PRESERVATIVES, PRIORITIES, AND PROCESSES

By

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Like most other industries at this time, the wood-preserving industry finds itself facing a serious emergency. During the year 1941 wood preservers treated a considerably larger quantity of lumber and timber than in 1940. No actual statistics are available on the amount of material treated in 1941 and it will be some months before such data can be published. The statements made by various individual plant operators, however, indicate strongly that 1941 will show a larger amount of timber treated than any other year since 1930. Whether this rate will be maintained in 1942 depends chiefly upon the demands for new construction for military purposes or munitions production.

Creosote Supplies

In the face of a great increase in demand for creosoted wood, there has been a substantial decrease in the amount of creosote available owing to a great decrease in the amount of creosote imported. This shortage is felt most keenly by plants on or near the Atlantic, Gulf, and Pacific Coasts, which have depended largely upon imported creosote but it is being felt to some extent throughout the country.

The import statistics for the last quarter of 1941 are not available for publication but for the 9 months ending September 30, 1941, they are reported by the Department of Commerce to have amounted to 12,971,656 gallons, which is probably very close to the total for the year. This is about 1/3 of the amount imported in 1940 and about 35 million gallons less than the average importation for the years 1936 to 1940 inclusive, as is indicated by the data in table 1.

What the creosote imports in 1942 will amount to, no one can safely predict. There appears to be plenty of creosote in the United Kingdom for export despite its use there for fuel and, presumably, we could look forward to an ample supply if the oil could be transported more freely. Since all

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imports and exports are under strict control, however, and are governed primarily from the standpoint of military strategy and war-time economy, other factors than the needs of the American wood-preserving industry must determine the creosote import policy in 1942. Those in control realize that creosoted wood is being used very largely on national defense construction, that it is a necessity in the maintenance of our transportation, communications, and power distribution systems, and that it is increasing in importance as a substitute for steel in many types of construction. It seems probable that enough foreign creosote could be allowed to enter the United States in 1942 to avoid plant shutdowns but it is certain that unlimited imports will not be permitted and that surplus stocks of imported creosote will not be accumulated.

There apparently was a large amount of creosote in storage in the United States at the beginning of 1941. Treating plant operators could see the prospective shortage coming and some of them, at least, kept their storage tanks well filled. There was also a large quantity of creosote in the tanks of the creosote producers and importers at the beginning of the year. There is no way to obtain an accurate estimate of the amount of creosote carried over from 1940 but it may have been 30 to 40 million gallons. This was about enough to make up for the shortage in imports and was a very important factor in enabling plant operators to increase the volume of timber treated in 1941 despite the shortage of imports. This condition does not exist at the beginning of 1942, however, since the stored creosote has been used up, and both the treating plants and the creosote suppliers have entered the new year with very low stocks. One important supplier reports that, although he will produce considerably more creosote in 1942 than in 1941, he will have less oil to sell in 1942 because he enters the new year with storage tanks practically dry.

A factor that has favored creosote plant operators in 1941 is the increase in the amount of domestic creosote produced. This increase is difficult to estimate with any degree of accuracy, but it seems certain to fall considerably short of compensating for the decrease in importations. The increase in creosote production has been brought about by an increase in the amount of tar available for distillation, an increase in the average yield of creosote per gallon of tar distilled and, to a lesser extent, an increase in tar distilling capacity.

The increase in the amount of tar produced in the country during 1941 has been a reflection of near-capacity operations of steel mills and coke ovens. However, tar production has by no means run parallel with coke production. The average yield of tar per ton of coal carbonized has fallen off as a result of the short coking periods which prevailed throughout the year in response to a heavy demand for coke; accordingly, tar production will show a much smaller increase during 1941 than will coke production. The increase in tar production has been offset to some extent by the large amounts of tar that were burned in open-hearth furnaces, especially during the first half of 1941. Local shortages of fuel oil or of tank cars, increased cost of fuel oil, and difficulties of obtaining fuel oil of suitable quality, have all encouraged the use of tar as fuel in open hearths. Thus
statistics for 1941, as compared with 1940, are expected to show a large increase in coke production, a smaller increase in tar production, and a still smaller increase in the amount of tar available for distillation.

Other conditions being the same, the yield of creosote per gallon of tar decreases with the coking period during which the tar is formed. However, a compensating factor has been an over-all increase in the distillation residue of the creosote which has been brought about to some extent by a refusal of some distillers to make a low-residue oil but, to a larger extent, by cooperation between producers and consumers. A considerable amount of low-residue oil has resulted from the production of roofing pitch and so-called electrode pitch which is a soft pitch that has been needed in relatively large amounts by the aluminum industry. One large steel company has continued to distill to a soft pitch to blend with fuel oil for open-hearth fuel and, in so doing, has produced a low-residue creosote. However, the general trend has been in the direction of higher residues.

The outlook for 1942, of course, is uncertain, but indications point to a further increase in domestic production of creosote over that of 1941. The supply of tar available for distillation seems to be the limiting factor; tar distilling capacity has not yet been fully utilized. The active demand by defense industries for coal-tar products other than creosote, especially naphthalene and the tar acids required for the manufacture of plastics, should influence the official policy in a manner favorable to the wood-preserving industry. The O.P.W. apparently has already been responsible for an increase in the amount of tar available for distillation by inducing certain steel mills to substitute fuel oil for tar. It does not seem likely, however, that domestic production alone, even when accelerated to the extent that may reasonably be expected, can supply all the creosote needed at the 1941 rate of consumption. On the other hand, a decrease in demand for creosoted timber would ease the situation appreciably.

