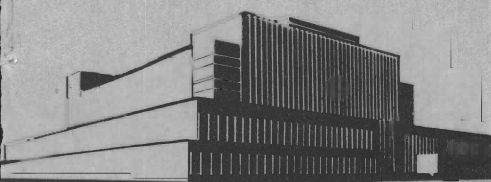
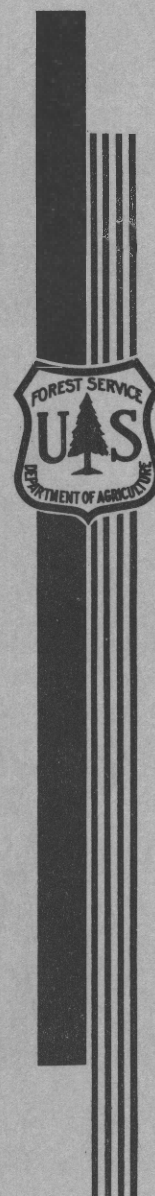


INSPECTION OF PRESERVATIVE TREATMENT OF POLES

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INSPECTION OF PRESERVATIVE TREATMENT OF POLES¹

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Introduction

The importance of inspection in the production of treated wood products by commercial plants has been recognized for a long time. In a paper presented at the 1912 meeting of the American Wood-Preservers' Association,³ R. L. Allardyce referred to the growing tendency "for the purchasers to have their representatives at the plant to inspect both the raw material as well as the treatment." Several papers on the subject have appeared in subsequent issues of the AWPA Proceedings.

In the 1921 Proceedings, a Committee on Inspection⁴ analyzed past practices in inspection and outlined recommendations for plant inspection as well as the qualifications and duties of a treatment inspector. A standing Committee on Inspection has given a report at the AWPA annual convention each year since 1938. The general procedure has been fairly well established for inspection at the plant to assure conformance with requirements on penetration and with retention as shown by gage readings.

The past several years have seen a renewed interest in inspection procedures based on determining retentions by the assay of borings. This in turn has stimulated interest in the possibility of inspection at destination. There has also been a growing awareness of the need for closer inspection of treated products by the producer. This has been stimulated to a considerable extent by the practice of branding treated products, which in effect transfers some of the responsibility for quality control to the producer. A quality control program by an industry association has been envisioned, whereby a licensed producer could brand treated products guaranteed to meet certain standards. The adoption of the boring assay method of checking retention has already had a pronounced effect on practices followed in the procurement of treated poles; its future impact on the wood treating industry might be even greater.

¹Presented at the Wood Utility Pole Conference, Iowa State University, Ames, Iowa, October 19-21, 1960.

²Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

³Allardyce, R. L. Inspectors and Inspection of Material and Treatments at Commercial Plants. 1912 Proc. AWPA pp. 223-225.

⁴Keig, J. R. et al Report of Committee 5-9. Inspection 1921 Proc. AWPA pp. 523-537.

Qualities Covered By Inspection

While the major portion of this talk will be devoted to questions arising from the relatively recent adoption of results-type specifications, it must be remembered that the checking of preservative retentions in wood is only a part of the entire inspection procedure. Actually, inspection of the raw material may start in the woods, at tie plants, at pole concentration yards, or at saw mills. Inspections prior to shipment to the treating plant are generally made by a representative of the producer, but sometimes a representative of the user is present. It is axiomatic that treatment of decayed wood does not restore its original strength; the importance of thorough inspection of poles "in the white" at the treating plant is, therefore a critical step in the production of quality poles. At the same time that he inspects a pole "in the white" for signs of decay, the inspector checks for compliance with requirements on shape, size, knots, framing, branding, and the like.

In the treatment itself, the most important responsibility of the inspector is concerned with the avoidance of practices that will damage the strength of the wood, such as excessive steaming, temperatures, and time cycles.

Of the various features of a preservative treatment, none is more important than penetration. Accordingly, the determination of compliance with penetration requirements constitutes one of the most important parts of an inspector's duties. Charges of Class A poles are commonly checked for penetration on the basis of a random sample of 20 borings. Experience has shown that it is a fairly reliable sample and yields results that are reasonably reproducible. Nevertheless, charges of Class B poles are generally spread and each pole is bored for observation of penetration. Individual poles that fail to meet penetration requirements are marked for retreatment. Charges of piling are also bored 100 percent.

