PRESENT STATUS OF RESULTS-TYPE SPECIFICATIONS FOR TREATED WOOD

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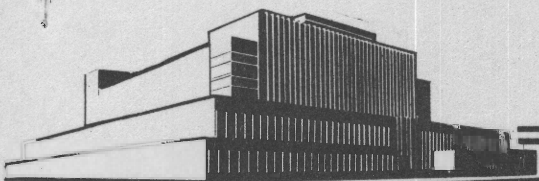

FOREST PRODUCTS LABORATORY
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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

PRESENT STATUS OF RESULTS-TYPE SPECIFICATIONS FOR TREATED WOOD[1]

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Synopsis

A high percentage of the preservatively treated poles now being installed are purchased under so-called results-type specifications whereby the average retention of preservative in a charge is determined by the assay of a composite sample of borings. The practice of purchasing piling under similar specifications is increasing. Considerable progress has been made toward the development of results-type specifications for treated lumber, but several questions concerning sampling technique remain to be resolved.

Practically all inspections of treatments are being made at the treating plant but there is a growing interest in inspection at destination. The feasibility of assaying individual poles and piles is also being considered.

For the present, inspections should be made at the plant whenever possible and average retentions be determined for each charge. Research should be continued on several problems concerning inspection such as the assay of individual poles and piles.

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[1] Presented at the Symposium on Timber -- A Tested Material for the Engineer, held at the Fourth Pacific Area National Meeting of the American Society for Testing and Materials, Los Angeles, Calif., Oct. 3, 1962.

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

Introduction

According to statistics on wood preservation in the United States for the year 1961,[3] the five leading wood items on the basis of volumes treated were:

		Cubic feet
1.	poles	76,438,254
2.	crossties	55,770,256
3.	lumber and timbers	38,847,393
4.	fence posts	15,014,657
5.	piling	14,332,784

The past several decades have seen a marked decline in the volume of wood treated in form of crossties. This is a reflection of the decline in railroad transportation and has been accelerated by certain technological changes that enabled some railroads to reduce the number of miles of tracks in some areas. In 1927, over 222 million cubic feet of wood in the form of crossties were given preservative treatment. As shown above, this figure had declined to less than 56 million in 1961. Crossties comprised 76 percent of the total volume of wood treated in 1911, but they accounted for only 26 percent in 1961.

Disregarding year-to-year fluctuations, the volumes of the other four treated items have held fairly steady during the past decade. Many commercial treating plant operators have reported a gradual decrease in orders for marine piling, but apparently this has been counterbalanced more or less by an increase in the use of land piles.

Slow but steady progress has occurred in the refinement and improvement of the various processes used to inject preservatives into wood. A process that has recently come into commercial use consists of the injection of toxics that are dissolved in liquefied petroleum gases. When the treated wood is released to atmospheric pressure, the solvent evaporates leaving the wood clean, dry, and paintable.

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[3] Wood Preservation Statistics. Gordon D. Merrick, Division of Forest Economics and Marketing Research, U.S. Forest Service, in cooperation with American Wood-Preservers' Association, 1962.

As for the preservatives used, two standard materials--creosote and pentachlorophenol--are now being blended at many plants that are engaged in the treatment of telephone poles. The list of waterborne preservatives now includes several mixtures of chemicals that undergo reaction within the wood to form relatively insoluble compounds resistant to leaching. Several new preservatives showing considerable promise are being investigated.

Perhaps the outstanding present trend in wood preservation consists of the growing use of so-called results-type specifications whereby retentions are determined, not by measuring the volumes of preservatives in working tanks before and after treatment, but by assaying some arbitrary sample taken from the treated wood. This has become the customary practice in the purchase of large quantities of poles, and seems very likely to attain the same status in the purchase of piling.

Most posts to be treated are not split so that, with their cylindrical form, a method for assaying them could be considered a mere modification of the methods being used for poles and piles. However, the assay of treated posts has not been widely adopted by industry so far, probably because of their relatively low cost.

Certain problems in the sampling of sawn products have retarded the development of results-type specifications for treated crossties and lumber. There is considerable interest in the possibility of assaying treated lumber and, with the experimental work that is in progress, the development of results-type specifications for lumber may be anticipated with confidence.

The following is a brief review of the present status of results-type specifications for poles, piles, and lumber. Attention will be called to a few of the technical questions that remain to be answered.