Supply of Salt Preservatives

The supply of salt preservatives in 1941 apparently was sufficient for we have received no reports that the operation of any treating plant has been hindered by a shortage of salt preservatives, although the amount of timber treated with preservative salts in 1941 was probably somewhat greater than in 1940. This favorable situation will not necessarily continue in 1942, however, for it can very easily be changed by military requirements and the decisions of the controlling agencies.

At the time this is written, there seems no immediate danger of a serious shortage of zinc chloride. The supplies of zinc-ore and hydrochloric acid appear to be adequate and there is no immediate prospect that this situation will change but we have ample evidence that changes can take place very suddenly. The amount of zinc chloride used for wood preserving in 1940, including that used straight as well as that in chromated zinc
chloride, totalled about 4-1/2 million pounds (14). The 1941 total is, of course, not yet available, but it was undoubtedly higher.

Zinc is also a necessary ingredient in zinc-meta-arsenite, of which some 200,000 lbs. were used for wood preservation in 1940. In preparing this preservative, the zinc is used in the form of zinc oxide and the arsenic in the form of arsenic oxide (As₂O₃). The supply of either one is not unlimited but has apparently been equal to the need thus far.

Chromium salts are, of course, important ingredients in several of the salt preservatives in extensive use. Sodium dichromate makes up about 18 percent of the weight of chromated zinc chloride and about 50 percent of Celcure, while Tanalith (Wolman salt) averages about 37-1/2 percent sodium chromate. The amounts of these preservatives reported used in 1940 (14) and the calculated amounts of chromium salts they contained are as follows:

<table>
<thead>
<tr>
<th>Preservative</th>
<th>Amount used in 1940</th>
<th>Chromium salts included</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pounds</td>
<td>Pounds</td>
</tr>
<tr>
<td>Celcure</td>
<td>242,739</td>
<td>121,370 (sodium dichromate)</td>
</tr>
<tr>
<td>Chromated zinc chloride</td>
<td>3,960,896</td>
<td>712,961 (sodium dichromate)</td>
</tr>
<tr>
<td>Wolman salts (Tanalith)</td>
<td>1,062,048</td>
<td>598,268 (Sodium chromate)</td>
</tr>
<tr>
<td>------------------------------</td>
<td>---------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Total chromium salts</td>
<td></td>
<td>1,332,599</td>
</tr>
</tbody>
</table>

The 1-1/4 million pounds of chromium salts used for wood preservation in 1940 were no doubt considerably exceeded in 1941.

With chromium salts, the situation is quite different than with zinc chloride for dependence must be placed almost entirely upon imported chromium ores. As a result, the amounts of chromium ore that refineries may consume and the uses and allocations of chromium and chromium chemicals are under very strict control by the Government. Naturally, the most urgent national defense uses receive highest priority ratings and nondefense uses are largely eliminated. The increase in chromium salts used by wood-preserving plants in 1941 over 1940, in the face of these restrictions, is possibly attributable to the fact that salt treatments in 1941 were considered mainly

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2 Numbers underlined in parentheses refer to list of references at the end of this paper.
for high-priority national defense structures. A prediction by the writers of what to expect in 1942 with regard to the chromate supply would be sheer guesswork.

In addition to the chemicals named above, sodium fluoride, sodium arsenate, and dinitrophenol are necessary ingredients in Wolman salts. Copper sulphate constitutes 50 percent of Celcure preservative. Of these chemicals, dinitrophenol and sodium fluoride are under close control but the supplies of all have been low for some time and their availability for wood preservation in 1942 will be so largely determined by needs for other uses that it cannot be predicted by the writers.

Other Preservatives Should be Considered

Although an acute preservative shortage does not appear certain, treating plant operators and users of treated wood will be unwise if they ignore the possibility that economic and military developments may change the entire picture. During 1918 to 1921, for example, when the supply of creosote was limited, there was plenty of zinc chloride available and the amount consumed per year rose from 26 million pounds in 1917 to more than 51 million pounds in 1921. That is not likely to happen this time, however, because there are other substitutes for creosote that are much better than zinc chloride for outdoor use. During the 1918 to 1921 emergency, also, the use of creosote-petroleum solution began in earnest but this practice has proved so effective that it has increased greatly since that time.

In considering what can be done in the event of inadequate supplies of creosote and of the customary salt preservatives, it is well to see what has already been done in some cases.

One large consumer of creosote-petroleum solution, who customarily has used not less than 50 percent of creosote in the mixture has had to reduce the percentage of creosote by half. In view of the uncertainty that this preservative will be sufficiently effective in the usual absorptions, he has increased the absorption from about 8 to 10 pounds per cu. ft. The net result of the change is that the ties receive only 2.5 lbs. of creosote per cu. ft., which is a net saving of at least 1.5 lb. of creosote per cu. ft. No general shortage of petroleum for wood preservation is anticipated but there may be temporary or local shortages due to transportation difficulties.

Other consumers, who have for many years insisted on creosotes with not over 20 percent (or 25 percent) distillation residue about 355°C, have been unable to secure adequate quantities of such oil and, for the time being, have raised the acceptable limit to 30 percent or even higher. Steps are now being taken to amend the Federal specifications for creosote and for creosote-petroleum solutions, for the duration of the war, so as to permit residues up to 35 percent. In general, a 5 percent increase in residue above 355°C, should increase the yield of creosote from tar by about the same percentage, which is important in a time of shortage.
The consumers referred to felt that they had good reasons for their former preference for a high percentage of creosote in their creosote-petroleum solutions and for relatively low residue creosote. The changes made do not constitute an abandonment of their former preferences but merely a realistic attitude and a logical conformance to the requirements of an emergency. Their emergency preservatives are still good preservatives, even though they may be less desirable in some respects than their preferred preservatives, to which they will probably return when that becomes practicable.

