The Use of Western Red Cedar Shingle Tow as an Insulating Material

by

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THESIS

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Introduction

Ten years ago lumber sold as fast as it was manufactured. The ready sale of timber products resulted in few merchandising problems. However, with investigations in other fields leading to the development of lumber substitutes and the marked decadence of the former rapid building program, it would now seem reasonable that new methods of manufacture and new products and uses for timber products and wastes would be essential to the continued well-being of the industry. In other words, research in wood products seems to be a vital element in future big-time lumber production. Sustained production demands expansive timber resources which in turn demands trained foresters for its management. Herein lies the forester's concern for products research.

Utilization of wastes from timber conversions is one, but an important result of timber research. Just as years ago the meat packing industry began to realize profits from close utilization of products, so now the forest products industry is attempting to obtain closer utilization. The field is wide open for investigations on all types of wastes, especially from logging and milling operations. Wastes, here, may be regarded as any materials from the raw product discarded during the operation, such as slashings, tree tops, sawdust, and shavings.

One waste of economic importance to the forest products industry is shingle tow. This material is shingle saw waste, or that material which is cut by the saw, as is sawdust, but is more like excelsior in composition. Much of the material is long, curled threads which packs together in a springy mass. Depending on the thickness of the saw kerf, shingle tow makes up 50 to 100% of the bolt. In other words, almost as much of the bolt is wasted as goes into shingles. Thus, it is that about 20 large bales of shingle tow comes from one machine each day. This is an enormous amount of material; for example if one of the larger plants maintained 20 machines, each producing 20 bales per day, the management would need to dispose of 400 bales of tow every day. The spongy composition of a mass of tow is not conducive to easy disposal by burning; although this is the usual method; consequently disposal costs run high.

At present shingle tow is used in packing nursery stock and other limited uses, but since money is paid to burn most of the material, shingle tow represents a waste of no little importance to the shingle operator.

Possibilities in the Utilization of Shingle Tow

It would seem that the large waste in the shingle industry would present a practical problem for investigation. As far as can be determined, no successful attempt has been made to discover a profitable or sufficient outlet for shingle tow. Suggestions that have been made would have this material used for wood briquets, wood flour, pulp and plastics, and fiber board and insulation materials. This thesis is concerned with the last named use--the possibilities of using western red cedar shingle tow as an insulating material.

In determining the practical value of shingle tow as an insulation material, there are at least three considerations, or phases to the investigation. First, the thermal conductivity, or insulating value, of the material must compare favorably with that of other insulations on the market. Second, chemical treatment for fire resistency and toxicity must be considered. And third, the possible drying technique must be investigated, as the material comes green from the saw; so it must be dried before installation.

Importance of the Project

At the present time the shingle industry is fraught with problems of labor, trade agreements, and a lack of general building. Therefore, this problem of utilizing shingle waste assumes no little importance to the industry. Shingle operators say that anything that can be done to add to their profits at this time will be most welcome. The problem is also important in the general field of wood utilization as it is typical of what can be done to aid the wood products industries. When it is seen that this large waste of shingle tow is practically untouched, the need, and opportunity then, becomes apparent for investigations along similar lines. Therefore, the solution of one problem, such as this one, could easily lead to other research projects in the industry.

Approaches

Because the primary consideration for insulating materials is the insulating value or thermal conductivity value, the determination of this phase was taken up first. In order to take advantage of any work already done on the insulating value of shingle tow, related previous studies were reviewed. All of the available Forest Products Laboratory publications and Bureau of Standards literature were studied. Apparently no test has ever been made to determine the actual thermal conductivity value of shingle tow. Other literature published by insulation manufacturers were also used. The closed indication of the insulating value of shingle tow was given by the thermal conductivity of sawdust and shavings. These values were comparable to values of commercial insulations, but in order to be scientifically accurate means other than mere comparisons needed to be employed. In other words, actual tests for the insulating value were necessary.

