durkee Insul-Aid	8.5	71	41
Koppers 600 Acrylic Emulsion over itself	6.23	73	63
Mautz Epoxy Enamel 920 over itself	5.44	7.9	94
Fuller O'Brien Pigmented Shellac over itself	11.06	46	86
Fuller O'Brien Pigmented Shellac over itself	10.47	52	87
Koppers Rustarmor 500 over itself	3.95	93	68
Aluminum Pigmented Varnish over itself	3.87	21	88
Mautz Deluxe Enamel E-725 over Aluminum Pigmented Varnish	8.79	36	76
Mautz Deluxe Enamel E-725 over Aluminum Pigmented Varnish	8.30	100	66

[a]Values are not corrected for a "background" contribution of 0.5 μg/m³.

[b]Percent effectiveness was calculated using the levels of penta in air for uncoated specimens.

mented Shellac (alcohol-borne) and Glidden Durkee Insul-Aid gave reductions of 74 and 84 percent and 63 and 46 percent, respectively (Table 6).

Pennatox Pentite, a waterborne material designed for use on dip-treated wood, was not effective when a single coat was applied by brush to specimens treated with penta in P9 type A oil.

Each specimen was reevaluated for penta vaporization (run 2, Table 6) approximately four weeks later and prior to the application of the second coating. Penta levels showed a slight increase for ten finishes during the second run. A slight decrease was found for six finishes and one finish showed no change between the first and second run.

After the application of the selected second coat (Table 2), the level of penta vaporizing from treated specimens was decreased only slightly (Table 7). The second coats of material did not reduce the levels of penta to the same extent the first coats did. For example, if the level of penta was reduced from 100 to 10 μg/m³ with one coating (90 percent efficacy), a reduction to 1 μg/m³ would not be expected to occur with the second coating.

Coating systems that showed promise in the first series of tests were retested to verify the earlier results (Table 8). All the coating materials which were selected for retesting were greater than 80 percent effective in reducing penta vaporization.

Coatings were evaluated for tackiness and oil bleed-through by both touch and visual inspection. The following coatings showed no signs of tackiness: Koppers 600 Acrylic, Mautz Epoxy Enamel, Aluminum Pigmented Varnish, Fuller O'Brien Pigmented Shellac, Varathane Super 100, Varathane Super 102 and Koppers Bitumastic 300M. These coatings were evaluated after the vaporization mea-

TABLE 8. Results of Evaluation of Coating on Specimens Pressure Treated with Penta in P9 Type A Oil.

Type of Coating	Wt. of Coating	Penta in Air Conc. (µg/m³)		% Effectiveness
		Uncoated	1 Coat	
Mautz Epoxy Enamel 920	8.47	180	32	82
Koppers Bitumastic 30011	5.11	270	35	87
Koppers Bitumastic 300M	7.97	260	11	96
Varathane Super 100 Clear Glass	7.93	189	30	84
Varathane Ultra-Plastic Super 102	7.03	160	20	88
Permatox Pentite	dipped	170	28	84
Permatox Pentite	dipped	190	18	85

surements were complete and the second coat had been applied. All other coatings showed significant signs of oil bleed-through or tackiness.

The effectiveness of coatings tested on specimens treated with penta in methylene chloride (Table 5) was significantly greater than that for specimens heated with penta in P9 type A oil (Table 6). This result indicates that the movement of oil through the coating contributes to the movement and subsequent vaporization of penta. For a coating to he effective in inhibiting the vaporization of penta, it must also be compatible with the oily surface of wood containing a type A solvent.

Permatox Pentite was greater than 96 percent effective in reducing penta vaporization when brushed on specimens treated with methylene chloride solvent systems. The apparent ineffectiveness of this finish, when brushed on samples treated with P9 type A oil carrier systems, is probably due to the incompatibility of the water formulation and residual oil (Table 6). The Permatox Pentite was 85 percent effective when the treated wood samples were dipped in the finish (Table 8).