Assay of Treated Poles

As stated previously, it is in the purchase of poles that results-type specifications for treated wood have come closest to general acceptance. A number of limited investigations of assaying nondestructive samples from poles were made in the early 1930's, and perhaps before; these efforts seem to have been discontinued until the early 1950's, however, when work on the subject was resumed in earnest. Within a few years, poles treated with pentachlorophenol were being purchased by one user under a specification calling for an analysis of a sample of borings. Shortly afterward a specification for creosoted poles was developed that called for the determination of creosote in a sample of borings by extraction with toluene. Gradually many other large users of poles adopted similar specifications.

Many formal tests and also practical experience have shown an erratic relation between the results of an assay of boring samples from poles and the average retention for a charge as shown by gage readings. At a given plant a reasonably consistent ratio generally exists between the average gage retention of a fairly large number of charges and the average assay value, but for any individual charge the ratio may deviate greatly from the mean. At one time there was considerable discussion of the reliability of a boring assay as an indication of average retention. The question is raised less frequently at present. Most pole users now feel that, when accompanied by penetration requirements and certain limitations on processing conditions, a properly conducted assay of borings will yield a reliable index of the quality of treatment. Disagreements with gage retentions are therefore disregarded by the purchasers.

Although the feasibility of the boring assay method is now generally accepted, differences of opinion persist regarding certain details of the procedure. One question concerns the portion of the boring to be used. In thick sapwood species, such as southern pine, the outer 1/2 inch of each boring is now commonly discarded, with the 1/2- to 2-inch zone of each being taken to form a composite sample. It has been suggested that the use of a longer boring that included the outer 1/2 inch would offer several advantages, namely (1) it should promote reproducibility of results obtained by different analysts; (2) with a boring of suitable length as determined by experimentation, a more consistent relation between assay values and true average retentions might be obtained (this might lead to a more consistent relation between assay values and gage retention than exists when the "inner zone" boring is used); and (3) it would remove the incentive to manipulate treating processes to obtain minimum retentions in the outer zone that is discarded in borings (the removal of this incentive should decrease the hazard of external decay in the groundline area).

The proponents of the "inner zone" boring point out that its use discourages packing of heavy retentions in the outer zone and thus decreases the percentage of bleeding poles. They also believe that the assay of this zone affords a better idea of quality of treatment than does the assay of a longer boring. This question is being studied by the Preservatives Committees of the American Wood-Preservers' Association; a large amount of data will be needed to clarify the conflicting viewpoints.

The earliest workers on the assay of treated wood focused their attention on only one departure from prevailing practices; this was the analysis of a sample of the final product instead of the measurement of preservative at hand before and after treatment. It was assumed that a sample representative of an entire charge would be analyzed and that such analysis would be conducted at the treating plant. The possibility of conducting the assay at destination rather than at point of origin was recognized, of course, but received little emphasis at first. Within recent years, interest has grown in destination inspection, although few purchases have been made under such system. Many users of treated wood are intrigued by the idea of foregoing the maintenance of an inspector at the treating plant, and instead conducting the assay at the most convenient time and place. Furthermore, transferring the responsibility for quality control to the producer would enable the user to exercise his discretion as to whether or not to sample and assay each shipment.

The advantages that a system of destination inspection offers to the user can hardly be questioned; nevertheless, certain difficulties must be recognized. As compared with plant inspection, the cost of adjusting disputes might be increased considerably. This would throw an increased importance on the accuracy of methods used in sampling and assaying a charge; the methods in use at present may be found to require further refinement. It seems advisable to recognize the magnitude of this proposed step, and to collect any data that may be needed on certain factors that affect the reproducibility of results obtained at varied intervals after treatment.

Another departure from traditional practice has been suggested, namely the purchase of poles (and piles) on an individual basis rather than on a charge or lot basis. The publication of a colorimetric method for assaying piles and poles by M. S. Hudson[4] has stimulated interest in the possibility of such procedure. It is being studied by the AWPA Preservatives Committees. It will be discussed further in the following section on piling.

Piling

Treated piling may be divided into (a) land piling in which retentions used are similar or somewhat higher than for poles, and (b) piling intended for use in coastal waters where protection against marine borers is needed

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[4]M. S. Hudson. Colorimetric Determination of Creosote Retention. Appendix to Report of Committee P-2, Proc. Am. Wood-Preservers' Assn. 57: 22-24 (1961)

and retentions approaching the maximum attainable are generally specified. While a few producers are assaying charges of land piling, a determination of retention by assay has been included only in certain specifications for marine piling.

The high retentions needed to protect piling from destruction by marine borers, especially limnoria, the high cost of replacing piling that have failed, as well as the possibility of errors in gage readings lend strong support to the practice of checking retentions by the assay of borings. Federal Specification TT-W-571g requires that retentions in southern pine and Douglas-fir marine piles be determined by the assay of borings. Similar requirements are under consideration by the American Wood-Preservers' Association; the assay of southern pine piles is now optional in AWPA Standard C-3 as it is in ASTM Tentative Specification D1760-62T.