Basic Problems in Determining Retention

In experimental work, it is feasible to dry the test specimens, weigh each specimen before and after treatment, measure the volume with a high degree of accuracy, and calculate the retention from the gain in weight and the known volume. In commercial treatments, poles generally contain an appreciable amount of water; this amount changes during treatment, and the change in weight due to a moisture content change may be relatively large in relation to the weight of preservative oil absorbed by the wood. The gross change in weight during treatment is therefore an unreliable basis for determining the retention for the charge. An accurate correction for change in moisture content is difficult to make.

Up until a few years ago, it was the almost universal practice to determine retention by measuring the volume of preservative (or in some cases, weighing the preservative in a working tank) before and after treatment. Here again water exchange between wood and oil complicates the determination of the volume of oil retained. Added to this are a number of other sources of error. The wood treating industry has paid lip service to the conception of accurately known retention, but those familiar with the subject have realized that, in practice, this property of treated wood is very difficult to measure.

The recognized pitfalls in determining retention by gage readings, as well as the desire of many purchasers for data that could be checked by the purchaser, lead to the development of the boring assay method for checking retentions.

Checking Retention by Assay of Borings

The idea of checking retention in treated wood by nondestructive sampling and analysis of the sample was considered many times in the past and was studied to some extent long before it was adopted by the industry. In 1934, R. E. Waterman^{5, 6} and coworkers at the Bell Telephone Laboratories discussed means of determining the amount of creosote in an individual pole. They pointed out that, if a number of cylindrical borings were taken from a pole, the sample would contain a disproportionate amount of the inner layers. They concluded that the most practical way of obtaining an approximately accurate sample was to take borings to the center of the pole, split them diagonally, and use that part having its small end at the center of the pole. While this procedure might be useful in research, the lack of mechanical means of splitting the borings would make it too time-consuming for the inspection of commercial charges.

Two papers on the subject were presented at the 1954 meeting of the AWWA. A. H. Hearn discussed sources of errors in retention as determined by gage readings and gave voluminous data on relations between gage retentions and the amounts of oil extracted from disks and borings taken from a large number of charges. He showed that in pine treatments the retention in a sample comprising the section 0.5 to 2 inches from the outside of each boring closely approximates the overall retention of the cross section from which the boring was taken. The retentions determined by extraction for 52 charges treated at 11 plants averaged 81.2 percent of the gage retentions. The relation on individual charges varied from 56.7 to 113.9 percent. He recommended an inspection procedure based on the assay of 1-1/2-inch segments of borings.

I also presented data on the extraction of borings from pine poles. Part of my work closely paralleled Hearn's, in that samples comprising the 0.5- to 2-inch segments of borings were extracted. Most of the data were obtained by extracting the entire treated sapwood of borings. My findings regarding relations between extraction data and gage retention were in fair agreement with the findings of Hearn. For 22 charges, treated at four plants, the retention by extraction averaged 75.2 percent of the retention by gage. On individual charges, the relation varied from 60.9 to 98.8 percent, a somewhat narrower range than was found by Hearn, who used the shorter boring in contrast to the entire treated sapwood I used. My findings showed that borings from a group of small poles contained considerably more oil than borings from a group of large poles treated in the same charge. I recommended the collection of a composite sample of borings such that the number of poles of a given size that were bored would be proportional to the total volume of poles of that size.

⁵Waterman, Robert E., and Wells, Charles O. Ind. Eng. Chem., Anal. Ed., Vol. 6:310-314 (1934).

⁶Waterman, Robert E., Koch, F. C., and McMahon, W. Ind. Eng. Chem. Anal. Ed., Vol. 6:499-418 (1934).

Sectioning of Borings

In the tests I had made on the extraction of the entire treated sapwood portions of borings, the time required to measure each boring was recognized as a serious disadvantage. It would therefore be practically imperative, in the inspection of commercial charges, to cut each boring to the same fixed length.