Treating practices, wood species, and the availability of suitable materials vary considerably throughout the United States and the supply of usable preservatives may also vary at any place from month to month. For these reasons, it is not to be expected that any one material can serve as the universal substitute when supplies of creosote or preferred salt preservatives fail. It is desirable, therefore, for both plant operators and users of creosoted wood to study the various possible substitutes and thus to have several to choose from, according to local availability of materials and the needs of the job to be done. The following discussion of preservatives and processes is presented in the hope that it will be useful in that connection.

Toxic Oils Other Than Creosote

Certain toxic oils other than coal-tar creosote are available to the wood-preserving industry. Some have been tested in service so that their degree of effectiveness is reasonably well established; others are still unproven and their use is attended with greater uncertainty as to results. In either event, they should receive careful consideration.

Chlorinated phenols.—Solutions of polychlorinated phenols in petroleum solvents have been attracting attention for some years as prospective competitors of both creosote and salt treatments. The most prominent of the group in the last few years has been pentachlorophenol but tetrachlorophenol and 2-chloroorthophenylphenol have also received attention. All three have high toxicities to wood destroying fungi. Bateman and Bacchler (4) report killing points of 0.002 against the fungus "Madison 517" for penta- and tetrachlorophenol. Carswell and Hatfield (6) reported a killing point of 0.006 for pentachlorophenol and Hatfield (10) reported 0.009 to 0.01 for 2-chloroorthophenylphenol. These toxicity values are not strictly comparable because of some differences in methods. They also cannot be compared directly with creosote toxicities for the latter vary widely, according to the character of the creosote. The toxicity of penta- and tetrachlorophenol, however, appears to be from 10 to 100 times that of coal-tar creosote, depending upon the creosote and the toxicity values used for comparison. Even when diluted to 5 percent concentrations, the toxicities of the 3 chlorinated phenols appear to be equal to or greater than the toxicities of the coal-tar creosotes in common use. From the standpoint of toxicity then, 5 percent solutions of these chemicals appear suitable for wood preservation when used in sufficient absorptions.
Toxicity alone is, of course, no assurance of preservative effectiveness since permanence, as measured by chemical stability, volatility, and leachability in water, is equally important. In these respects, pentachlorophenol is reported (7) to be highly satisfactory and the other two, from such other information as is thus far available, are also satisfactory.

Laboratory tests, no matter how extensive, are not a final measure of the value of a preservative and wood preservers naturally want to know the results of service tests and actual use experience. Although solutions of these 3 chlorinated phenols have been used alone or in mixtures (20) for some years as preservatives for window sash and other millwork, very little information of value to the pressure treating industry is available from this experience. The absorptions and penetrations obtained in the 3-minute immersion treatment, which is the minimum standard treatment of the National Door Manufacturers Association (20), are rather low, the service conditions are usually not comparable to those for structural timbers, and service records on treated millwork are almost entirely lacking. Nevertheless, the results obtained appear to have been generally favorable.

The manufacturers of the chlorinated phenols have numerous service tests under way which include treated saplings, 2 by 4-inch stakes, fence posts, and other forms of experimental material. Most of these are ground tests in which exposure is to decay and termites but some are salt water tests. Data from all these experiments are said to indicate a satisfactory degree of protection when suitable absorptions and penetrations were used but the data have not yet been published. A considerable quantity of lumber, land piles, poles, and other structural material has also been pressure treated with pentachlorophenol solutions, some for railroad use. Most of it has been installed too recently to furnish service data of value and no results have been made public on any of it.

As early as 1931, 2 by 4-inch test specimens were treated by the Forest Products Laboratory with alcohol solutions and with petroleum solutions of tetrachlorophenol and installed in the Barro Colorado Island tests (12). Still other tests with pentachlorophenol solutions in 2 by 4-inch test specimens have been started by the Laboratory in cooperation with a preservative company but too recently to provide useful information. In 1934 the Forest Products Laboratory started field tests on fence posts pressure treated with solutions of tetrachlorophenol in waste crank case oil and, since that date, has started other field tests in which solutions of tetrachlorophenol or pentachlorophenol have been used for fence post treatment. The results available to date from these various tests are given in table 2, together with some results with creosote and creosote-petroleum solutions in the same tests.

Examination of table 2 shows that in most of the experiments, pentachlorophenol and tetrachlorophenol solutions are giving good results. Poorest results have been obtained when using alcohol as a solvent. Fence posts appear to be giving better results than 2 by 4-inch test specimens. This is true with creosote and creosote-petroleum solutions as well as with the chlorinated phenol solutions. It is probably due in part to the greater area exposed per unit volume in the smaller specimens, and partly to the severity of the exposure conditions.
These experiments do not settle the question of the relative effectiveness of creosote and solutions of chlorinated phenols nor do they determine the optimum concentration of solution or absorptions to be used with such solutions. They indicate, however, that petroleum solutions of pentachlorophenol and of tetrachlorophenol, when of sufficient concentration and retention, can give a high degree of protection against decay and termites and are promising materials to use when creosote is hard to get or is too expensive. It is highly desirable that all other obtainable data from experiments and from use experience with these preservatives be made available as soon as possible.