This latest revision of Federal Specification TT-W-571 not only requires that retentions be checked by assay but also that retentions be very high. Two grades of southern pine piles are covered, one treated to retain 20 pounds per cubic foot of creosote-coal tar solution in the outer 3 inches and the other 25 pounds per cubic foot. The latter grade is recommended for use where limnoria are very active, as they are in many tropical and semitropical harbors. The corresponding grades in Douglas-fir piling are required to contain 17 and 20 pounds per cubic foot, respectively, in the outer 2 inches, with distillate creosote being permitted as an alternate to creosote-coal tar solutions.

A number of treating plants have experienced difficulties in meeting the above retentions. Several plants treating southern pine piles have attempted to treat green piles and have failed to meet required retentions. At least a short air-seasoning period seems necessary for production of the 20-pound grade without an excessive percentage of charge retreatments. For the 25-pound grade, a longer air-seasoning period is advisable. A pretreatment prior to air seasoning may be needed in some areas during some periods of the year in order to avoid decay in seasoning. It has been reported that some purchasing agents, cognizant of the plant operator's difficulties, have been inclined to waive the extraction requirement and accept charges based on gage readings. This practice should be discouraged and will no doubt tend to decline as production problems are solved. A share of the responsibility falls on the shoulders of the purchasing agency. Ample lead time--perferably at least 90 days--should be extended to the producer of pine piling in order to provide time for air seasoning in addition to the time required for procurement and treatment.

As in the case of some users of poles, some purchasers of piling are considering the possibility of checking treatments at destination. Here again more data are needed on the difference in results that may be obtained by two inspectors, one of whom assays borings from 20 piles immediately after treatment,while the other at destination assays borings from 20 other piles of the same charge after a considerable period of time has elapsed since treatment. Such data would indicate to the treater the extent to which the piles need to be overtreated in order to provide a safety factor to compensate for any evaporation loss that might occur and for a possible experimental error on the low side. The additional cost would naturally be passed on to the buyer.

Commercial standards for southern pine and Douglas-fir marine piles have been developed recently by the American Wood Preservers Institute. They permit an option of inspection at destination within a given time limit to determine compliance with physical properties and also retentions as shown by assay. They further describe methods for extracting a sample of preservative from an end disk for the purpose of checking the quality of the preservative present in the piling.

The possibility of assaying piling individually is likewise intriguing to some users of piling. This conceivably could be done at the plant, where rejection of a piece would call for retreatment, or it might be done at destination, where the adjustment of a dispute might be very costly. The toluene extraction method does not appear suitable for this purpose because of the size of sample required as well as the time required to extract one sample, but a colorimetric method such as that described by Hudson offers promise of being fairly rapid and also reasonably accurate when a sample of the oil is available.

Individual borings from the same piece may vary in appearance; without doubt, they also vary in creosote content but very little information on this point has been published. In a composite sample for a charge, it is recognized that any given boring may not be representative of the piece from which it is taken but this variability presumably averages out satisfactorily in a sample of at least 20 borings. However, if piling were to be accepted or rejected individually, the variability in borings from the same piece would affect the accuracy of a sample of some given number of borings. Obviously, information on this point is needed to provide a sound foundation for individual assay.

The variability between individual borings from the same piece could be expected to be greater in partially seasoned than in thoroughly seasoned material. A limited amount of data have been collected on three well-seasoned short southern pine stubs treated to known retentions as shown by gain in weight. These stubs were approximately 9 inches in diameter and 6 feet long. They were air seasoned outdoors for 7 months and then stored indoors for 2 weeks prior to treatment. They were given a full-cell treatment with creosote. Retentions as shown by gain in weight were 20.7, 29.3, and 30.2 pounds per cubic foot. Omitting 12 inches from each end, a spiral pattern was drawn around each piece and three replicate borings were taken 2 inches apart longitudinally at 10 uniformly spaced areas along the spiral. Only the outer 3 inches of each boring was saved, the remainder being discarded.

One set of 10 borings was extracted with toluene to obtain an average value of the piece. On the same day, a second set was assayed individually by the colorimetric method of Hudson with standards being prepared from a sample of the creosote taken after the treatment was made. Borings from the third set were wrapped individually in aluminum foil and stored for future tests to ascertain the effect of aging on results by colorimetry.

Table 1 shows the results obtained on fresh borings. Data on aged borings were not yet available.

