WOOD TANKS

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WOOD TANKS

By

R. P. A. JOHNSON, Senior Engineer

Tank stock is choice, carefully selected, and carefully manufactured stock, and brings a good price. Varied industries and processing operations put it to essential uses. Forest products industries are naturally interested in holding and possibly expanding the market for it. Manufacturers of other materials are interested in substituting their products for wood. As a result, there has developed considerable competition between materials for the tank market. A preliminary study has been made by the Forest Products Laboratory to determine how extensive the substitution of other materials for wood in tanks has been and to determine the cause of the trend in the individual industries and what technical requirements as to service must be met to hold or recapture the market. The requirements which must be met have been fairly easy to determine; just how they can be met is not always apparent.

The work reported here was intended as a background against which the specific technical problems encountered could be analyzed and perhaps subjected to experimentation and testing where needed. However, war demands have occasioned such transfer of personnel that the original plans must now be abandoned and further work along this line held in abeyance. This report, therefore, is prepared merely to record preliminary data.

The latest available Census, 1937, showed about 75,000 establishments in the groups of industries which are heavy users of tanks. Many establishments in other industries use one or two tanks for water storage or for processing. The most practical method of covering such a large field was thought to be the selection of typical plants of the more important groups of heavy users for visit and examination. In addition, the number of tank manufacturers being comparatively small, a large percentage of them located in the East and Mid-West were interviewed. The tank manufacturers furnished not only the names of typical users but also considerable information on the trend and practices in the various industries and on species and grades used.

Information was obtained on the use of tanks for food products, beverages, textiles, chemicals, leather products, iron and steel products, and water storage. It was not possible to cover all the products produced by those industries.
General Consumption Trend

The general trend in the use of wood in tanks must of necessity be based on the available Census statistics. Granted they are meager and possibly incomplete, nevertheless they furnish a more accurate base for determining the general trend than do the broad impressions of individuals connected with the tank industry or any figures that it was possible to obtain in the survey here reported.

The only accurate figures available on the amount of wood used for tanks are those obtained for 1933 and for 1940 by the Forest Survey. Only 1933 figures were available at the time the bulk of the work on this project was done. Since the first draft of this report was written, preliminary figures for 1940 have become available, and these 1940 figures have been used in Figure 1 and superimposed on the data as originally drafted in Figure 2. Substitution of 1940 for 1933 figures as a base of estimates could not be made in Figure 2 because "Value of Product" comes from the biennial census of manufacturers which is taken only for odd years. In line with the above Forest Survey, figures show that 22,929,000 board feet were used in 1933 and 45,529,000 board feet in 1940. Using the 1933 figure and the figures for the value of the product from the biennial census, an estimate was made of the lumber consumption in odd years from 1927 to 1939, inclusive. These estimates are shown by the red line in Figure 2. The actual 1940 figure is shown as a detached point. The estimated lumber consumption for the 12-year period from 1927 to 1939 varied between 31 million board feet, which occurred in 1937, and a consumption of 13,000,000 in 1933. The figures are probably low, for some users make their own tanks and few, if any, of these get in the census returns. The trend as shown by the data is toward an average consumption of about 25 million board feet, varying above and below that figure with shifting economic conditions.

The data do not prove a loss of market to other materials for the period of record. A comparison of the value of the wood tank production with that of steel over the 10-year period 1929-1939 on the basis of percentage of change (Fig. 3) indicates that steel dropped faster during the depression, was slower to start recovery, and did not recover as completely as wood. The deduction drawn from the curves of Figure 3 is that the wood tank at least has held its own with the steel tank over the 10-year period. That overall trend, however, does not apply in the case of individual industries. In some industries wood tanks have given way to metal tanks; in others wood has been partially replaced. The fairly constant production of wood tanks shown in Figures 2 and 3 is accounted for by the opening of new markets or expansion of old ones and the replacing of lost markets.

Species Used

The number of woods used in commercial tank construction is limited. Of six species used, redwood, Douglas-fir, and cypress furnish about five-sixths of the tank stock (Fig. 1). Other woods of commercial
FIG. 1
LUMBER SPECIES USED IN TANKS
(PRELIMINARY 1940 FOREST SURVEY)
FIG. 2
COMPARISON OF VALUE OF WOOD AND STEEL TANK PRODUCTION AND ESTIMATED LUMBER CONSUMPTION
(SOURCES OF VALUES—BIENNIAL CENSUS AND FOREST SURVEY)
FIG. 3
TREND IN VALUE OF WOOD AND STEEL TANK PRODUCTIONS
importance are southern yellow pine, cedar, and white oak. Of less importance but sometimes used are white pine and other species. The decay hazards that exist in varying degrees where tanks are used are accountable for the small number of species used, for only highly or moderately decay-resistant woods can satisfactorily meet the use requirements. The demand for wood for tanks, therefore, will continue to be for the species now used. The only trend observed is toward an increased use of the moderately decay-resistant and medium-priced woods where the requirements are less exacting. That trend is largely the result of attempts to meet the competition of other materials.