The problem, then, necessarily evolved into one of original experimentations requiring time-consuming laboratory and experimental work, rather than lengthy reference work. The Mechanical Engineering Department at Oregon State College offered to make available their equipment and personnel aid necessary for testing the thermal conductivity of the tow.

Standards Necessary in Testing

The thermal conductivity, or K value, is a standard value that can be applied to any material, no matter what the size or thickness of the commercial material as long as standard units are used for testing. In this way different materials may be compared with each other for insulating qualities. It is important, of course, that standard material, units, and tests are used in all cases in order that accurate comparisons can be made. This transmission constant is expressed as K- British thermal units per hour per degree of temperature difference per inch of thickness and per square foot of conducting material.

Due to the fact that wood is a variable material it follows that shingle tow (shingle saw waste) may also vary according to the site and part of the log from which cut. Although such variations might have but little effect on the insulation qualities; nevertheless, specific gravity tests showed enough variation to warrant testing for K for both high and low specific gravity material. The results of these tests are shown in Figure 1. Another variation in testing for thermal conductivity is the density of the material tested in pounds per cubic foot. This must not be confused with density of the wood, specific gravity, but it is the density of shingle tow, which is, of course, much less dense than the wood. The tow, then, must conform in density to other shredded and loose materials for accurate comparison, or about 5 to 10 pounds per cubic foot of insulating material. A weighted sample of tow was placed in a 12" by 12" by 12" box and a load in 50 pound intervals was applied to a 600 pound maximum. This test was made for both the lightest

FIG. 1

SPECIFIC GRAVITY TESTS

$$\text{Sp. Grav.} = \frac{\text{WT. OF BLOCK (Gms.)}}{\text{WT. OF } H_2O \text{ DISPLACED}}$$

Sample No.	Type of material	Sp. Grav.	
1	High Elev. - Coast Range	0.374	
2	" " " "	0.329	
3	" " " "	0.390	
4	" " " " Heart	0.338	
4	" " " " Sap	0.306	Low
5	Sea Level - Old Growth - Butt	0.416	
6	" " " " "	0.455	
7	" " " " Top	0.384	
8	" " " " Butt	0.487	High
9	" " " " "	0.540-?	

Tests on blocks of Thuja plicata
Taken from same trees as tow samples

Tests by For. Prod. Lab. show:

Thuja plicata - Wash. - 0.356
" " - Alaska - 0.330

and heaviest specific gravity samples. As each 50 pound weight was applied the thickness of the tow, becoming less, was measured. A curve was drawn, plotting thickness of tow against load. The density of the sample was computed in pounds per cubic foot for each 50 pound interval to obtain a curve, plotting load and density. Thus, a relationship was established to determine the amount (in weight) of tow to use in order to obtain a test sample of 5 to 10 pounds per cubic foot (standard densities for thermal conductivity test). These curves are shown in Figure 2.

Equipment for Testing

The equipment for the specific gravity tests consists merely of a scale balance and small water tub for water displacement tests. A box twelve inches square, inside dimension, and twelve inches high was constructed for the density determinations of the tow. For determining K, the hot plate method,* generally accepted as standard for determining the thermal conductivity coefficients of homogenious materials, was used. The advantage of this equipment over others is that the conductance is determined from surface to surface of the material under test, thus eliminating the surface resistances. The general design of the hot plate apparatus is shown in the accompanying diagram in Figure 3. The copper hot plate, as seen by the diagram, is divided into

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* "Heat Transmission Through Building Materials" - Bulletin of the University of Minnesota, No. 6, 1932.