It may be seen that results for average retentions by either toluene extraction or colorimetry agree fairly well with retentions shown by gain in weight. A high percentage of individual borings fell within a few pounds per cubic foot of the average for the piece from which they were taken.

It is planned to obtain some comparative data on partially seasoned pine and also on Douglas-fir.

It is difficult to judge the need for individual assay of marine piling or to estimate the potential advantage to the user. There is a dearth of information on several pertinent points so recourse must be made to speculation.

In considering the possible advantages of individual assay over charge assay, poles and marine piles should be considered separately because of differences in treating processes used; as a rule poles are treated by the empty-cell and marine piling by the full-cell process. Even in material of uniform moisture content, there will be a pronounced spread in retention by individual pieces treated in the same charge by either process. Because of the generally higher average retentions in marine piling, the spread in individual retentions tends to be relatively narrower than in poles. It has been found that, when seasoned southern pine stakes intended for field tests are treated by an empty-cell process, no consistent relation is apparent between density and net retention as determined from gain in weight. It appears that a higher-than-average gross retention in absorptive pieces tends to be counterbalanced by a higher-than-average loss by kickback.

On the other hand, when test blocks are given a full-cell treatment, a fairly consistent inverse relation between density and retention is found. It seems likely, therefore, that in full-cell treatments of piles, the more absorptive pieces retain higher-than-average amounts of oil. It also seems likely that such absorptive pieces need higher-than-average initial retentions to counter-balance a more rapid loss of whole oil during service. Furthermore, since the more absorptive pieces tend to be lower in density and hardness, they may be more vulnerable to attack by borers. Several facts support the theory that the full-cell process tends to have a leveling effect on the true quality, or rather the life expectancy, of individual pieces treated together in a charge.

The foregoing theories are based on the assumption of relatively uniform average moisture content. Variability in the moisture content of individual pieces in a charge no doubt contributes toward variability in quality; this factor, however, is not governed closely in present specifications.

Extensive information is recorded on the spread in service life obtained from pieces that presumably received the same treatment and were exposed to ground contact under supposedly similar conditions. Mortality curves have been prepared from voluminous service data on crossties given the same standard treatment. It has been shown that the life of poles and posts and also of small stakes in test plots follow similar trends. Analogous data on commercially treated piles exposed to marine borers are practically nonexistent in the literature. This makes it impossible to estimate the benefits that might accrue from the use of individual assay to eliminate any very-low-retention pieces from charges having satisfactory average retentions.

Studies of piles have shown that the quality of preservative used is highly critical. An analysis of the preservative prior to treatment is presumed in both Federal Specification TT-W-571 and in AWPA Standard C3. This, of course, is the most convenient point for obtaining a sample of the preservative. As has been mentioned, a specification recently prepared by the American Wood Preservers Institute includes a method for extracting a sample of creosote from the treated pile for analysis at destination if desired.

Lumber

A large percentage of the treated crossties, poles, and piles that are produced commercially are sold to large companies that either maintain their own inspection departments or retain commercial inspectors. Treated lumber, on the other hand, may find its way to a small user who is not equipped to assay it and whose requirements are too small to justify the cost of commercial inspection. This type of user would be served best by a ready availability of treated lumber of guaranteed quality. The standardization of such quality could be accomplished most effectively by basing retentions on the assay of nondestructive samples.

The sampling of treated lumber presents a more difficult problem than the sampling of round stock because lumber may have faces and edges of heartwood that is very difficult to treat, whereas round stock contains an outer zone of sapwood that treats quite uniformly as a rule. A nondestructive method of sampling lumber to obtain a measure of the average retention has not been developed. Because of the obvious difficulties involved, certain students of the subject are reconciled at present to what amounts to a compromise method of sampling. This involves taking borings from either the sapwood alone or the heartwood alone, depending upon the species that is treated. For example, borings would be taken from the sapwood of southern pine lumber because such lumber normally contains a high percentage of sapwood; in Douglas-fir, heartwood would be bored because it normally predominates in quantity.

In a project sponsored at the U.S. Forest Products Laboratory by the American Wood Preservers Institute, chemical analyses were made of four zones cut from cross sections of treated southern pine and Douglas-fir 2 by 6 lumber. Four preservatives were used to treat the test specimens--creosote, pentachlorophenol, ammoniacal copper arsenite (ACA), and a fluor-chrome-arsenate-phenol mixture (FCAP).

The results were given in a paper presented at the 1962 meeting of the American Wood-Preservers' Association.[5] The data are shown graphically in figures 1 to 4.