Grades

The use of unsuitable grades is responsible for loss of some markets and for the failure of many wood tanks to render satisfactory service. The names of the grades are sometimes misleading and confusing to consumers, and responsible for part of the trouble. The names principally responsible for the trouble are No. 1 and Selects. Consumers sometimes specify these grades, believing that No. 1 means the best and that Selects means that the lumber has been especially selected for tank purposes. Tank manufacturers, of course, know the fallacy of such assumptions, but report that they are often forced to furnish tanks made of these grades either because they are specified or to meet competition. The requirements of practically all tanks are such that sapwood will not render satisfactory service. No tank manufacturer interviewed recommended the use of sapwood in any tank. Practically all complained that the use of sapwood by some competitor has not only caused them to lose individual orders, but has been partially responsible for the shift to other materials.

Lumber manufacturers generally have recognized the necessity of all-heart stock. They have established special tank grades, all of which, except the A Tank Stock Grade of redwood, prohibit sapwood. All-heart tank grades are available in cypress, redwood, western redcedar, and Douglas-fir. There are no special tank grades in southern yellow pine, oak, and eastern white-cedar, now known as Atlantic white-cedar. The Bureau of Standards Department of Commerce, has prepared a commercial standard CS92-41 for cedar, cypress, and redwood. Tank-Stock Lumber Specifications requiring tank stock to conform with that standard will assure satisfactory stock. A suitable grade of the principal tank species, cypress, Douglas-fir, western redcedar, and redwood can also be obtained by specifying "tank grade, all-heart," for there is only one grade in each species that meets that specification. There are few, if any, uses of wood for which it is easier to specify the proper grade. The trouble is that users who are not familiar with wood properties specify the cheaper grades containing sapwood either because they are misled by the grade name, do not realize the importance of all-heart stock, or are sold on price rather than quality.

Contrary to the general belief, decay is not the principal cause for the substitution of other materials for wood in tanks, although it is a hazard common to all uses, and in water storage tanks is the principal cause of trouble and replacement. The substitution by industry
of tanks made of other materials than wood is more often the result of a change of process; a desire for better sanitation, economy of space, or safety of employees; the action of chemicals on wood; or leakage. Problems created by such causes are more difficult to solve than the decay problem, and have not received the study and attention necessary for their solution.

Industry generally is interested more in service than in price. In many places where metals are being substituted for wood, the change involves much higher original costs, sometimes two to three times what wood would cost. Even the overall long-time cost is often higher, but is made because safety, sanitation, appearance, or other service requirements are better met by metal than by wood. The conclusion drawn from that situation is that the wood tank industry must concentrate more on improving designs and service and meeting industry’s requirements better even though it means tanks that cost considerably more than those now furnished. In addition, where tanks are used with machines, as in the textile industries, closer cooperation with the machinery manufacturers, as well as the users of the machines, is needed.

Tanks for Food Products

An enormous number and variety of tanks and vats are used in processing food and kindred products. The Bureau of the Census reports 48,727 establishments in that group. The tanks range from small rectangular ones holding about 85 gallons to large circular ones holding 25,000 gallons. The trends vary with the products, and no general statement can be made for the industry as a whole. Data were obtained on meat; dairy products, principally cheese; pickles; vinegar; and corn products.

Meat Packing

The meat packing industry uses a large number of tanks. One plant had in service about 5,000 tanks, vats, and hogsheads. Most of these were small, under 100 gallons. A few large tanks are used for brine storage. The principal use for the small tanks is the curing of ham and bacon. Two factors are adversely affecting that market for wood tanks; an improvement in the processing method, and the substitution of metal for wood.

Improved processing methods for curing ham have reduced the storage period in brine from 30 to 10 days. That means that only about one-third as many containers are required now as in the past. The result is that the packing plants have on hand (early 1941) a surplus more than sufficient to take care of expansions and replacements. The containers are 40 inches high, 40 inches in diameter at the head, and are usually made of white oak. They hold about 1,400 pounds of meat in a curing solution of salt, sugar, and a small amount of sodium nitrate. They are hogsheads rather than tanks, and last a long time, for the decay hazard is low. Their maintenance, due principally to mechanical wear similar to that on barrels, is cheap.
Metal tanks or boxes have for several years been replacing wood in the curing of bacon. These are small, rectangular tanks, 40 by 32 by 30 inches, made from 3-inch stock, or 30 by 22 by 20 inches made from 2-inch stock. Several thousands of such tanks are used in a single large plant with the dry-cure, tight-pack, box curing method (Fig. 4). That method consists of a dry pack of salt, sugar, and other ingredients forced into the tanks, with hydraulic pressure applied to a wood top, thus reducing the voids to a minimum. Four reasons are given for the substitution of metal for wood tanks: (1) the cost of handling is reduced for the metal tank can be handled by one man whereas the wood tank takes two men; (2) the metal tank has smaller overall dimensions but the same meat capacity due to thinner material and the absence of cleats; (3) the metal tank is more sanitary, being more easily and quickly cleaned, which means reduced costs; (4) and the first cost of metal is less than that of wood. Manufacturers believe that the cost over the life of the tank is also less.