Pentachlorophenol and tetrachlorophenol are much more versatile preservatives than creosote for they are sold as technically pure solids or in concentrated solutions and can be carried in a variety of solvents. Where stronger solutions than 5 percent are required they can easily be made. Where practically colorless treatment or nonbleeding treatment is desired, it can be obtained by choosing suitable solvents. In using creosote-petroleum solutions with a low concentration of creosote, pentachlorophenol may be added to increase the toxicity.

On the other hand, it is still wise to be cautious and conservative. There is a tendency for some promoters of pentachlorophenol preservatives to make extravagant claims for their products. Remarkable penetrating properties are most frequently claimed and the easily convinced are misled into believing that superficial treatments with pentachlorophenol solutions are equal to pressure treatments with creosote or accepted salt solutions. This idea is not new, of course, for similar claims are made for many proprietary preservatives, including several of the creosote or carbolineum type. In considering such claims, it should be remembered that pentachlorophenol and tetrachlorophenol by themselves do not penetrate wood and that the penetrations obtained with their solutions depend upon the solvents chosen and the treating conditions used. Petroleum solvents of very low viscosity do penetrate better than creosote, which has higher viscosity. Substantial absorptions and deep penetrations can often be obtained in easily treatable wood by merely soaking it for a day or more in low viscosity solutions of pentachlorophenol at atmospheric temperatures. Rather surprising results can also be obtained with creosote under the same conditions. There is no known practical solvent, however, that penetrates deeply and quickly into wood that is resistant to penetration. The cheap byproduct petroleum oils of the fuel oil type ordinarily have viscosities as high as creosote, or higher, and cannot be expected to excel creosote in penetrating properties.

The cost of pentachlorophenol will undoubtedly have much to do with its ability to compete with creosote in the future but, under present abnormal conditions, availability may often be more important than cost. Pentachlorophenol solutions appear to be as freely available now as creosote and at competitive costs but the situation can be changed at any time by priority orders. For this reason, it cannot safely be predicted that pentachlorophenol solutions will take up the slack if the creosote supply becomes inadequate. After the war the supply of both creosote and pentachlorophenol should be adequate and cost will be a much more important factor. Creosote will still have the advantage of a century of successful use experience, but
if experience with pentachlorphenol solutions continues to be favorable and their cost per unit of timber treated is lower than that of creosote, their use is likely to grow at the expense of creosote.

**Water-gas tar.**—Most of the water-gas tar now being produced is used in road tars. The exact amount used in wood preservation, including that which is distilled to produce a creosote and that which is blended with coal-tar creosote, is difficult to ascertain. Water-gas tar varies greatly in viscosity according to the oil from which it is made, as well as the conditions of manufacture. Much of it is too viscous to be suitable for wood preservation but satisfactory absorptions and penetrations may be obtained with the less viscous tars. Service tests (2, 24) show that water-gas tar is a very good preservative when properly applied and is well worth considering as a substitute for coal-tar creosote for land use.

**Low-temperature tars and creosotes.**—Low-temperature coal-tar creosotes differ in chemical composition from high-temperature coal-tar creosotes as shown by pronounced differences in a number of properties, such as specific gravity of fractions, sulfonation residue, tar-acid content, and naphthalene content. Some of them have given very good results in service tests (2) and a paper by Dr. Reid (22) reports interesting and favorable laboratory data about another. The total amount of these oils available for wood preservation is not large and apparently it is being used mainly in mixture with high-temperature coal-tar creosote.

The tar produced by the Curran-Knowles process is sometimes referred to as a low-temperature tar, but in most of its characteristics it lies between a high-temperature and a true low-temperature coal tar. The few service tests that have been started on the tar alone have not yet reached a stage where conclusions may be drawn. At present all of it is said to be sold for wood-preservation purposes and is used undistilled and mixed with coal-tar creosote. It apparently finds favor for this purpose because of its low viscosity, distillation residue, and benzol-insoluble content.

The low-temperature coal tars and Curran-Knowles tars produced in the United States result for the most part from the manufacture of smokeless domestic fuel. Certain indications point to an increased use of these processes in the future, but because of priorities on building materials any great expansion in any of them is not to be expected for some time. The total production of these materials probably comprises less than 5 percent of the coal-tar creosote used annually.

Lignite coal-tar creosote has been used by one railroad company for some years, in mixture with coal-tar creosote and petroleum oil. The limited service data thus far available (24) fail to show that lignite-tar creosote is equal to coal-tar creosote, but in certain regions and under certain conditions its use may well be an economy.

The Portland Gas and Coke Company, in carbonizing petroleum oils for the manufacture of municipal gas, produces an oil tar from which a
Table 1.--Imports of coal-ter creosote from various sources for the years 1936 to 1940 inclusive.