It was found that a cross section from the middle of a piece practically always had a somewhat lower average retention than the piece from which it was cut. This was attributed to the higher retentions in the ends. Zones cut from cross sections showed a fairly steep gradient in preservative concentration, especially in pieces treated with the two waterborne preservatives that were studied. The outer 1/8-inch zone showed retentions

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[5] Studies on the Assay of Pressure-Treated Lumber. R. H. Baechler, J. O. Blew, and H. G. Roth. Presented at the 58th Annual Meeting of the American Wood-Preservers' Association, Detroit, Mich., April 17-19, 1962.

appreciably higher than the average for the cross section. The outer 5/8-inch zone generally contained retentions of the same order as the average retention for the piece, as determined by gain in weight during treatment. The 1/8- to 3/8-inch zone also showed retentions similar to average retentions. It was pointed out that while the analysis of either of these zones could not be used as an accurate measure of average retention of pieces regardless of length or sapwood content, it should nevertheless supply a reliable index of the quality of treatment. It was further recommended that similar data be accumulated on other sizes and other kinds of lumber.

Acknowledgment

Experiments on the assay of short piling stubs were made by H. G. Roth under a project financed by the U.S. Navy Bureau of Yards and Docks. The author gratefully acknowledges helpful advice as well as the loan of colorimetric apparatus by Dr. M. S. Hudson.

Table 1.--Retentions in individual borings from same piece

Piece No.	Average diameter	Average moisture content, 1-1/2 inch depth	Retentions: Average for piece: By gain in weight	Retentions: Average for piece: By extraction	Retentions: Average for piece: By colorimetry	Retentions: Individual borings: By colorimetry
	In.	Percent	Lb. per cu. ft.	Lb. per cu. ft.	Lb. per cu. ft.	Lb. per cu. ft.
1	9.0	22	29.3	31.8	28.6	28
						25
						29
						29
						30
						32
						32
						32
						20
						29
2	8.5	22	30.2	32.0	30.7	33
						30
						31
						30
						34
						29
						32
						30
						28
						30
3	9.0	24	20.7	21.2	18.8	17
						16
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						18
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						18
						23