The data published by both Hearn and myself showed that relations between extraction data and gage retentions tended to be erratic, but left unanswered the question of which values were closest to true retentions in poles. The closest approach to experiments that might throw some light on this question has consisted of some limited tests on heavily treated piling. At the 1958 annual meeting of the AWWA, I presented data on the extraction of borings from 19 charges of heavily treated piling, 15 being Southern pine, and 4 Douglas-fir. Three charges of air-dried pine piling were weighed before and after treatment. In one charge there was excellent agreement between retentions found by weighing and gage retentions. In the second charge, the values were 16.35 by weight versus 19.50 by gage; in the third charge, they were 14.68 by weight versus 19.17 by gage. Average retentions shown by gain in weight were close to the amounts found in samples comprising the outer 3-1/2 inches of borings. Samples comprising the outer 3 inches yielded slightly higher amounts of oil on the basis of unit volume, but here again the extraction figures were similar to average retentions for the charge as determined by weighing.

The similarity between retention by weighing and the retention in an "average" boring somewhat shorter than the radius is readily explained. The mathematical error in a cylindrical boring as a sample of the cross section increases with the percentage of the radius that is included. Excluding some inner portion of the boring reduces this error and at the same time introduces an error of opposite sign. Thus, the negative error inherent in a cylindrical boring tends to be counteracted by a positive error that is due to the exclusion of the lightly treated interior portion. For any individual piece, there is some length of an "average" boring which would show the same retention as the overall average for the piece. This length would vary with the diameter and the distribution gradient.

It would seem that, in poles of a given size with thick sapwood, treated to some standard retention, it should be possible to find a length of standard boring that, when repeated in a sample of adequate size, would yield extraction data agreeing fairly well with true average retention for the charge. No data are available to show the range of error in this method of estimating charge retention in poles.

There has been a tendency on the part of some to discount the importance of knowing average retentions accurately. This attitude may account for a decline in efforts to develop the techniques of checking average or charge retention by the extraction of borings. The erratic relations between extraction data and gage retentions found in earlier work lead to the assumption by many that there is no practical means of obtaining a reasonably reliable measure of true average retention by the extraction of borings. This assumption may or may not be correct.

Many proponents of boring assay have arrived at a philosophy that may be summarized about as follows: The assay of borings of fixed length gives a reliable index of retention in that part of an average pole from which the boring is taken. If a proper section of boring is taken, the results should give a good indication of the quality of treatment as far as retention is concerned. The results should therefore be directly related to the

average service life of poles in a charge. The average retention, even if it were precisely known, would not be an exact measure of quality because distributional factors are involved. A lack of agreement between extraction data and average retentions is therefore of minor significance to the user of the product.

I question the soundness of this philosophy. I believe that it would be very desirable to have a better idea of relations between true average retentions and retentions in composite samples of borings of various lengths. While our ideas regarding retentions needed in poles are influenced to a large extent by service records involving gage retentions of questionable accuracy, they are also influenced by field tests on specimens in which retentions are known with accuracy. Research on relations between extraction data and true retentions tends to be costly because retentions as determined from gage readings are of inadequate accuracy. However, the cost of such study seems justified by the importance of the subject.

Setting aside for the moment the question of whether or not a standard boring of some fixed length including the outer zone would give results approximating average retentions, this type of sample deserves consideration from the standpoint of the relation of assay data to quality of treatment.

Since its adoption by the Western Electric Co., the sample boring from a creosoted pine pole comprising the 1/2- to 2-inch segment has become more or less a standard in the pole treating industry. It has several theoretical disadvantages when compared with a larger boring that includes the outer 1/2 inch. The shorter boring requires a cutting in the zone of steep retention gradient, thereby introducing a source of disagreement between check samples. With the smaller volume of sample for a given number of borings, there is less precise laboratory work in determination of whole oil. Thus, the reproducibility of results obtained by two operators would be expected to be enhanced by the use of a longer standard boring that included the outer zone.

The recognized advantage of the 1/2- to 2-inch boring is that it discourages the packing of heavy retentions in the outer zone. This, no doubt, reduces the percentage of bleeding poles. Furthermore, it is believed by many that, when the retention is based on an interior zone, a better idea of quality of treatment is obtained. This theory is open to some questions.

It is well known that the average retention of oil in the outer zone of a pole decreases with time. However, not all of the oil is lost that disappears from the outer zone of the upper portions of a pole. There is a downward gravitational movement of oil which leads to the accumulation of surface deposits in the groundline area. Experience has shown that, as would be expected, surface decay is less likely to be found in poles containing such coatings in the groundline area. The oil that is lost from the below groundline portion may possibly have some beneficial effect in sterilizing the soil.