<table>
<thead>
<tr>
<th>Country</th>
<th>Amount of creosote imported</th>
<th>1936</th>
<th>1937</th>
<th>1938</th>
<th>1939</th>
<th>1940</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gallons</td>
<td>Gallons</td>
<td>Gallons</td>
<td>Gallons</td>
<td>Gallons</td>
<td>Gallons</td>
</tr>
<tr>
<td>Belgium</td>
<td>7,506,934</td>
<td>9,136,788</td>
<td>5,891,147</td>
<td>9,588,787</td>
<td>16,452</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>1,026,429</td>
<td>2,569,751</td>
<td>268,177</td>
<td>532,018</td>
<td>449,794</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>--</td>
<td>2,849,347</td>
<td>7,159,220</td>
<td>4,568,565</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>4,644,584</td>
<td>5,614,314</td>
<td>4,869,725</td>
<td>5,672,901</td>
<td>5,065,074</td>
<td></td>
</tr>
<tr>
<td>Kwantung</td>
<td>--</td>
<td>859,213</td>
<td>1,216,250</td>
<td>--</td>
<td>367,500</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>4,141,753</td>
<td>12,329,470</td>
<td>6,261,601</td>
<td>2,811,449</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>--</td>
<td>--</td>
<td>1,089,340</td>
<td>6,139,892</td>
<td>--</td>
<td></td>
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<tr>
<td>United Kingdom</td>
<td>24,063,995</td>
<td>24,815,077</td>
<td>28,017,758</td>
<td>22,554,836</td>
<td>33,110,968</td>
<td></td>
</tr>
<tr>
<td>All others</td>
<td>--</td>
<td>15,567</td>
<td>18,372</td>
<td>8,154</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>41,383,695</td>
<td>58,189,527</td>
<td>55,391,590</td>
<td>51,876,602</td>
<td>39,009,788</td>
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<tr>
<td></td>
<td>Average annual importation during the five years, 49,170,240 gal.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

\(^1\)Data from published reports of U. S. Department of Commerce (Industrial Reference Service, Part 1, Chemicals and Allied Products).
<table>
<thead>
<tr>
<th>Form of test</th>
<th>Location of test</th>
<th>Number</th>
<th>Preservation</th>
<th>Concentration of preservative</th>
<th>Average absorp. in %</th>
<th>Date at last inspection</th>
<th>Length of treatment</th>
<th>Condition of timber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Tetrachlor-phenol in alcohol</td>
<td>2.6 10.7%</td>
<td>1931 ex. 10</td>
<td>5 years</td>
<td></td>
<td>40% destroyed</td>
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<td></td>
<td></td>
<td>7</td>
<td>Tetrachlor-phenol in petroleum</td>
<td>5.0 2.1%</td>
<td>1931 ex. 5</td>
<td>5 years</td>
<td></td>
<td>15% destroyed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>Tetrachlor-phenol in petroleum</td>
<td>5.0 13.8%</td>
<td>1931 ex. 10</td>
<td>10% sound</td>
<td></td>
<td>70% destroyed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>Tetrachlor-phenol in petroleum</td>
<td>9.4 17.3%</td>
<td>1931 ex. 10</td>
<td>10% sound</td>
<td></td>
<td>90% destroyed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>Tetrachlor-phenol in petroleum</td>
<td>12.5 21%</td>
<td>1931 ex. 10</td>
<td>10% sound</td>
<td></td>
<td>90% destroyed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>Tetrachlor-phenol in petroleum</td>
<td>14.5 27%</td>
<td>1931 ex. 10</td>
<td>10% sound</td>
<td></td>
<td>90% destroyed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>Tetrachlor-phenol in petroleum</td>
<td>16.0 30%</td>
<td>1931 ex. 10</td>
<td>10% sound</td>
<td></td>
<td>90% destroyed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>Tetrachlor-phenol in petroleum</td>
<td>17.6 33%</td>
<td>1931 ex. 10</td>
<td>10% sound</td>
<td></td>
<td>90% destroyed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>Tetrachlor-phenol in petroleum</td>
<td>5.0 8.8%</td>
<td>1931 ex. 10</td>
<td>10% sound</td>
<td></td>
<td>50% destroyed</td>
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<td>50% destroyed</td>
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Note: The table above shows the results of exposure tests on experimental material pressure treated by the Forest Products Laboratory with tetrachlorphenol and pentachlorophenol solutions.
creosote may be distilled. Some tests on this creosote (23) by the block method indicate that it has considerable promise as a wood preservative.

**Aromatic petroleum oils.**—The importance that petroleum oils used as diluents of creosote have assumed in the wood-preserving industry is well recognized and the possibility of extending our supplies of creosote by reducing the creosote percentage in these mixtures has been mentioned. In addition to furnishing the inert oils that are now being used as diluents or solvents, the petroleum refining industry might be a source of toxic oils. This field, which has been sporadically explored in the past, is now of renewed interest because of changes in conditions. As a general rule, straight distillate oils from petroleum are too insoluble to kill wood-destroying fungi growing either on agar or wood. They usually exert some retarding effect and within a given boiling range the tendency to be toxic increases with the aromaticity of the oil. By the use of certain preferential solvents, it is possible to extract from petroleum oils, constituents that will kill wood-destroying fungi.

In cracking heavy petroleum oils to produce gasoline, the unconverted residuel oils tend to increase in aromaticity. In applying the different basic cracking processes and their variations to different crudes, a large number of different oils of varied properties are produced by the petroleum industry. Certain refining processes other than cracking also tend to increase the aromaticity of oils. The yields of some of these oils are small on a percentage basis but, because of the tremendous volume of oil processed, the volumes of the byproducts are large by standards of the wood-preserving industry.

Determinations of toxicity have been made on a number of samples of aromatic petroleum oils. As a general rule, they are not quite soluble enough to kill the organism growing on agar, but their inherent toxicity is shown by the fact that very small amounts permit only a very feeble growth. It is possible that these oils would show fairly good preservative properties in service and it might be possible to fortify them with relatively small amounts of toxic chemicals or creosote. Some preliminary tests have indicated that mixtures of creosote and aromatic petroleum oils may be more toxic than equivalent mixtures of creosote and petroleum oils now being used in the wood-preserving industry. It is hoped that these studies may be continued.

One patented process (21) is said to produce an oil from petroleum residues that is practically identical with coal-tar creosote so far as all ordinary tests show. If this can be substantiated, it will be of great interest, but thus far, little if any progress has been made towards commercial production of the oil.