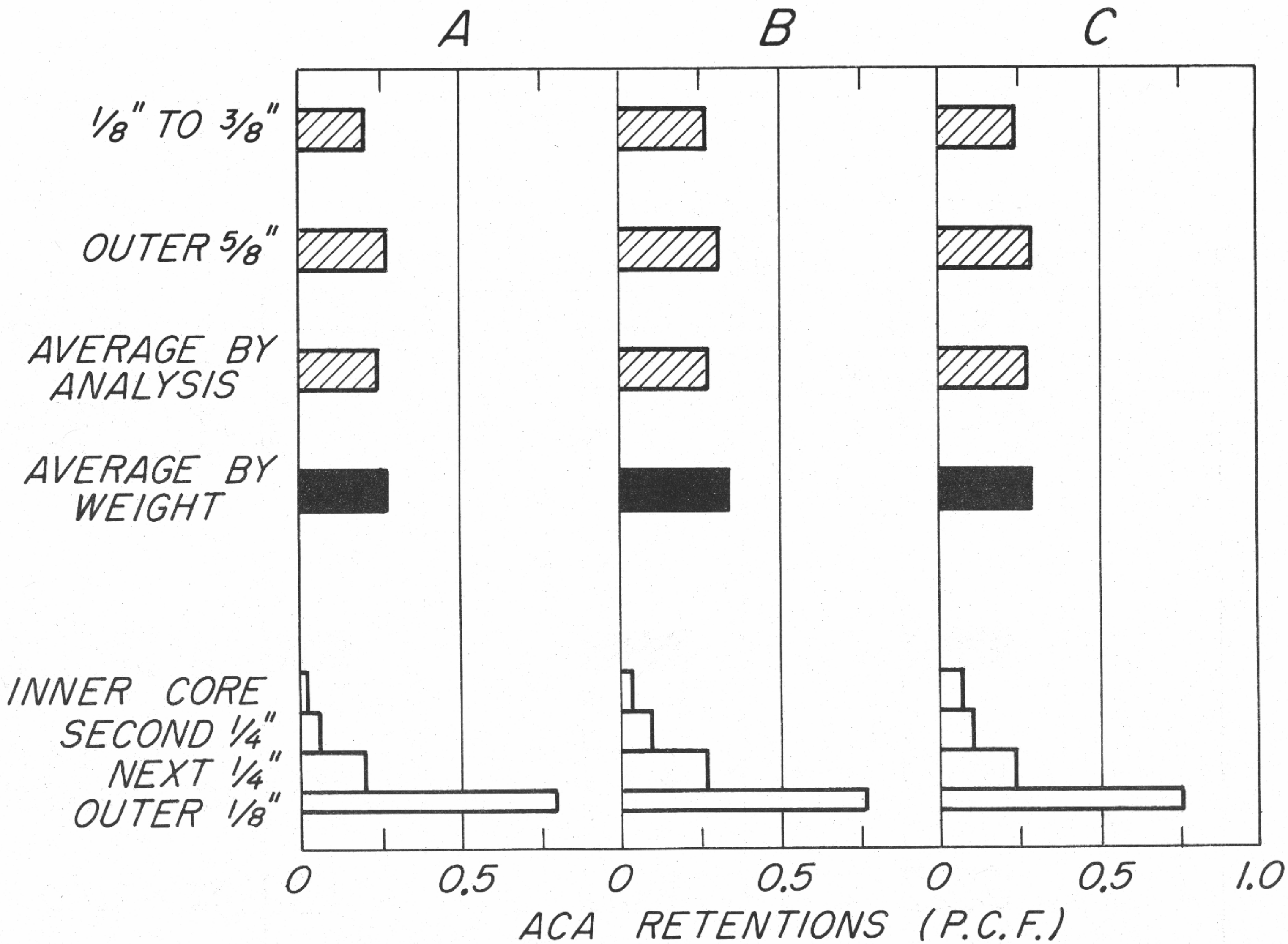

Fig. 1.--Distribution of ammoniacal copper arsenite in cross sections cut from treated lumber. A, unincised Douglas-fir; B, incised Douglas-fir; C, southern pine sapwood.

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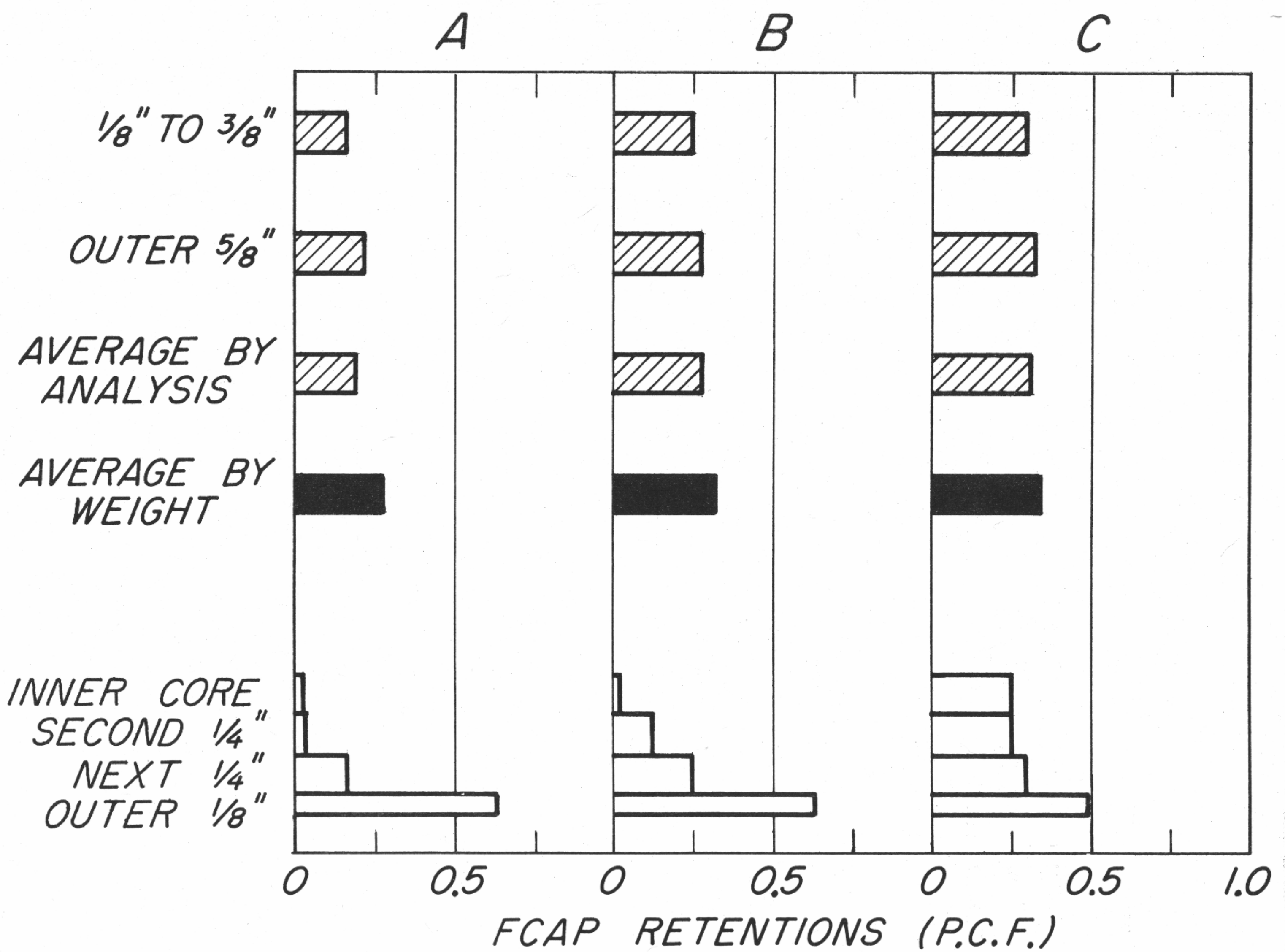