The combined savings resulting from reduced cold storage space requirements and labor saving in handling and cleaning are considerable and are responsible for the change rather than any failure of wood to render long satisfactory service.

The prospects of wood holding or regaining this market are not good. To hold the market, a wood tank would have to be designed that would match the metal tank in economy of space, light weight, and ease of cleaning. To accomplish that would require a radical change of design. Moulded plywood, possibly compressed, may eventually make possible such a wood tank, but it is not practical in the present state of compropregnated wood development.

Brine storage tanks are of wood. There is no tendency to shift to other material for these tanks. A battery of six or more 5,000-gallon rectangular tanks is required for brine. They contain cooling coils which lower the temperature of the brine to about 38° F. The low temperature is possibly responsible in part for the absence of fungous attack, and mechanical wear is slight. The life of the tanks is long, and replacements, if any, are the result of remodeling or obsolescence. Tanks 15 years old appeared to be as serviceable as when installed.

Dairy Products

The dairy industry uses tanks for the storage and handling of milk and the manufacture of cheese. Manufacturers estimate that about 90 percent of the tanks used in the dairy industry are wood. There is a trend away from wood resulting from the rulings of health and inspection authorities. These officials have a preference for metal tanks, because they claim they are easier to clean and sterilize. Some rulings have been issued requiring metal tanks for sanitary reasons. So far the metal tank has not made heavy inroads into the market for wood tanks for milk processing and transportation. Unless the objections of the inspection authorities are met, however, this market for wood tanks will be lost. An investigation is needed to determine what the authorities want and, then, how those demands should be met with improved designs. A study should be made to determine how and why wood fails
to meet the sanitary requirements, if it does, and to determine the value of wood's insulating characteristics in protecting milk in storage and transit.

Both round and rectangular tanks are used in the manufacture of cheese. The rectangular tanks, 16 to 18 feet long, 60 inches wide, and 20 inches deep, are made of 2-inch stock. A rack on the bottom of the tank (Fig. 5) supports a tin-plated pan liner. The wood lasts from 12 to 15 years before requiring reconditioning and relining; then the tank is good for another 5 to 10 years. The average wood tank outlasts two tin-plated liners. The reconditioning is usually made necessary by decay in one or more boards in the ends or bottoms. Decay is not general, and some tanks last 25 to 30 years without any wood replacements when relined. Occasionally tanks last only 6 to 7 years. It is these short-lived tanks that are responsible for the trend toward substituting steel for wood. The steel tank costs about one-third to one half more than wood, depending on whether it is insulated with cork or fiber board, and also on the character of the steel. Insulation is used principally to protect workmen from burns, for the contents of the tanks are maintained at about 200° F. Insulation also conserves steam and improves working conditions.

The principal advantages of wood are its higher insulating value, the protection it affords workmen, its impregnability against whey corrosion, and its low cost. Against these, the advantages claimed for steel are: no leaky joints, no swelling and shrinking, and no warpage. The principal trouble with wood tanks results from warping, swelling, and shrinkage that open the joints and result in leakage. Swelling lifts the pan liner off the slat supports, throwing the load on the sides and ends, and causing them to buckle inward. The trouble increased when firms went from air-dried to kilndried stock. The stock apparently was too dry, and the desirability of simple study to determine the moisture content in service is apparent. Some companies ascribe the trouble to excessive end shrinkage. It is possible that some compression wood gets into the tank stock, and care should be used to eliminate it in grading. Manufacturers should be furnished information that will enable them to eliminate any compression wood that gets by the graders.

In general, although manufacturers believe that a good wood tank is better than a steel tank, some have shifted in recent years to steel because, they explained, it was too hard to get a good wood tank. The problem of selecting a wood that will render satisfactory service should not be difficult. The means and knowledge are available. Some data are needed on moisture conditions in service, so that the present knowledge can be applied to the solution of the problem. Unless the problem is solved, the trend toward steel will again increase, even though the present war emergency ends, especially if steel costs are lowered.

Vinegar, Pickles, and Cider

Wood is used almost exclusively for the storage and processing of vinegar, pickles, and cider (Fig. 6). There is practically no trend toward other materials. Some experimental concrete storage tanks for cucumbers
have been tried with indifferent success. The dominance of wood is based on
the long life of the tanks, freedom from decay, acid resistance of wood, the
absence of any contamination of food products, and its low cost as compared
to any substitutes than can meet the use requirements. The average life of
tanks is 30 years or more, and 50-year old tanks are not uncommon. There is
practically no trouble from decay. The principal cause of trouble is leakage,
for vinegar is difficult to hold. The leakage is objectionable, not because
of loss of contents, for vinegar is cheap, but because of corrosive action of
the acid on hoops and its injurious effect on concrete floors.

Leakage in new tanks is believed by manufacturers to be due most
frequently to the use of improperly dried staves. Experience has indicated
that staves for vinegar tanks should have about a 12 percent moisture content
at the time of assembly. In old tanks, leakage is usually due to the drying
out of the staves while the tanks are empty or partially empty. The hoops
are tightened to take up the shrinkage, and when the staves are wet they
swell under compression, which causes them to set. The repetition of that
process eventually reduces the width of the staves to a point where it is
impossible to tighten the hoops sufficiently to take up the set.