**Wood-tar creosotes.**—Although wood-tar creosotes have been available in small quantities for many years, they have never been used extensively in pressure treatments. This has been due in part to the relatively limited quantities produced and, to some degree perhaps, to lack of sufficient standardization. For the most part, these products appear to have been sold for nonpressure use although there have been substantial exceptions.
No very positive statements can be made about the effectiveness of wood-tar creosotes because of the differences in character of the products obtained from different sources. The test data available indicate a considerable degree of effectiveness but do not show that the wood-tar creosotes can be safely assumed to be equal to coal-tar creosotes. Red oak ties with an absorption of about 10 lbs. of wood-tar creosote per cu. ft., in test for 21 years at Madison, Wisconsin, (2) will probably have an average life of about 20 years or more. Another group of hardwood ties in the same test that are mostly red oak and were treated with 9 to 10 lbs. of a 50-50 mixture of wood-tar creosote and coal-tar creosote per cu. ft. will have an average life of about 27 years or more.

In the Forest Service fence post study in Mississippi (24) southern pine fence posts pressure treated with 6.6 lbs. of a wood-tar creosote per cu. ft. were showing more deterioration at the end of 3 years than similar treatments with coal-tar creosote or a 50-50 mixture of coal-tar creosote and waste crank-case oil. In the Berro Colorado Island tests also (15) the specimens treated with wood-tar creosote are not standing up quite so well as those treated with coal-tar creosote.

While the evidence fails to indicate that wood-tar creosotes are equal to coal-tar creosotes in ability to prevent decay and termite attack, the wood-tar creosotes do have considerable protective value. They have been used occasionally in the past in mixture with coal-tar creosote, as an accommodation to the wood-tar producer. Opportunities may now occur when this would be of advantage to both the producer and the user of the wood-tar creosote, and thus serve to extend the supply of coal-tar creosote. When such mixtures are contemplated, it will be advisable to consider the quality of the wood-tar creosote very carefully and, if possible, have it meet a definite specification. High acidity and high volatility in the wood-tar product should be avoided. Tests should also be made to assure that the oils used will mix satisfactorily without producing a sludge during the mixing operation or subsequent heating.

Naphthenates.—Copper naphthenate and, probably, some of the other metallic naphthenates have considerable value as wood preservatives. Their use, up to the present time has been confined almost exclusively to surface applications which necessarily has limited their effectiveness and, until very recently, they were sold only in proprietary preservatives. One such preservative has been in use for many years in Europe, particularly in Denmark and in England, but the sale of naphthenate preservatives in the United States appears to have only begun during the last 4 or 5 years. The growing interest in the naphthenates as preservatives appears to arise from the increasing quantities of naphthenic acids being produced as byproducts of the petroleum industry and the urge to find markets for them.

The effectiveness of the naphthenates as wood preservatives has not received adequate study and no data are available as to the absorptions that should be injected for best results. It is possible that petroleum solutions of copper naphthenate could be made to protect wood as well as creosote does but it remains to be seen what solution concentrations and absorptions would be necessary and whether they would be economically.
feasible. The fragmentary information available from various minor studies of copper naphthenate give favorable indications with regard to toxicity, permanence, and field tests. Brush treatments with a naphthenate preservative are said to have given only mediocre protection but apparently satisfactory protection from substantial absorptions injected by pressure. Field tests have been started recently by the Forest Products Laboratory, in cooperation with a producer of naphthenates, in which surface and impregnation treatments in a variety of absorptions are being compared but these tests will yield no results in time for the present emergency.

It seems likely that copper naphthenate will be sufficiently plentiful or cheap in the near future to be of much use as a substitute for creosote in pressure treatments. At prices comparative with current creosote prices, however, copper naphthenate solutions would warrant serious consideration. They appear sufficiently promising to justify extensive experimental use even now, despite their present cost.

Preservative Salt -- Oil Treatments

Card treatment.--The Card treatment with a mixture of creosote and zinc chloride solution, which was used extensively for tie treatment prior to 1934, was originally developed as a means of economicizing on cost by reducing the amount of creosote used per tie. It does not offer much of value in the present situation, however, because equal or greater saving of creosote can be accomplished by using creosote-petroleum solutions, which are more desirable and more effective than the Card mixture.

Zinc chloride-petroleum treatments.--Several types of zinc chloride-petroleum treatments have been described by E. R. Boller (5). Since these treatments use no creosote, they have a distinct advantage over Card mixtures from the standpoint of creosote economy. Service records are not sufficiently comprehensive or complete to permit an exact comparison between these two treatments but it seems quite possible that the petroleum combination would at least equal the Card mixture in effectiveness and, because of the larger amount of petroleum oil injected per cu. ft., it might exceed the Card treatment. The effectiveness of the zinc chloride-petroleum treatment can undoubtedly be varied considerably, according to the absorptions of zinc chloride and petroleum used.

A disadvantage of the zinc chloride-petroleum treatment is that it is a two-movement process and, therefore, more complicated and expensive than a one-movement process. Another disadvantage is the uncertainty as to the zinc chloride supply but this is true of practically all preservatives.