Fig. 2.--Distribution of fluor-chrome-arsenate-phenol mixture in cross sections cut from treated lumber. A, unincised Douglas-fir; B, incised Douglas-fir; C, southern pine sapwood.

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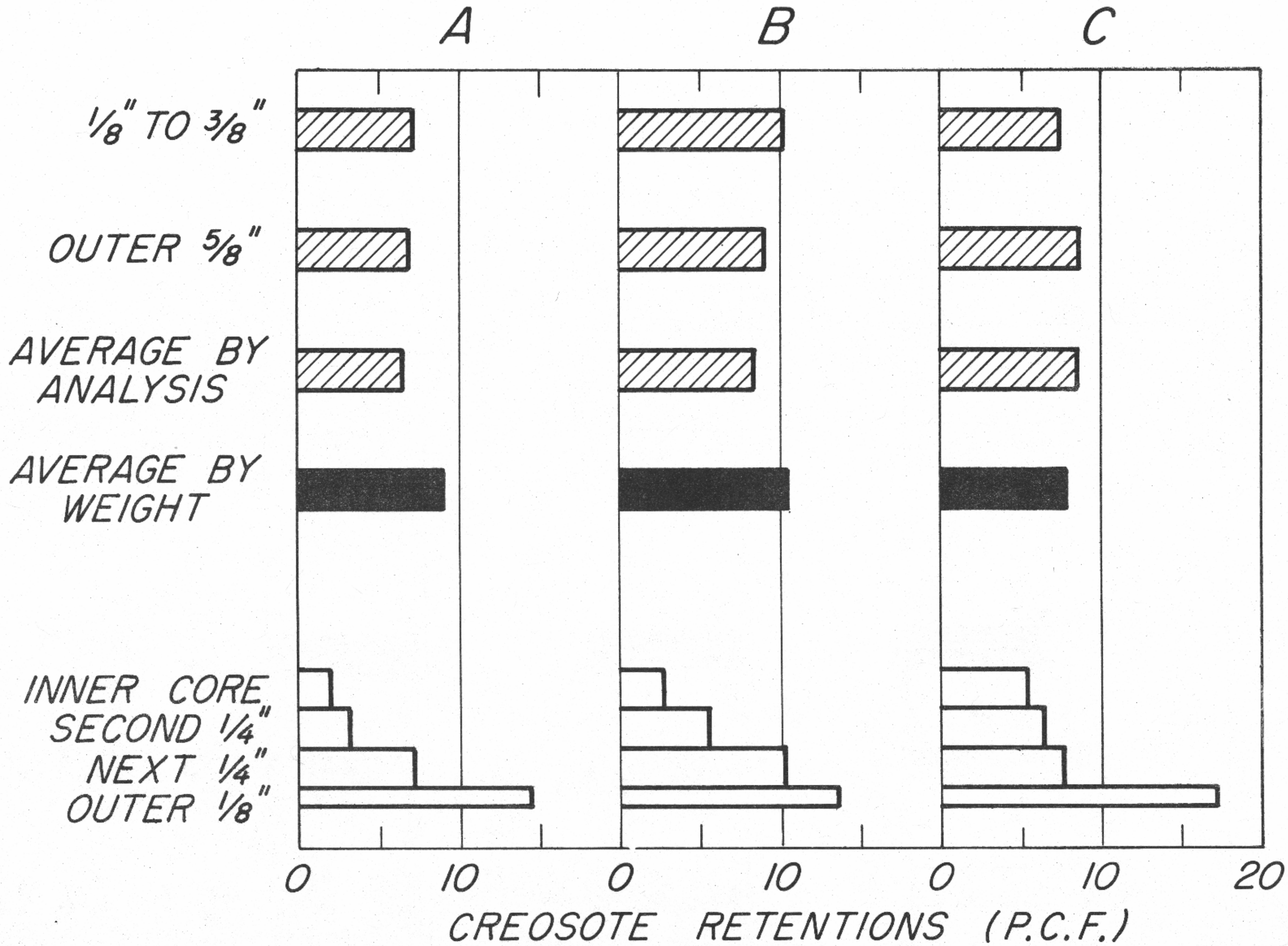

Fig. 3.--Distribution of creosote in cross sections cut from treated lumber. A, unincised Douglas-fir; B, incised Douglas-fir; C, southern pine sapwood.