Where leakage occurs, and there is some leakage or seepage in
practically all installations, concrete floors can be protected by a coating
of asphalt. The injurious effect of leakage on hoops is more difficult to
combat. One vinegar manufacturer had a narrow strip of asphaltic paper under
each hoop. The paper was flared out from the tanks, and the hoops were thus
protected from leakage. The idea could be applied more generally and possibly
improved.

There is need for some experimental work on moisture contents, for
the 12 percent recommended by manufacturers is not supported by any factual
data. While it is possibly close to the optimum, it is possible that leakage
could be reduced if more were known of the moisture content of staves in
service and the moisture content at the time the tank is assembled.

Douglas-fir is generally credited with holding vinegar better than
other species used for tanks. More definite information on the best species
is desirable, for if Douglas-fir is superior and materially reduces the
leakage problems the wood should be more extensively used for vinegar. It
clearly has sufficient decay resistance, for the hazard is low and practically
no replacements are made because of decay.

Cider vinegar is much easier to hold in tanks than distilled vino-
gar. The wood does not absorb the liquid so rapidly and there is less
trouble from leakage. All tank woods are, therefore, used with cider vinegar.

Pickles are processed in brine, leakage of which is injurious to
the hoops. Much trouble from leakage results from lack of care in the off
seasons. Tanks are allowed to dry out and the hoops are tightened, causing
the set previously described as responsible for much of the leakage in
vinegar tanks.
Figure 4.--Wood tank used in curing bacon, now largely replaced by galvanized metal.

Figure 5.--A wood cheese vat before installation of metal liner or pan.

Figure 6.--A battery of wood tanks for storage of vinegar. Tanks and hoops are coated with asphaltic paint for protection of hoops against the action of acid.

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Figure 7.—Wood tank cars for vinegar. This is one of the uses in which wood tanks are holding their own.

Figure 8.—Portable vinegar tank coated with aluminum paint to protect hoops and metal chassis from vinegar. Note blistering of the paint.
The principal trouble in many food processing plants results from the period when the tanks are not in service or are only partially filled. The swelling and consequent compression set that staves take when the tanks are again filled results in leaks and eventually necessitates replacements. Filling the tanks with water during off-periods is not always an entirely satisfactory solution, and cannot, of course, be done with partially filled tanks. If provision for changing the water is not made, it stagnates and may foul the tank. Some method of supplying water to the staves of empty or partially filled tanks would materially improve the service and lengthen the life of wood tanks used for food products and in other types of industries. Water is supplied to staves in some oil tanks by means of grooves between the staves. A modification of that method might be devised for tanks in other industries where seasonal or partial use creates a leakage problem.

There is little or no immediate danger of the substitution of other materials for wood tanks used to store vinegar and for the brine processing of foods. That does not justify the wood tank industry's becoming too complacent and ignoring known problems. Those problems should be solved, for with the termination of the present emergency the manufacturers of substitute materials will be hunting markets for an enormously expanded production.

Corn Products

Starch liquors and corn syrups are processed largely in wood. The sulphur dioxide in syrups bars the use of uncoated steel. The cost of copper and stainless steel is considered prohibitive. The average life of wood with good maintenance is about 30 years. There is little tendency toward the use of steel except in rectangular tanks, which are used where circular tanks are impracticable. The temperature of the contents varies from ordinary room temperatures to temperatures of 182°F. The primary cause of replacements is decay, which, in tanks used for starch liquors, damages 3-inch thick staves more than 2-inch ones. Seepage is believed to keep the exterior of 2-inch thick staves wet enough to reduce decay action, whereas 3-inch thick staves have a drier exterior surface, and, therefore, are subjected to a greater decay hazard. Investigations might well be made to determine what stave thickness gives the best service and, where thicker staves are required for strength, how they can be kept in a condition unfavorable to decay.

The principal threat to the wood tank lies in the possible development of a lining which will permit the use of cheap metal tanks.

Beverages

Brewers are probably the most important users of tanks in the beverage group. Tanks are used principally for storage and fermentation in a ratio of about three for storage to one for fermentation. Wood tanks are giving way to steel for storage, but not for fermentation. The general policy with storage tanks is to replace wood tanks with wood, but expansion and new construction consist of steel tanks, principally of the glass-lined type. The replacements are wood because the storage space generally was designed for vertical wood tanks and is not readily adaptable to the horizontal.
steel variety. In addition, the steel tank is assembled at the factory, and cannot be placed in position without opening the walls of the structure. Wood, on the other hand, is assembled in place, and can be carried in through the regular entrances.

Unlined steel tanks are slightly cheaper than wood but require coating with mammut, which must be renewed as often as on wood tanks and the removal and re-coating are equally as hazardous as with wood. The increased safety, sanitation, and economy claimed for glass-lined tanks are not applicable to manuth-lined steel. Some breweries use steel for pressure tanks because they are not so subject to leakage as wood and because white oak, the wood preferred for pressure tanks, is expensive and difficult to obtain in the quality and sizes desired.