When modern penetration requirements are met, external decay in the groundline area of Southern pine poles is found more often than is internal decay. Since the producer receives no credit for oil left in the outer 1/2 inch, there is an incentive for him to recover as much as possible by steaming. Theoretically at least, the practice of removing the outer half inch from borings to be assayed discourages the type of treatment that is most likely to prevent early surface decay in the groundline area of poles. Whenever the question of service life outweighs the factor of cleanliness, the use of a boring that includes the outer portion merits consideration. A task force of AWPA Committee P-2 is reviewing the entire subject of the assay of borings; it is hoped that data will be collected that bear on this point.

The foregoing discussion has been focused on the assay of borings from creosoted pine poles, but the questions raised apply in a general way to treated poles of any species. In creosoted poles of species with thin sapwood, a segment of boring 0.1 to 0.6 inch from the surface is generally taken. The same segment is taken from poles with thin sapwood treated with petroleum solutions of pentachlorophenol. When species with thick sapwood are treated with penta-in petroleum solutions, a third size of boring is taken, namely 0.5 to 1.0 inch from the surface. The differences in portions of borings taken from wood treated with creosote compared with wood treated with petroleum pentachlorophenol solution stems largely from differences in the size of sample that is considered the best compromise between accuracy and convenience. This will be discussed further in subsequent pages.

Number of Borings Per Sample

The size of a sample of any material that needs to be taken depends on the heterogeneity of the material and the accuracy desired. Treated wood is known to be very heterogeneous with respect to the factor under consideration, namely the amount of preservative in the wood. For this reason, a sample of convenient size cannot be expected to represent a batch of material as accurately as is possible in the case of certain other materials. On the other hand, retentions called for in specifications generally involve a safety factor. Furthermore, tolerances in retentions are commonly allowed in commercial wood preservation in recognition of the difficulty of obtaining the exact retention that is aimed at. The requirements as to accuracy of sample are therefore not so critical in the case of treated wood as they are in some other materials.

Individual pieces from 20 well-seasoned pine piles weighed before and after a full-cell treatment showed a range in retentions from 20.53 to 32.73 pounds and averaged 26.47 pounds per cubic foot in my experiments already mentioned. The data on variability in retentions by individual pieces were used to calculate the probable sampling error due to this factor alone. The 95 percent confidence interval of a 20-boring sample was found to be 1.63 pounds per cubic foot. Similar data on empty-cell treated poles were lacking when this was written⁷.

During a symposium on Results-Type Specifications at the 1957 meeting of the AWWA, W. R. Yeager presented data on 30 charges from which 2 samples from different poles had been assayed. Agreement was within 1 pound per cubic foot in most cases. Poor agreement was shown in several cases.

The 20-boring sample will certainly distinguish between the very good and the very bad. In borderline cases, the sampling error in a sample of this size will no doubt lead to occasional erroneous decisions regarding the acceptability of a charge. Some charges that are below standard in retention will be accepted while other charges that actually contain adequate retention will be marked for retreatment. Results need to be checked in all questionable cases. Where inspection is made at destination, it would seem logical for a treater to assay more than one 20-boring sample before shipment and to insist that a check be made of any assay conducted at destination if the result indicates cause for rejection.

⁷G. Q. Lumsden published data on creosote retention in individual poles in the September 1960 issue of the Forest Products Journal pp. 456-462. These data have not yet been analysed from the standpoint of sampling error.

To summarize, the 20-boring sample seems to have served its purpose satisfactorily so far; nevertheless, the question of sample size should receive further study.

Analysis of Samples

Of the two essential steps in assaying a charge, namely sampling the charge and determining the amount of preservative in the sample, sampling involves more complex problems. The methods used to determine the amount of preservative in a sample are considered of satisfactory accuracy when applied to samples of ample size.

Two general types of analyses may be used. In oil-type preservatives, the oil may be extracted from the sample with a solvent, toluene being used most commonly. The loss in weight of the sample corrected for the amount of water collected during the extraction is taken as the amount of oil in the sample. For wood treated with oil solutions of a toxic chemical such as pentachlorophenol, or for wood treated with water-borne preservatives, the active chemicals may be determined.

