WOODEN SCOWS— SOME FACTORS AFFECTING THEIR DURABILITY.

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FOREWORD

THIS REPORT is not the result of experimental work done by the Forest Products Laboratory. Hence it is not possible for the Laboratory to accept responsibility for all of the information contained herein, although it has been compiled from various reliable sources and is believed to be authentic.

Where no dates are given, figures of estimated costs may be taken as those applying in March, 1932.

Much useful information has been obtained from the following sources: "Creosoted Wood Construction in the Marine Field," a paper by H. A. Thompson, Plant Superintendent, U. S. Engineer Dept., Fourth Mississippi River District, in Proceedings of the American Wood Preservers' Assn., 1928; from the Canada Creosoting Co., Ltd., Vancouver, B. C.; and from various scow owners and operators in the lower mainland of British Columbia.

THE PROBLEM:

In 1931, the Vancouver Laboratory, Forest Products Laboratories of Canada, Department of the Interior, was asked by owners and operators of wooden scows to suggest methods of prolonging the life of these craft, annual charges for repairs, maintenance, and depreciation (chiefly on account of rot) being uniformly very high. The Laboratory undertook to canvass the situation and to investigate possible methods of experimentation whereby durability of these craft could be increased. The present report is the result of enquiries into this subject.

There are in Vancouver, Victoria, and New Westminster, some 300 wooden scows, used for carrying lumber, coal, sand, gravel, etc. There are, in addition, some 150 fish scows.

The standard scow is 32 feet wide, 90 feet long, and 8 feet 6 inches or 9 feet in depth (a 500 ton scow), although larger scows (40 feet by 120 feet) are in service, and some smaller ones. The standard scow has been found the most suitable for carriage of general cargo. At one time it was customary to build them longer and narrower; but such scows were found to be dif-

difficult to control at sea and sometimes rolled so heavily that cargo was lost overboard. Scows have a straight rake at bow and stern, and a flat bottom.

In normal times a scow of standard dimensions cost \$7000 to build. The cost in 1932 was about \$4800. The total capital investment in these waters in scows, therefore, is in excess of \$2,000,000. The annual depreciation allowed by the Dominion Government for income tax purposes is 10 per cent. On this basis there is a minimum annual depreciation, therefore, of \$200,000 on account of the deterioration of scows.

LIFE OF SCOWS:

In these waters, pressure-treated, creosoted scows are, with one or two exceptions, absent. Various expedients are in vogue for attempting to preserve the timbers of the untreated scows, which are described later. The life of untreated scows varies greatly. One firm, normally operating about 50 standard scows, states that the effective life of untreated scows is only three to four years in river water, and about five years in salt water. There are other operators who claim that they get a life of fifteen to twenty years in salt water, and about ten years in fresh water.

The effective life of a scow seems greatly to depend upon the manner in which it is looked after and repaired, and a great deal also depends upon the kinds of cargo carried.

Of the scows in use in the vicinity of Vancouver, only about 30 per cent are actually insured. Of the remainder, a considerable number are inspected once a year for seaworthiness by the underwriters. A scow must be "seaworthy" before its cargo can be insured. A number, however, are operated without insurance, and it is in this class of scow that the heaviest depreciation from rot probably occurs.

CAUSES OF DETERIORATION IN SCOWS:

Mechanical wear:

Apart from rot, certain scows are subject to considerable wear and tear. Where scows are used for carrying donkey engines and other logging equipment to camps up the Coast, they may sometimes be badly damaged. In such cases the scow is pushed ashore. While resting on the bottom (where there may be rocks or snags which can break the planking) the heavy logging equipment is dragged across the deck and down an inclined plane of planks to the beach. Old scows are often used for such work. The life of an individual scow, therefore, depends largely upon the work it is called upon to do, and the way in which it is looked after.