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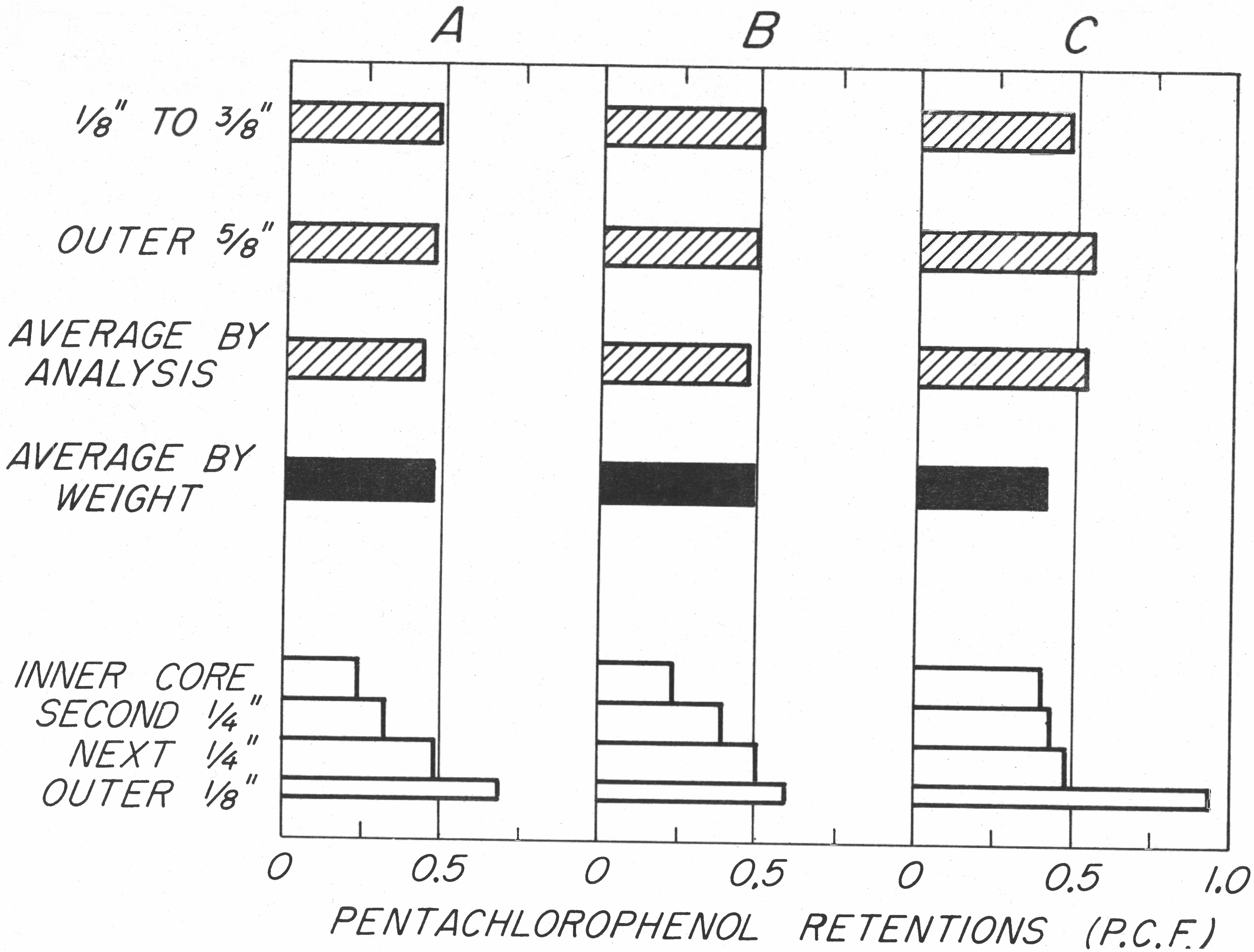

Fig. 4.--Distribution of pentachlorophenol in cross sections cut from treated lumber. A, unincised Douglas-fir; B, incised Douglas-fir; C, southern pine sapwood.

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