The extraction of oil from a sample is subject to a number of recognized sources of error. Fortunately, they tend to be small and are not of the same sign, so that the method yields accurate results when used by a careful operator. The determination of water is perhaps the principal bottleneck in the precision of the method. The error is relatively small on samples large enough to be truly representative of a charge. In research work, situations sometimes arise in which only a small sample is available; the results on such samples must be accepted with reservations, because the probable error in determining water content is large in relation to the amount of creosote in the sample.

Wood treated with pentachlorophenol solutions theoretically may be assayed either by the extraction of the oil or by the determination of the pentachlorophenol itself. The most common practice has been to determine the amount of pentachlorophenol when treatment has been made with petroleum oil solutions, but to extract the oil when treatment has been made with a solution of pentachlorophenol in creosote. A solution of pentachlorophenol in petroleum may also be determined by extraction. Toluene does not completely extract all of the pentachlorophenol from treated wood, but this introduces only a small error in the determination of the amount of solution present.

A recently issued REA specification calls for the extraction of the solution rather than the determination of the solute in the assay of borings from poles treated with petroleum solutions of pentachlorophenol. The AT&T specifications as well as the AWWA Standard C4 call for the determination of pentachlorophenol.

At first glance, it may seem inconsequential whether one specifies x pounds of pentachlorophenol or x times 20 pounds of a 5 percent solution. In actual practice, there may be a fairly wide difference between the penta content as determined by direct assay and the penta content as calculated from the amount of solution extracted and the concentration of the solution at the time of treatment. The discrepancy probably is due mainly to evaporation of the more volatile constituents of the petroleum. Such evaporation may take place during final steaming or final vacuum or during the interval between the withdrawal and the boring of the charge.

If treating and sampling procedures are such that evaporation losses are held to a minimum, the extraction of the oil coordinated with an analysis of the treating solution

should constitute a satisfactory check on retention. When the above conditions do not prevail, as for example when considerable time elapses between treating and sampling, the direct determination of pentachlorophenol would be expected to yield more reliable data on the initial retention.

Differences of opinion exist regarding the relative advantage of extraction versus chemical analysis. Proponents of extraction point to the advantage of using the same procedure for determining total retentions of different types of oil preservatives. Other advantages claimed are that it is simpler than chemical analysis, requires fewer man hours, and may be used on a much larger and therefore more reliable sample than can be used in the lime-ignition test.

Those who favor chemical analysis argue that it is logical to analyze for the more expensive ingredient of a penta-petroleum solution--which, of course, is the penta. Other objections to the extraction method are based to a large extent on the fact that the petroleum oils generally are less viscous and more volatile than creosote. As was mentioned before, it is felt that the movement of oil during the final vacuum, as well as any evaporation losses during steaming or after treatment, would result in considerable change in retention in the zone taken for assay.

The lime-ignition test was at one time used exclusively in the assay of borings from penta-treated poles. Under most conditions, it is reasonably convenient and accurate. One shortcoming lies in the limited size of sample that can be handled conveniently. Furthermore, the method is not applicable to wood that has been floated in sea water because the sodium chloride thereby absorbed, raises the apparent penta content. The copper pyridine method for determining penta and tetrachlorophenols is unaffected by sodium chloride and is coming into fairly wide use. A larger sample may be used than in the lime-ignition method. The method has been adopted by the AWWA as a tentative standard method. It tends to yield somewhat lower results than the lime-ignition method; this needs to be considered when it is used because present requirements on solution concentrations and penta retentions are based on results obtained by the lime-ignition method.

Instrumental analysis, specifically the use of the x-ray spectrograph, has been found to be readily adapted to the determination of pentachlorophenol. A substantial reduction in time is possible by this method, especially when a large number of samples are on hand for analysis. Because of the high cost of the instrument, its use has been confined to research rather than to commercial inspection.

In conclusion, it may be said that the general principle of checking retentions in poles by the assay of borings has been widely accepted. Certain aspects of it remain somewhat controversial and merit careful consideration both by producers and users of treated poles. Details of sampling in particular should be given further study in order to develop the procedures that give the best assurance of quality of treatment.