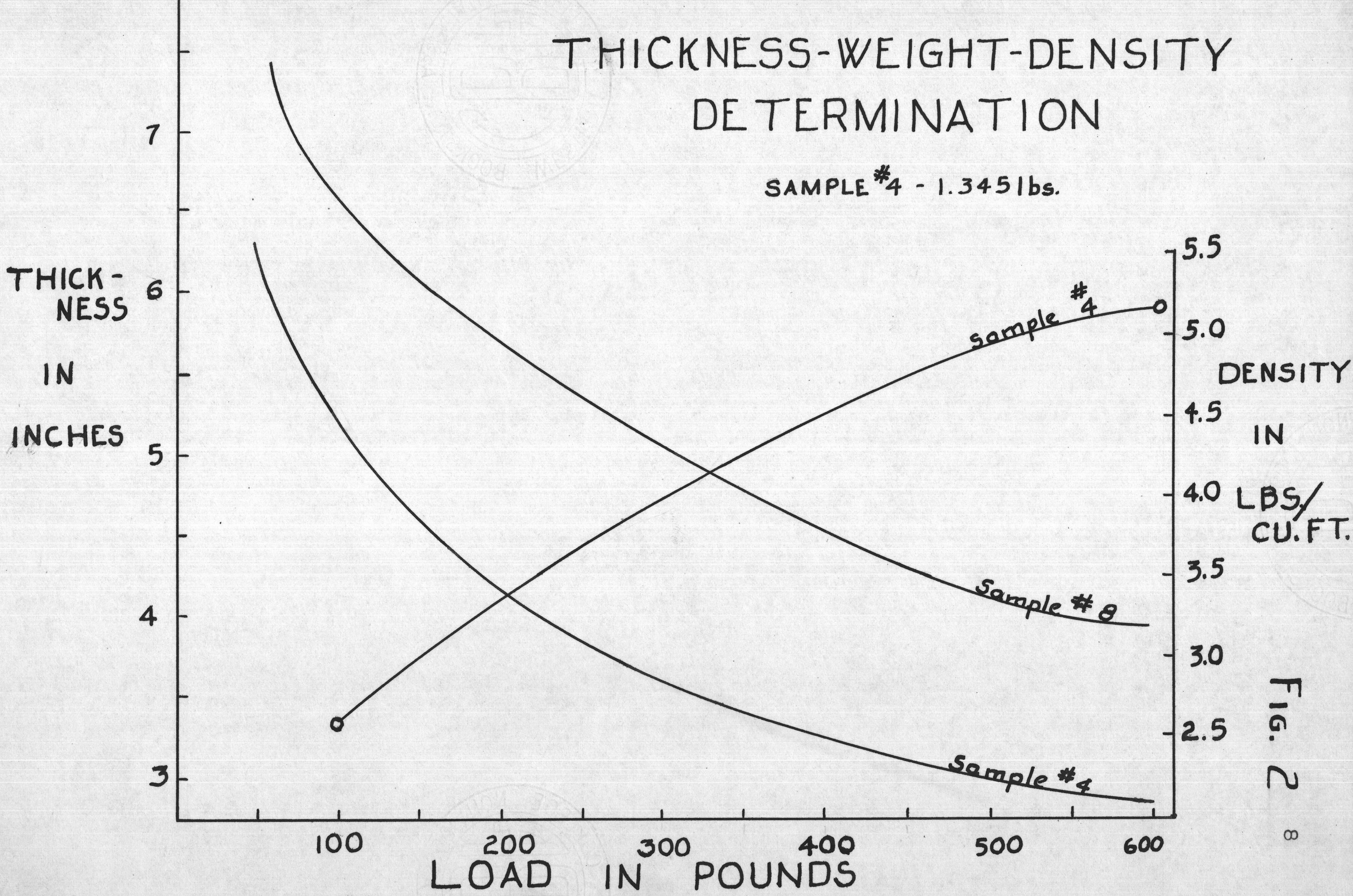
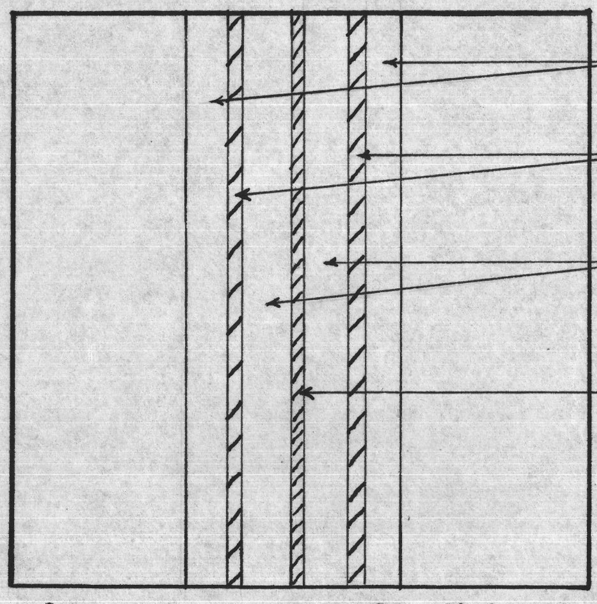
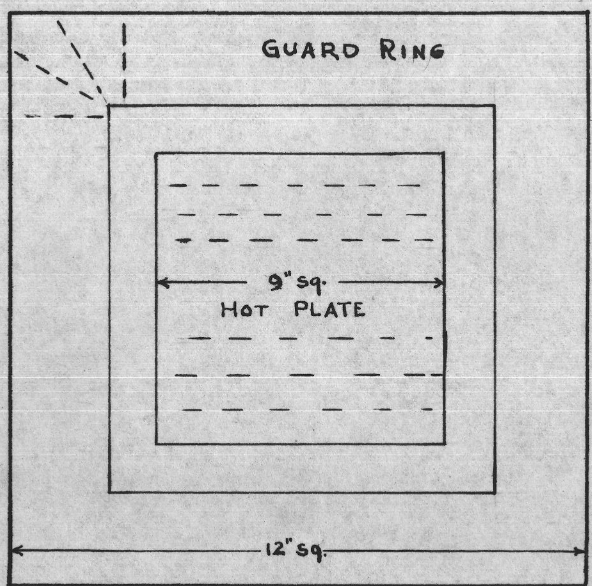