Rot:

Rot, decay, or dote, in wood is caused by the action of certain fungi, which are low forms of plant life. Their characteristic form in wood is in thread-like, branching filaments, which ramify through the cells of the wood substance. Each advancing and growing thread is able to eat through and actually absorb elements from the wood as it passes, by secreting certain chemicals at its growing tip. As long as physical conditions are favourable, the fungus continues to digest the wood, until none is left but a crumbly residue. The individual, branching, colourless thread is known as a *hypha*. Collectively, they are known as *mycelium*. When growth is prolific, the hyphae may form a matted tissue of mycelium on the surface of the wood in which the fungus is growing. From this tissue, tiny *spores* (similar in function to seeds) may be produced in countless numbers, which are carried about by air currents and infect adjacent material.

The disintegration, through rot, of any structural material of wood, therefore, is a cumulative process which may have its inception in one of two ways, or both; viz., through development of fungi present in the standing tree and therefore dormant in the cut lumber, or through surface infection by means of spores or mycelium from adjacent material.

As with all living organisms, the growth of wood-inhabiting fungi is governed by four main factors. The absence or removal of one or more of these necessary governing factors results in the prevention of decay, or the preservation of wood. Before one may examine methods of preservation or prevention of decay, it is important, therefore, to understand just what conditions are necessary to promote decay: these are —

1. Presence of suitable food supplies;
2. A suitable amount of moisture in the wood;
3. A temperature favourable to growth;
4. A supply of air to furnish the necessary oxygen.

Food supplies. — The mycelium, being actually a living plant, must have nourishment in order to grow. This it finds in the various constituents of the wood substance, as well as in certain sugars, starches, and organic acids present in the cell walls and their cavities.

Artificial preservatives introduced into wood "poison" it, and thus prevent the development of fungi.

Moisture. — A supply of moisture is necessary for the growth of fungi, and as long as wood is kept sufficiently dry, infection cannot take place, nor can fungi which may be already present in the wood continue to develop. A moisture content in excess of 25 per cent, as a rule, is required for the best development of fungi in wood.

Temperature. — Wood-destroying fungi develop best during warm, wet, or humid weather. Temperatures of 70 to 80 degrees Fahrenheit favour the development of most wood fungi, although some of them thrive at considerably higher temperatures, while others thrive at lower temperatures. Growth is generally inhibited at winter temperatures, but cold weather does not necessarily kill them. A temperature in the neighbourhood of 125 degrees Fahrenheit will kill most fungi after a few hours.

Climatic conditions, therefore, have an important bearing upon the longevity of wood in service. In out-of-door situations, warm, humid climates encourage the development of rot much more rapidly than cold, dry climates.

Light and air. — Light is not an extremely important factor, although the majority of fungi seem to develop somewhat better in a diffused or weak light.

A certain amount of air is necessary for fungous development. Under ordinary conditions the air supply within the wood is sufficient.

Stagnant, damp air surrounding wood is highly conducive to decay. If the wood at first is sound (i.e., free from decay) and dry, it is likely to absorb moisture and act as a host to fungi; while if it is already infected, the moisture supplied will enable the process of decay to continue.

Air currents produced naturally or through ventilation usually cause evaporation of moisture from the wood, and by reducing the moisture content tend to prevent the development of fungous spores on the surface and the spread of decay within the piece. As a general rule, ventilation is beneficial; it is possible, however, for well seasoned timber, continually ventilated with damp air, to absorb sufficient moisture to permit fungi to grow.

It is thus seen that conditions in the interior of a scow are extremely favourable for the development of decay organisms. No matter how carefully a scow is handled in relation to mechanical abrasion, rot very early attacks the interior of an untreated scow. The bottoms are little affected, the salt in the bilge (there are usually two or three inches of bilge in the bottom of any scow) and the absence of air supply in the submerged timbers apparently giving the bottom timbers a measure of preservation, and the decks and upper parts of the side strakes and keelsons are most affected. If no salt or other preservative is used, inside of six months a thick mat of fungal mycelium will form on those portions of the structure just under the deck, in some cases so luxuriantly that it can be pulled off in great sheets or festoons. As decay progresses, it is eventually found that the deck begins to sag ominously under a load, and the scow has then to be scrapped.