Combination salt and oil treatments are not limited to zinc chloride but are possible with all accepted salt preservatives. Zinc chloride has the advantage over the other salt preservatives for this purpose, however, in that its solutions can be heated to over 200°F. without causing undesirable chemical reactions that reduce the concentration of preservative in the solution. This permits a high-temperature Ruping
treatment with the zinc chloride solution, followed by a vacuum that evaporates some of the surplus water, and then the immediate application of the oil treatment. With preservative salts that cannot be heated to such high temperatures, less water is removed during the vacuum period and the wet wood is less suitable for the oil treatment. Air seasoning between the salt treatment and the oil treatment will, of course, remove the excess water and put the wood in excellent condition to receive a good oil treatment. This method is practicable with all the salt preservatives but the extra handling for seasoning and retreatment is expensive and the time required for the seasoning prolongs the processing period.

In short, petroleum-salt treatment can be applied in various ways, gives longer life than straight salt treatment, and avoids the use of creosote but has the disadvantage of being a two-movement treatment.

Other Preservative Salts

The preservative salts thus far mentioned, namely, Celcure, chromated zinc chloride, Tenalith, zinc chloride, and ZMA, are not the only water-borne, salt-type, preservatives that can be used. Various others are known that have more or less value even though not so extensively used. Their cost, availability, priority limitations, and other considerations greatly limit the ability of these materials to relieve the shortage of other preservatives, nevertheless they may in individual cases be very practical and economical to use and they should not be overlooked. Among them are the following:

**Aczol** is a proprietary preservative solution containing copper and zinc salts and ammonia. In one test (13) Aczol in heavy absorptions has given excellent results but in another test (2) it has not done so well. It seems unlikely that Aczol can be made available in sufficient quantity to contribute much to the relief of the shortage of creosote and other preservatives or that it will be economical to use in the high absorptions that appear to be desirable for a high degree of protection. Nevertheless, Aczol undoubtedly has preservative value and should receive consideration when it is available in an emergency.

**Borax** has been shown (4) to have greater toxicity to fungi than zinc chloride and in a service test on 200 red oak ties (2) with absorptions of 0.24 and 0.59 lbs. of borax per cu. ft., only about 4 percent have been removed for decay in 13 years. A group of 31 southern yellow pine fence posts pressure treated with an average 1.05 lbs. of borax per cu. ft. shows about 55 percent removals after 15 years service in Wisconsin. The Barro Colorado Island tests (13) indicate that borax treated wood in contact with the ground does not have high resistance to termites but it cannot be determined from these tests whether the lack of resistance was due to leaching or to low inherent toxicity to termites. Until that question is settled, it would not be wise to depend upon borax for protection against termites, even where there is no opportunity for leaching.
Borax is rather strongly alkaline in reaction and may possibly have some effect on the strength of the wood. The service tests thus far fail to indicate any adverse effect on strength but they are no proof that there is no such effect. So far as fence posts and similar products are concerned there seems little to fear, but for timbers that must carry heavy loads some caution should be exercised.

Bateman and Baechler (4) suggested that a mixture of borax and boric acid, being neutral in reaction, would be less likely to damage the wood (and paint) and would still be nearly as toxic to fungi as the straight borax solution. Only one service test of such a mixture appears to have been started (24). One hundred southern yellow pine fence posts pressure treated with an average absorption of 0.9 lbs. of 50-50 borax-boric acid per cu. ft. and placed in test on the Harrison Experimental Forest in Mississippi showed no removals at the end of 4 years but 4 percent were showing evidence of termite attack.

In normal times, borax is cheap and plentiful and the borax-boric acid mixture should be competitive in cost with other salt preservatives. Under present conditions the demand for borax for other uses is heavy and its availability for wood preservation is questionable. This situation may change, however, for there is plenty of borax in the ground and increasing the refining capacity could provide all the borax and boric acid needed for all uses. Whether that will be accomplished in the near future we are unable to predict.

Chezonite is a proprietary copper-arsenic-ammonia wood preservative (3) that has found some commercial use on the Pacific Coast. Its continued availability obviously will depend upon the availability of the chemicals of which it is composed. The preservative has not been fully evaluated or generally accepted nor is it yet certain that the optimum absorptions have been arrived at. Nevertheless it appears to be doing very well in unreported service tests and there can be no doubt that Chezonite preservative, when properly applied, can give a considerable degree of protection against decay and termites to wood in contact with the ground. It has not yet reached the stage of development that would justify its general acceptance as a so-called "standard" preservative because it has not had sufficiently extensive use over a long period of time. The results that have been obtained to date, however, are very promising and justify favorable consideration. It certainly should not be ignored for land use where it is economically available and where it may often be a practical alternate to turn to in emergency. Its suitability for marine use is open to question and has not been sufficiently demonstrated to justify our recommending it for the protection of piles in salt water.

Mineralized-cell preservative.—This is a proprietary preservative said to contain arsenic trioxide, zinc sulphate, and copper sulphate, all of which are known to have preservative value. It stands to reason, therefore, that wood properly impregnated with a sufficient absorption of this mixture will have its decay and termite resistance increased. Since the preservative has found some use for the treatment of piles in Pacific
Northwest for a number of years, it should be possible to obtain service records that indicate the magnitude of its effectiveness but none are known to have been published. It is not reasonable to suppose that a preservative of this character would give much protection to piles in salt water and the published (18) and unpublished information available recommends strongly against its use for that purpose. It may, however, compare well with various other salt preservatives for land use and may properly receive consideration for such use when available in an emergency.

Miscellaneous salts.—There are, of course, other salts, which either should have or are known to have more or less preservative value, that have not been used to any significant extent for commercial pressure treatments, if at all. Such salts, however, are unlikely to be freely available now. About all that need be said about them now is that they could probably be used to advantage if they were available at reasonable cost. Among these are mercuric chloride, which is a powerful preservative but expensive, corrosive and poisonous; Bolden salt (9); greensalt (Asc) (17,19); sodium fluoride; copper sulphate; arsenates and other salts of nickel; and a variety of others that have been included in various field experiments but not commercialized as wood preservatives.