THICKNESS-WEIGHT-DENSITY
DETERMINATION
SAMPLE #4 - 1.345 lbs.
THICKNESS IN INCHES
7
6
5
4
3
DENSITY IN LBS/CU.FT.
5.5
5.0
4.5
4.0
3.5
3.0
2.5
Sample #4
Sample #8
Sample #4
100
200
300
400
500
600
LOAD IN POUNDS

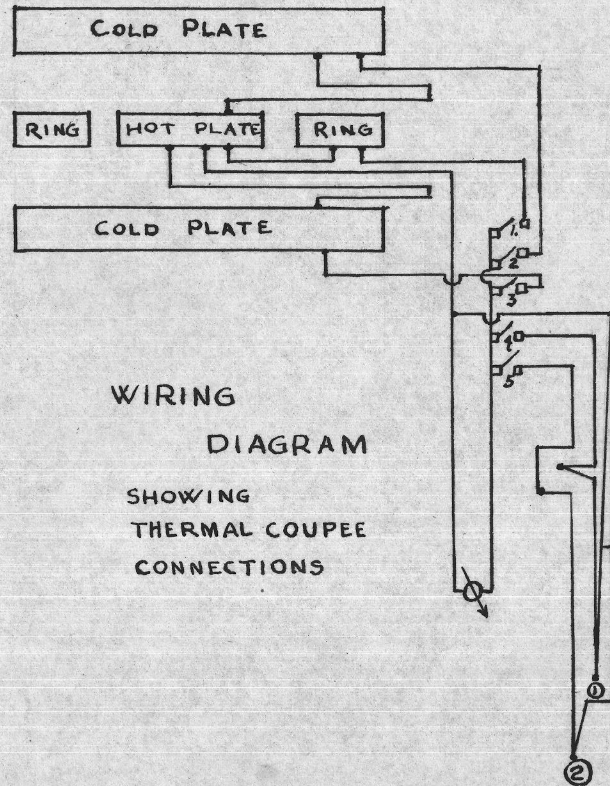
FIG. 2



SIDE VIEW OF HOT PLATE APPARATUS



FRONT VIEW OF HOT PLATE



WIRING DIAGRAM

SHOWING THERMAL COUPEE CONNECTIONS

FIG. 3

two parts in order to eliminate heat flow from the sides of the specimen. The inner section, about nine inches square, is insulated from the outside guard with a copper constantan differential thermocouple across the two in order to maintain a balance temperature. Thermocouples are also provided on the plates for measuring the surface temperatures of the plates which are taken as the suraface temperatures of the test material.

Heat is supplied separately to the inside plate and the guard ring by electric heating elements, and the power controlled by separate reostats to maintain equilibrium between the inside plate and guard ring. The power is measured by a wattmeter. The outside cooling plates with circulating water are also provided with thermocouples so that the temperature difference between the heating element and the cooling plate can be read simultaneously with a galvanometer. Thus, the insulating value of the tow will correspond to the heat loss from the sample (temperature difference), if the thickness and area of the sample are known. The wattage to maintain the sample of 90 degrees F. must also be measured.

Procedure in Testing

Six tests were made, three with the low specific gravity material and three with the high specific gravity. In both series of three tests, the material of the first test was approximately an inch and a half thick, one inch for the second test, and one half inch for the third. In this way any variation of K for various thicknesses could be note (although K is known to be a direct function of the thickness of any homogenious insullating material).

In making the tests, data was taken every five minutes for a period of an hour or more. The data recorded each time included: the time, temperature of the cold plate, galvanometer readings, and the wattage. To determine the temperature differences, galvanometer readings were taken for: (1) plate to ring, (2) plate to one cold plate, and (3) plate to opposite cold plate. A number of calibrations and adjustments were necessary. The three thermocouples were calibrated for the galvanometer. These galvanometer readings were than plotted in order to ascertain the correct temperature differences. Also, the wattmeter readings were corrected by calibrating the wattmeter with correction readings from a voltmeter and ammeter.

By the following formula the data referred to above was used to determine the K value for each test:

$$K = \frac{\text{B. t. u./ hr x thickness}}{\text{2 x temp. dif. x area}}$$

in which: watts x 3.413 (a constant) = B. t. u./hr.

<u>Results of Thermal Conductivity Tests</u>

The results of these tests show very little variation in the thermal conductivity of shingle tow either for thickness of material or density of the original wood. No correlation was apparent between samples 1½" thick and ½" thick or between samples from the heaviest and lightest specific gravity logs. From the six tests made the K value of shingle tow is apparently from 0.34 to 0.36, or approximately 0.35, which compares favorably with other commerical materials used for insulating purposes. The actual test results appear in Figure 4.

The first seven materials are manufactured specifically for insulating and building purposes and are rather representative of the best commercial materials now available for that purpose. Thus, with no expense of manufacture, such as is necessary with the above materials, shingle tow could be used for insulating purposes with approximately the same insulating values of the better commercial materials.

<u>Other Phases of the Problem</u>

It was hoped to touch the other two phases of this problem: treatment for fire resistency and chemical toxicity for insects and rodents. However, due to lack of time and equipment, only recommendations can be made on these phases at the present time. It is hoped that the original work in determining the thermal conductivity value of shingle tow is sufficient contribution to make this investigation worthwhile.