The inroads of glass-lined tanks have seriously affected the business of tank manufacturers who specialize in brewery tanks. Brewers and tank manufacturers generally believe that the glass-lined tank will eventually displace the wood tank for storage although some of the older brewmasters still believe that storage in wood is necessary for highest quality beer.

The shift to glass-lined tanks is based on claims of reduced maintenance costs, better sanitation, safety, more efficient use of storage space, and reduced building construction costs. Maintenance costs are lowered by the ease of cleaning and elimination of leaks and re-cooperage; by the absence of joints to catch and hold liquids or solids, which makes glass-lined tanks more sanitary. The permanent lining eliminates the necessity for hazardous removal and application of interior coatings. Efficient design results in an increase of 25 to 50 percent in cold storage capacity, and, by supporting one tank on another, one or more floors can be eliminated from the building. In addition, the larger breweries have gone to tanks 40 feet and longer, which are not practical for wood, especially when subjected to pressure.

The wood tank has stood the test of time. Many tanks in old breweries have been in service ever since the brewery was opened. Because of the low temperature in storage cellars, the decay hazard is low, and decay is seldom responsible for replacement. Fifty-year-old tanks are apparently sound. Wood has much better insulating value than steel, and holds beer at a more even temperature. In the event of trouble with the refrigerating machinery, wood provides a much longer time for repairs without detriment to the beer than does steel. Improved refrigeration machinery, however, has largely removed the danger of spoilage from long shutdowns.

Glass-lined tanks cost from 2-1/2 to 3 times as much to install as wood tanks. Estimates vary from $5.50 to $7.50 per barrel for glass-lined tanks and $2.00 to $2.50 per barrel for wood tanks. Some brewers estimate that the saving with the glass-lined tanks will pay the difference in cost in ten years. Others claim that, when overhead is figured, the cost for storage in glass-lined tanks is higher than in wood tanks. Differences in estimated costs are due to a lack of records on the life and long-time maintenance costs of glass-lined tanks.

The substitution of steel for wood tanks in breweries shows that low price, even when combined with long years of good service, will not hold a market against improved service and appearance combined with low operating and maintenance costs, even though the latter are coupled with high initial installation costs. Reduced costs and cheaper wood tanks will not reapture the market. That can only be done by improving and developing wood tanks so they can compete in service, appearance, and safety with the improved designs of other materials. This, in turn, involves research on coatings or linings, and designs radically improved and different from any now in existence. Such tanks may cost two or three times what the present wood tank costs and still have better chance to compete.

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Figure 9.—A. Old type brewery tanks with flat hoops. These tanks are still in service after 40 years. B. A modern wood tank with round hoops and lugs for take up. It is easier to maintain and largely eliminates the necessity for employing trained coopers. Compared with A, it shows improvement in wood tanks.
Figure 10.1: Early type of metal tank for breweries. A. A battery of modern glass-lined metal tanks. Note wire catwalk, which is the only floor between tank tiers. The improvement in design and appearance shows advances made since the advent of steel tanks. B. Support used with glass-lined metal brewery tanks. Supporting one tank on another conserves cold storage space and eliminates floor between tiers.
The improvement in appearance and design of wood and steel tanks is compared in Figures 9 and 10. Figure 9A shows a 40-year-old wood tank and Figure 9B shows a new wood tank. Figures 10A, B, and C show the improvements that have taken place in the past ten years in steel tanks. A is one of the early 1933 cheap unlined steel tanks, and B is a modern battery of steel-lined tanks. The struts used to support one tank upon another are shown in Figure 10C. A cradle or strut can be designed to achieve similar space saving and reduced structure costs with wood.

Textiles

The textile industry uses tanks for dyeing, bleaching, boiling off, and washing. Wood is still the principal material used for dyeing tanks. Boiling off tanks are now practically all of metal. This shift is due primarily to a change in the boiling off process, and metal is rapidly being substituted for wood for bleaching tanks.

The use of tanks for dyeing by the textile industries is in a state of transition. Some plants, principally the older and smaller ones, use wood tanks exclusively; others are experimenting with metal linings for wood tanks. Some are using a few metal tanks and lining the wood tanks with metal, and a few have practically eliminated wood and are using metal tanks with metal hoods for all operations. It is obvious that the trend is strongly toward metal, especially in new plants and in the expansions of existing plants.

Price is retarding the trend, for metal is much more expensive than wood. The estimated ratio of the cost of metal to wood is about 5 to 1. The initial cost of changing from steel to wood is so high that many of the smaller companies cannot finance it even though the preference of the executives is for metal.

The biggest advantage steel has over wood for dye tubs is the ease with which colors can be changed. Abrupt changes from dark to light dyes cannot be made with wood. Colors have to be changed gradually. Some plants have separate tanks for each color. It was estimated that, where a wide variety of colors are used, two to three times as many wood tanks as metal are used for the same production.