Summary

A wide variety of interior- and exterior-type coatings (waterborne and solvent-borne) were evaluated for efficacy in reducing the vaporization of pentachlorophenol (penta) from treated wood specimens. Essentially, all coatings evaluated were very effective in reducing the levels of penta vaporizing from specimens pressure-treated with penta in methylene chloride or dip-treated in mineral spirits–penta formulations. Both pigmented and unpigmented (clear) coatings were evaluated.

Coatings which were compatible with the oil in specimens pressure-treated with penta in P9 type A oil were also effective in reducing penta vaporization. Those coatings which remained tacky or allowed the oil to bleed to the surface were generally less effective than the other coatings tested. A bituminous coating and a two-component epoxy paint were the most effective coatings found for reducing penta vaporization from treated wood.

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Discussion

C. M. Rou: Have any levels been set for penta vaporization in buildings to be occupied by humans?

MR. FEIST: I will ask Lee Gjovik to respond to your question.

L. R. GJOVIK: I can't say what the acceptable penta air level should be for a log home. EPA has established 0.5 mg/m^3 of air as the threshold limit value for a worker over an eight hour day. It is also stated that the no-Observable Effect Level or the Acceptable Daily Intake for humans vanes from 3 to 5.8 mg/Kg/day.

E. E. FUNCHESS: I thank you both for this particular work on this subject. I am not a chemist myself. However, I am in contact with persons who would he consumers of these types of products.

I appreciate the slide you had of the log cabin because you cannot believe the number of questions that people bring to us regarding construction of this type home—questions regarding the use of penta in heavy oil which we use for utility products. I would caution anyone from recommending this product in that type of construction. We are also questioned on use of clean treatment type wood preservatives such as penta in a light solvent vehicle that would seem to he more appropriate but even then not in that type of use. I would again say the industry might be cautioned as far as using an industrial type product in a pole that would be used in a home regardless of these coatings. What brings this to my mind was the slide we saw several years ago in the slide presentation regarding the conventionally treated enclosure around a swimming pool and the gentleman's wife could not understand why the plants were dying. I believe this was uncoated but, again, not being a chemist I certainly have reservations myself. and would like to hear the comments that anyone would have in using an industrial type product. We manufacture poles treated with pentachlorophenol as one of several products, and I would appreciate any comments anyone would have in that regard.

MR. FEIST: If I didn't make it clear, the real justification in doing this work was to he able to determine if we could have some effect on controlling penta movement from constructions already up, that is existing structures. In no way would that promote the use of any of these products. The big concern is what's already there with any number of buildings which use treated poles. People would inadvertently use penta in either dip treatments or spray and so the concern was to try to help the existing situation not promote the new ones. I think some of the things you said would be very valid.

R. D. ARSENAULT: I would like to ask a question and also answer questions that have been asked. The example you were looking for is already available. A large office building complex in Long Beach, Calif., I think it is ahout a 200,000 square foot State office building, was built with laminated beams treated with penta-light solvent, and the vapor concentration of penta was so high in the air that the State Department of Human Health Services and State OSHA banned occupancy of the building. The Varathane Super 102 type coating was put on and with a single coat the ambient levels of penta had dropped to background levels, none were detectable after the coatings had dried and the measurements taken. The building was then allowed to he occupied by the State.

A similar type of situation occurred in Alaska in a project that I was also involved in. Enough penta was put into the wood of a utilidor structure that would be about equivalent to a carload of penta in wood that was to he buried into city streets. Due to the amount of penta that was in the air inside that utility structure there was concern over the workers' health so the same type of coating was shipped to Barrow to he applied over that treated wood. It has not yet been applied hut it will be in the future.

I would like to ask, concerning the type of wood treatment in the dip process, how long a dip was that, Bill?

MR. FEIST: I would have to guess 15 to 30 seconds, it was relatively short.

MR. ARSENAULT: Would you expect that if you had a larger piece of wood, such as a laminated beam that was loaded with penta, could this surface coating that reacts with the penta immobilize it? It was a quatenary ammonium compound, as I understand it, which would form a complex with the penta. Once that is used up, would it still he effective to hold the penta in the wood?