Chemicals suitable for fire resistency treatment have been suggested by Mr. T. R. Truax, Wood Technologist with the Forest Products Laboratory. In a letter to Mr. Glenn Voorhies he says, "Ammonium phosphate and ammonium sulphate are perhaps the two most commonly used chemicals for making wood fire retardant." These chemicals are put into a solution for impregnation into the material to be treated. The suggestion was made by Mr. Richard Kerns to soak the tow in

FIG. 4

RESULTS OF Shingle Tow THERMAL CONDUCTIVITY TESTS

TEST NO.	SP. GRAV. OF WOOD	THICK. OF TEST UNIT	LBS. PER CU. FT.*	COEF. K
1	0.33	1.54 IN.	3.2	0.35
2	0.33	0.98 "	5.1	0.34
3	0.33	0.54 "	9.3	0.35
4	0.49	1.61 "	4.0	0.36
5	0.49	1.06 "	6.2	0.35
6	0.49	0.62 "	10.5	0.35

* shows degree of compactness of tow in Pound per cubic foot.

"K" VALUE OF OTHER MATERIALS:-

Cabots Quilt	.25	Insulex	.35
Redwood Bark	.27	Sawdust	.41
Cork board	.27	Planner Shavings	.41
Rock wool	.27	Beaver Board	.50
Masonite	.33	Yellow Pine	1.00
Celotex	.34	Brick & Cement	5.00

each of several selected chemicals for a specified period and dry the samples to a uniform moisture content. Test for flash points of each sample would give an indication of the effectiveness of each chemical.

The best assurance of eleminating decay of the shingle tow by fungus attack after installation is low moisture content of the material. If the tow can be dried below 15 to 18 moisture percent, little or no trouble will be experienced with fungal attack. Insects, such as carpenter ants, beetles and termites, can be effectively dealt with by the use of arsenic salts or orthodichlorobenzene.* These substances are also in solution for treatment of the tow. The same procedure as suggested for the fire retardant tests should also be followed to determine the best chemicals for toxicity treatment.

To eliminate fungal attack and increase the general effectiveness of the shingle tow as insulation, the material should be dried to 10 or 15 percent moisture before installation. A suggestion has been made to make use of flue gases from the boiler to dry the tow. This could be done by building, in a chamber heated by the flue gases, a drying apparatus, consisting of a slowly moving screen on which the wet tow is dumped at one end and baled dry at the other. Another method, modeled after the Wood Briquet material dryer, would have the material shuffled thru a large tube by means of a screw arrangement. The tube would also be heated by flue gases. These methods would be simple to construct

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* Wood Handbook, Forest Products Laboratory, 1935, pp. 255-258.

after a design, sufficient to take care of the correct volume of tow, had been evolved. The operating costs would be low by utilizing the high temperature flue gases. Therefore, the drying technique once solved would present no great difficulties in preparing the material for commercial use.

Summary, Conclusions, and Recommendations

The significant finding of this project is the determination of the thermal conductivity of shingle tow. This value of 0.35, compares favorably with other commercial insulations so that the tow may be regarded as a good possibility for insulating purposes. Much work of this type yet needs to be done in making repeated tests for checking these few tests made here and also in ways of discovering the optimum conditions of density and thickness of tow. Further check with different equipment or with a new set-up might reveal even better values, but these results have so little variation and approximate the values of similar materials that for all general purposes the K value of shingle tow may be regarded as approximately 0.35, or of the same insulating value as Celotex or Rock cork.

There may be several good ways in which the tow could be installed in house and building construction. One simple method would be to insert the material between the walls and between the joists in the ceilings. This could be done similar to the method used to insulate with rock wool. Another method might be to install the material in mat form.

The tow could be inserted between two sheets of building paper or similar material and cut into strips which would fit between the studs and joists. This latter plan would entail more expensive manufacture, but installation costs would be smaller. More study and planning needs to be done on this particular phase, but at least the material would be no more difficult to handle than other insulating materials.

These conclusions and recommendations are based on laboratory tests and observations and experience with similar materials. As yet nothing definite can be determined concerning the practical commercial value of shingle tow as an insulating material. However, the possibilities look very bright. It is hoped that the way may be made clear for putting shingle tow into particular use by the shingle industry. If this particular project has contributed nothing more than an indication of the possibilities of the use of western red cedar shingle tow, then it is hoped that the efforts included here may be considered worthwhile.