Wood tanks with a heavy metal lining eliminate the advantage steel has for color changing. A number of manufacturers are lining their old wood tanks. When fairly heavy steel liners were used they have proved satisfactory. Light-weight metal liners have not proved satisfactory. Manufacturers would prefer to buy wood tanks already lined, but say these are not readily available on the market. Such tanks could be constructed of No. 2 grade lumber instead of the tank grade. This would bring the price more in line with the straight wood tank, and within the financial reach of smaller companies.

The ease with which colors can be changed with metal lined tanks cannot be fully realized when wood paddle wheels are used, for the dye
absorbed by the paddle wheels will contaminate the color. Manufacturers are, therefore, shifting to metal paddle wheels. Observations of the use of a special coating on "boil off" sticks indicated the possibility of using a similar coating on paddle wheels and possibly on tanks. One promising coating is Tropolite black, which was applied in three coats and baked. Another, Bakelite Varnish 4044 B.K., was reported as materially reducing the absorption of dye, standing up well in service, and thus making it easier to change colors in wood tanks. Experimentation with these and other materials might lead to the development of a coating that would eliminate the necessity for metal linings for wood tanks.

Wood's insulating properties give it an advantage over steel. It reduces the temperature in the dye room, improving working conditions. Where color is influenced by the temperature of the dye, the matching of colors is easier in a wood tank because it is more easily held at a constant temperature and reduces steam consumption. Those advantages, however, are not sufficient to offset ease of changing color, lower maintenance and operating costs, absence of leaks, and elimination of fog in the plant by the use of metal hoods.

The lower maintenance and operating costs are due to the fact that fewer machines and men are required to maintain production, as well as to the absence of leaks. The advantage of metal could be largely overcome by the development of a satisfactory coating for wood of either pan or surface type and the development of a hood for wood tanks.

The life of wood varies widely. Plants where the tanks are set on the floor or below the floor level report a life of about 10 years, replacements resulting from decay. Plants where the tanks are set above the floor level with adequate ventilation report an indefinite life of 30 years or longer and replacements from obsolescence rather than from decay.

A change to a new, continuous "boiling off" process has resulted in the substitution of a metal machine for the wood tanks formerly used. The one machine may replace a half dozen or more tanks. The life of the unlined wood tank was about six years, due to the chemical action at high temperatures, approximately 200° F. The general belief is that the wood tank is definitely out for the "boiling off" process. The efficiency of the improved technic precludes a return to the old system using wood tanks. The use of metal lined wood for the tank used in the continuous process machine is claimed impractical because of the difficulty of obtaining good connections, especially as a metal lining would be necessary for permanence. That is probably true in the present state of development, but it does not follow that satisfactory methods for connecting pipes and other fittings cannot be devised.

Wood bleaching tanks are being replaced by metal. The life of unlined wood tanks for this purpose has generally proved to be too short to be practical. Wood tanks lined with nickel of adequate thickness are reported to cost almost as much as metal and are not so permanent.
Even a casual inspection of a plant equipped with all-metal hooded tanks or machines reveals why metal is replacing wood. Such plants are dry, clean, and practically free from fog. They are equipped with complete textile machines, not wood tanks used as a part of or in connection with a machine. Few wood tanks have hoods, and the fog in plants without hoods is thick, objectionable, and a decay hazard for the building. Wood has lagged far behind steel in the production of a complete self-contained piece of equipment. Apparently, designers have given little consideration to the development of textile machinery with wood rather than metal as the basic material. Some textile manufacturers believe that there is a field for the combination of wood and metal in textile machinery. They believe that, by utilizing the advantages of each material, machinery better and less expensive could be developed than anything now on the market. The greatest obstacle to the development of such machines is that the machinery designers and manufacturers are not wood workers. Both naturally think in terms of their own material, and there exist no satisfactory connecting links to bring the two together.

Tanneries

Tanneries use four types of tanks or vats. Two of them are machines, revolving drums and paddles rather than tanks, and are used for washing, tanning, dyeing, and pickling. Rectangular vats, usually set with the top flush with the floor level, are used to soak hides and remove the hair "lining." Round tanks are commonly used for leaching, storage, and the mixing of tanning liquors. All types are of wood, and there has been little, if any, substitution of other materials for wood.

The vats used for washing and "liming" have a life often as long as that of the plant, especially those used for soaking the hides in water. The liming vats do not last as long, for they must hold a strong alkaline solution of lime with a pH of about 12. Replacements are the result of a combination of decay and chemical action. One plant was planning to build concrete tanks lined with 2-inch plank. The cost would be higher than for wood, and there was considerable doubt as to the success of the experiment.

The market for leaching tanks has largely disappeared because of a change in process. Many plants have shifted from vegetable to chrome tanning. Chrome tanning requires only two or three mixing and storage tanks where vegetable tanning requires 40 to 60 tanks for leaching the tannin from the bark. The chrome process is replacing the vegetable process, with a resultant decrease in the demand for tanks. The chrome process is harder on wood than the vegetable process because the tanning acids used are stronger. A demand is thus being created for tanks and drums that will resist chemical action better than wood. So far, other materials have not gained much of a foothold, but the change in process is a distinct threat and a challenge to the wood tank industry. Wood tank manufacturers must devise means of meeting the more severe service conditions, or a trend away from wood will develop.
Some experiments with a new rubber plastic that can be applied with a trowel are in progress. While it can be applied to both wood and metal, it is more likely, if successful, to benefit metal than wood, for one objective of the experiment is to make practical the use of metal vats.