MR. FEIST: I would guess if we are talking ahout wood that was dip treated with penta. you are talking ahout getting access to most of it pretty quickly.

With pressure it would depend on how deep the pressure treatment had gone and so on. I really don't know about the extent of control except to state the results found by dip treating. We had reasonably good effectiveness over a pressure treated system.

P. D. GABRIELE: We are actively involved in photooxidation and in studying the photoxidation in penta. Something was very interesting in looking at your results in that it seems that those materials that seem to form a tighter cross-link seem to have the best protection in preventing penta from vaporizing. However. something you have to consider in practice is that the autoxidation and photoxidation of those resins are all quite different in actual reduction to practice. In fact where you show that epoxy is very good in protecing against vaporization. epoxy is also extremely susceptible to autoxidation. That brings up the subject that it would he interesting to see this study run over time under conditions of different types of oxidation, thermal, photo, auto.

I also have another comment and that is, in our studies with photoxidation we show that depending upon the resin system you are using, you can either accelerate or decelerate the photoxidation and the photoxidized end products, all are quite different.

MR. FEIST: Thank you, Pete. Pete has a point. I did not mention that this study really touches only the surface of the problem. We have done absolutely nothing on long-term studies, even long-term studies under control chamber conditions for several months. We don't know any of the effects of heat, light, water, varying conditions or even what happens when the coating is stretched and shrunk by the shrinking and swelling of wood as the moisture changes. No longer term studies have been carried out. We weren't able to continue funding at MSU and outside of continuation of the evaluations in the existing structures there is no real work going on currently. Just the follow-up on the houses so we really need to do that to get a better appreciation of what happens to the various coatings and treatments over a function of time.

C. R. COGGINS: Just a comment on Mr. Rou's question. The environmental unit of the Building Research Establishment in the U.K. have recently derived acceptable daily intake figures for penta, based on World Health Organization figures. I am sorry I haven't got the figures with me hut I am sure they would he willing to let you have them. The work, in fact, will he published very soon and that obviously gives a much better basis for saying, Lee as you did, the TLV values have no relevance to living accommodations. I have the feeling that you are still guessing a hit at the moment about what are the right levels to he working with in buildings.

MR. GJOVIK: We have co-op work continuing with the center for disease control in Atlanta and Mississippi State Univ. where we are monitoring urine, blood serum and air in log homes that have inadvertently been treated with pentachlorophenol. They monitored the people there before a surface coating treatment and they have been hack with two follow-up measurements. Actually they are ready to go in for the third one which hopefully will he the last check on the occupants and take air samples.

MR. COGGINS: Can I just follow that with a little comment. Following the explosion at Soveso when dioxins were released into the atmosphere, the only fatality from that explosion was the plant manager who was murdered by the Red Brigade. There were no other fatalities.

B. F. MURPHY: The personnel on this project are to he complimented for an informative useful hit of infomiation. As I listened to this it is an endeavor to obtain an effective vapor harrier to control penta emissions. Now one item that wasn't mentioned here was the film thickness. In any coating system usually film thickness is the most important item both for durability and impenetrability. I believe this fundamental should he investigated further. Now, as far as biological estimate or evaluation concern goes, rabbits, guinea pigs and so on could he in a log cabin or anything else over a period of time to establish durability and effectiveness of your vapor harriercoatings.

SESSION CHAIRMAN HITE: Bill, thank you very much. Our next paper is entitled "Effect of Two Heat Levels on Matched Gum Crossties–Update" by H. C. Martin, J. L. Watt and T. S. Wagner. Mr. Wagner will make the presentation.

Ingram, Leonard L.. Jr.; McGinnis, Gary D.; Pope, Paula M.; Feist, William C. Effect of coating systems on the vaporization of pentachlorophenol from treated wood. In: Proceedings, seventy–ninth annual meeting of the American Wood–Preservers' Association; 1983 April 17–20; Kansas City, MO. Stevensville, MD: American Wood–Preservers' Association; 1983; 79: 32–41.