Processes

To the operators of commercial pressure treating plants, there would seldom, if ever, be any advantage in turning to a nonpressure treatment. For the user of pressure treated wood, however, certain nonpressure treatments may be useful in an emergency when the customary pressure treated material is unavailable. Similarly, users of butt-creosoted poles, in facing a creosote shortage may have to turn to other methods as well as preservatives.

Standing pole treatments.—Standing poles that have begun to decay at the ground line can have their service life materially prolonged by ground line treatment if the upper parts are in good condition and the decay at the ground line has not progressed too far. Several types of such treatments have developed during the last 10 or 15 years. Their relative effectiveness and economy has not been worked out but enough information has been obtained to indicate that a number of them have merit undernormal economic conditions and that they can extend the life of poles several years. In the present emergency they may prove very useful to public utilities in the event of a shortage of their preferred creosoted poles and with the necessity of making their standing poles last longer.

These various ground line treatments have been described in publications or are being actively promoted by their proprietors and it seems unnecessary to describe them individually here. Several of these treating methods use coal-tar creosote, including the charring and spraying method (11), the "sand-collar" method developed by the Hydro-Electric Power Commission of Ontario (15), the "impregnated sawdust collar" method (16), pouring creosote in the earth around the poles, and no doubt others. They, of course, use
less creosote per pole than is required to treat a new pole and in that way economize on creosote. Still greater creosote economy is obtainable, however, by using pole base treatments that contain less creosote, such as the Osmose and Pfister treatments, or the Anaconda arsenic paste method, which uses no creosote.

The Osmose method.—The Osmose method is a nonpressure method of treating lumber, poles, mine timbers, posts, and similar materials in the green condition and without the use of creosote. Its economy and effectiveness in comparison with "standard" preservatives and treatments remain to be worked out. No doubt they vary widely under different circumstances. The fluoride-chromate-arsenic-phenol preservative that is applied to the surface of the wood in paste form does penetrate appreciably under favorable circumstances, however, particularly in sapwood. Such treatment should have effectiveness in proportion to the absorption and penetration obtained and, in pine posts and timbers, has been shown to be considerable. The nature of the preservative is such that the treatment cannot be expected to have the effectiveness of creosote impregnation in material that must be in contact with the soil or water but in emergencies, and particularly in places remote from pressure treating plants, the Osmose treatment warrants consideration. The chemicals of which the Osmose preservatives are made, however, like most other preservative chemicals, are available in limited quantities and this restricts the extent to which treatment by this method can be expanded.

The steeping process.—Merely soaking green or dry wood in a heated or unheated water solution of preservative salt for a week or two, is much more efficacious than is commonly supposed. Its use, of course, depends on the availability of preservative salts and its value is primarily in places remote from pressure treating plants or for quantities of material too small to interest such plants. When mercuric chloride is applied by this method, remarkable results are sometimes obtained and very good results have been obtained with zinc chloride and sodium fluoride, as is shown in the 1942 report of the Committee on Post Service Records (1).

Oil-salt combination for poles.—A pole treating method that has had some use in recent years is to apply full length pressure treatment with a salt preservative then, with or without subsequent seasoning, to apply a hot-and-cold bath creosote treatment to the butts. This serves to economize on creosote as well as to provide a pole that is "clean" above the ground line. The process appears to have considerable merit and for some uses it justifies careful consideration.

There are various other methods of treatment that might be mentioned (11,3) including several of the Boucherie type, that can sometimes be used in an emergency or under special conditions, but it seems unnecessary to catalogue them here.
Summary

The foregoing discussion has forecast that the amount of creosote produced in 1942 for wood preservation from domestic sources will considerably exceed the domestic production in 1941 but that we enter 1942 with such low stocks that the amount of domestic creosote available for use in 1942 may not exceed that of 1941. If the authorities decide that the military needs permit, enough foreign oil can be imported to supply all requirements not met by domestic production. This is strictly a problem of war-time economics, however, and what the decision will be only those in control can determine.

The preservative salts in common use or that might be used are all of more or less limited availability. Zinc chloride seems least likely to be seriously restricted but not one of them will be available in unlimited quantities and it should cause no surprise if any or all of them should be less available for wood preservation in 1942 than in 1941.

The only toxic preservative that, at present, seems likely to be more available in 1942 than in 1941 is pentachlorphenol. Extenders for creosote and solvents for pentachlorphenol, either in the form of ordinary fuel oils or aromatic byproducts of petroleum cracking processes seem likely to be available in any quantity that may be needed for wood preservation.

Among the substitute materials or practices that seem most promising today for immediate use if needed for large volume treating requirements are the following: use higher percentages of petroleum or tar in creosote solutions, raise the limits on the percentage of creosote distillation residue above 355°C, where such limits have been set up, and use pentachlorphenol in petroleum solutions. Obviously the practicability of these and other methods will vary considerably in different places and circumstances and may be upset at any time by new developments. There is also the possibility that the need for them may be largely avoided by a reduction in the amount of timber to be treated.

The results of adversity are not always evil and not infrequently the things we are forced to do against our will have unexpectedly beneficial results. The research for substitutes should broaden the knowledge of us all and we may find that some of the substitute materials or methods will prove economical and desirable for continued and even expanding use under the highly competitive conditions that we all expect to exist after the present emergency is over.

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