The drums and "paddles" are subjected to heavy mechanical wear and chemical action as well as a high decay hazard. Replacements were reported as resulting from all three actions individually and in combination.

The temperatures run from 130° F. to 180° F., but are not maintained over long periods. The drums used for washing hides are subjected to a weak alkaline solution. They last about 20 years. A strong sulphuric acid solution, consisting of about 1 pound of sulphuric acid to 20 gallons of water, is used in pickling drums. Failure results from the action of acid on the bolts and the wood around them. The bolts are protected from the acid by wood plugs. Improvement in the protection now given bolts by wood plugs would materially lengthen the life of the drums. The tanning drums carry a load of about 2 tons of water and hides. They are subjected to heavy impact from the contents and to chemical action from a solution of about 4 pH. Only an acid-resistant metal could be substituted for wood, and it would have to be heavy to resist the mechanical action of the rotating water and hides. Thick acid-proof metal is considered too costly at present prices to be practical. Wood tanning drums last about 20 years. Color drums are subjected to more severe conditions than the tanning drums; their average life is 10 to 12 years.

The failure of drums is often the result of too much bolt play. There is a possibility that timber connectors could be used to lessen the trouble from that source.

Decay is responsible for some replacements. Here again the bolts and fastenings are the critical points. They may be responsible for much of the bolt play by reducing the strength of the wood at the joint.

Leakage is a problem in tanks, drums, and vats. It develops both as the result of long shutdowns and in tanks that are only partially filled a large portion of the time. Some method of keeping the staves tight is badly needed in tanneries as well as in other industries.

The wood tank and vat are not in immediate danger of displacement in the tanning industry. So far, the advocates of metal have not been able to devise ways and means of overcoming wood's natural advantages. However, they are pointing out the advantages of metal and the disadvantages of wood in trade magazines and in publications prepared especially for the tanning trade. When the present emergency is past, they will undoubtedly renew and increase their efforts to obtain a foothold in the market. Wood's best defense is to improve the tanks and the machinery associated with them so that there can be no serious troubles to provide an incentive to change.
Wood tanks render long, satisfactory service in the manufacture of ink. They are subjected to mild acid solutions that apparently have little effect on wood, for oak tanks at one plant had been in service 25 years without any replacements and were still rendering good service.

The principal problem was maintenance of hoops and the deterioration resulting when the tanks were out of use for a long period.

There was no evidence of a trend away from wood. Glass-lined tanks would be considered for expansion of the plant, but the general feeling was that the advantages they offer would not justify the greater cost.

Soap, Cleaning Fluids, and Candles

The wood tank has never been entirely satisfactory for processing soap, cleaning fluids, and candles. Leakage, and the necessity for a lead lining in tanks used for boiling fatty acids, are largely responsible for the dissatisfaction. In recent years this dissatisfaction has increased. Four causes are responsible: a change in the manufacturing process involving use of higher temperatures and pressures; poorer wood in the tanks; the failure of tank companies to service tanks; and the increased importance which manufacturers are placing on appearance and safety.

Increased temperatures and pressures have caused more leakage, and manufacturers question whether the wood tank can meet these requirements. They claim no attempt has been made to improve the tanks to meet the more exacting requirements.

They also claim that wood tanks are not so good as they were in the past. That claim is based on the belief that wood now used is not as good. Insofar as the presence of sapwood is concerned, that is probably true. It is not true, however, that wood equally as good as that used in the old tanks cannot be obtained today. The increase in sapwood has resulted from competition between tank companies and the failure of the buyer to recognize the importance of all-heart stock. An extreme example cited by one company was an old tank still in service that was installed 30 years ago, while a recently installed, unlined tank used for cooking fatty acids went out in one year.

Factors such as the severity of the use undoubtedly had more influence on the life of the two tanks than did the quality of the wood, although sapwood and high moisture content at the time of erection probably were contributing factors.

The discontinuance of the practice of servicing a tank for one year after installation has undoubtedly favored the use of other materials. As much as 25 percent of the cost of the tank was said to be necessary to cover the service cost. Under that system, tanks which were maintained to meet the service requirements for one year require comparatively little maintenance afterwards. Now, as they express it, "the tank is our baby as soon as it is
installed." They have continual trouble and high maintenance costs, and they are trying to eliminate them by using other materials even though the original cost is much higher -- from two to four times as much.

Manufacturers generally are placing more emphasis on appearance and safety. Campaigns for improving the appearance of the grounds, plant, and equipment have been adverse to wood, principally because metal causes less leakage. One large manufacturer went so far as to replace a serviceable wood tank with metal because it appeared out of place in a battery of metal tanks. Leakage is also the key to the objection to wood tanks from both appearance and safety standpoints. Grease or soap leakage is traced through the plant, making floors and stairways slippery and thereby increasing the number of accidents and compensation costs and giving the plant an unsanitary and messy appearance.

The substitution of metal for wood is well under way. In large plants, it is largely an accomplished fact; in small ones, it is being accomplished as rapidly as finances will permit. Manufacturers are of the opinion that the trend can only be stopped by the development of a leak-proof tank of pleasing appearance. Temporarily the trend has been stopped by the inability to obtain metals, such as aluminum and stainless steel, because of war requirements.

Much could be accomplished in reducing leakage by a study of service conditions, especially the moisture content in service. Lead and other linings are now used. They have to be renewed -- for some types, too often to be satisfactory. The development of a satisfactory permanent lining that can be installed or sold as part of the tank would largely solve the leakage problem.

**Water**

Water storage probably furnished a market for more wood tanks than any other use. A glance over the roofs of any city gives some idea of the large number of tanks required for water storage. Many industrial plants have one or more tanks for the storage of water used in processing. Industries also use water storage tanks for their sprinkler or other fire protection devices, the railroads use water storage tanks to supply locomotives, and small towns and municipalities use water tanks either for or in connection with the water supply system.

Practically all tank companies make water tanks. However, most of the tanks on high buildings or trestles are now erected by companies that specialize in that type of work. There are several causes back of that situation. Tanks that are to be erected on high trestles require men who can work high above the ground, and in some cities the hoisting of staves to the tops of buildings must be done by specially trained and licensed workmen. Some tank companies do not have sufficient business of that type to justify keeping the necessary trained personnel. They, therefore, build only water tanks that they can readily erect.
Water tanks used in connection with sprinkler fire-protection systems are usually purchased and installed by the sprinkler companies. Once they are in place, the owner of the building is responsible for their maintenance.

Competition for business has caused the sprinkler companies to go largely to cheaper tank woods and sometimes to cheaper grades of tank stock. The sprinkler companies claim that the more expensive tank woods and tank grades make wood tanks cost as much as steel. The reputation of the wood tank has suffered as the result of leakage, accumulations, and short life of the tank purchased for price rather than quality. The preparation of standard specifications for such tanks and some extension work with code authorities of cities to establish control over quality of tanks permitted would materially improve the situation.

The sprinkler companies' general practice is to use wood for tanks with capacities up to 50,000 gallons and steel for all above that capacity. They claim that wood is not practical in the larger sizes. Just why, is not apparent, for railroads use wood for 100,000 gallon tanks. Concrete tanks have been used, but cracks developed which were explained as being the result of stresses set up by the settling of the building. The result has been that few concrete tanks are now used except in special cases.

One of the principal causes of the decreased demand for water storage tanks, either wood or steel, is the trend toward hooking fire-prevention equipment directly to water mains. That practice has been made possible by improvements in water systems, especially the increase of pressure in water mains and installation of pumps and other auxiliary equipment for boosting pressure in buildings. The trend has been further accentuated by the increased installation of water systems in small towns and suburban communities under grants made by the W.P.A., P.W.A., or other Government agencies. The new systems not only are hooked directly to the fire prevention equipment but eliminate a large portion of the market for tanks in which water for domestic and other uses is stored.

There are still advantages in the use of tanks for plant processing and fire-prevention equipment. They give emergency protection against either the failure of power plants that run pumps or the failure of water systems as a result of explosions or other causes. That advantage is responsible for the fact that many users maintain their tanks as an auxiliary supply and continue to use tanks on new buildings.

The railroads generally favor wood over steel tanks for water storage. A recently compiled tabulation of railroad water storage tanks made by the railroads showed that of the 26,000 water tanks in service two-thirds, or 18,000, were of wood, of which 4,000 were constructed of treated timber. Most of these tanks had a capacity of 100,000 gallons. Some 1,200 steel tanks in use at oil fueling stations, with sprinkling systems, and for purposes other than motive equipment are not included in the figures.

The railroads have probably the most complete and systematic records of tank performance in existence. These records extend back fifty
or more years, and, for some roads at least, contain detailed data on maintenance, replacements, life, and costs. An intensive study and analysis of these records by the tank industry would probably be valuable in improving the quality of water tanks generally, and helpful in holding the railroad market against inroads of other material.

The preference of railroads for wood tanks is due to the low cost of erection and maintenance, the long, satisfactory service rendered, and the comparative ease with which wood tanks can be moved. More than 90 percent of the railroad water tanks have to be moved in the course of 25 years due to changes in location of the tracks. That fact is largely responsible for the preference of wood. The concrete tank, being permanent, is a total loss if the track location is changed. It is claimed that a steel tank costs as much to take down as does the erection of a new wood tank.

Leakage and decay are the principal causes of trouble with water tanks. That troubles from both of those causes are more prevalent than they need be is indicated by tanks still in service after 30 to 40 years and still tight. That type of service can be obtained from a high percentage of tanks by good workmanship, elimination of sapwood, good maintenance, and proper selection of grades and species.