Poor ventilation. — The rapid development of decay in the interior of scows is largely due to the almost complete lack of ventilation under the decks. Particularly in warm weather, this enclosed space furnishes nothing more nor

less than a forcing chamber for the growth of wood-destroying fungi. If hatches (there are usually one, or two, small hatches at each end of the scow) could be opened every day or two for a few hours the problem of preserving the interior would be largely obviated. Some scows, however, may take several weeks on a voyage, during which time hatches cannot be lifted especially if covered with cargo. They cannot be lifted while the craft is at sea, since a loaded scow has little free board and even a slight sea will cause water to wash over the deck. If hatches are lifted while it is moored, there is no place in which to stow them, so that they may be knocked overboard accidentally, or, in some cases, thrown over-board by irresponsible parties, when they are lost.

It was the custom for some years to use ventilators, composed of 6-inch iron pipe, about 6 feet high, running through holes in the deck near the stanchions. As ventilators they were useless. They created little or no air circulation. The stanchions afforded little or no protection to the adjacent ventilators, since the stanchions themselves are frequently broken off while loading cargo. The ventilators are soon knocked off, or become loose and fall out, owing to decay of the timber in which they are set, leaving a jagged hole in the deck, which soon fills up with sawdust, chips of wood, and other debris. Some builders are now using cedar stanchions, since Douglas fir rots at the deck line. Others are turning to the use of Australian gum for towing bitts, instead of Douglas fir.

Ventilator pipes seem to accelerate decay rather than reduce it, and the underwriters have now condemned their use. Provision of adequate ventilation in scows remains an unsolved problem.

Teredos and Limnoria. — These marine organisms give no trouble in scows used on the Fraser river. On Burrard inlet and the Coast generally, on the other hand, they are very active. No British Columbia native wood species seems to be immune to them. They are said to be most active from March to July.

The method used to counteract teredos is to use copper paint on the bottoms and sides up to the *light* water mark. The painting has to be done thoroughly, since only a small area of unpainted wood is required for a number of teredo spawn to enter. About 10 gallons of copper paint are required to paint a scow of standard dimensions. It is usually done once a year, but should be done twice. February and June are good months in which to do this. Before painting, the bottom and sides are scraped to remove barnacles and mussels, and teredo and limnoria infested or rotten timbers are removed and replaced. Fresh caulking is also applied. It is considered that the paint should be applied with a brush, and not sprayed, since the latter method gives an uneven coat, leaving places of entrance for the young teredos. Furthermore, the paint has to be thinned with turpentine in order to spray it on properly,

which decreases its efficiency. Above this line, to the flush of the deck, the rakes and sides of the scow receive, usually, a coat of coal tar. Before the deck is sheathed, it also receives a coat of coal tar.

A lining of felt is sometimes placed around a scow between an exterior lining and the side strakes. Felt is not often used, since the outer sheathing required with its use is easily broken off during the rough handling most scows get, and, furthermore, it is not considered that felt definitely prevents the passage of teredos, but merely deters them. To cover a standard scow about 95 thousand feet are required. This large amount of felt required and its cost are other factors which have contributed to its disuse.

Construction. — Galvanised spikes are used. After a time the salt water has a softening effect on these spikes, so that after some years of use they may become as plastic as putty. A suitable substitute for galvanised spikes is now being sought by scow owners and builders. About 1650 pounds of galvanised spikes are required for a standard scow, as well as 2½ tons of drift bolts and iron. The widespread use of brine applications in various forms greatly accelerates the deterioration of bolts, spikes, and other metal parts.

A well constructed scow has its timbers (Douglas fir) in one piece. Builders who are not particular use "scarfed" timbers. These latter naturally do not give as long service as the former, construction is not as rigid, and the scow will not stand shocks and jars as well.

A number of builders state that the use of green timbers is responsible for the rapid development of decay in scows, and there may be some justification in certain cases for this belief. As a rule, there is little or no attempt made to season scow material, and in some cases it may be placed in position when green from the saw. Seasoned stocks of material of scow size are, as a rule, not carried in lumber yards, and there is difficulty in obtaining it when needed. Other conditions being equal however, there is no reason why green timbers should not be satisfactory. There are instances of wooden sea-going vessels, made from green material, in use for 40 years, and still insurable. It should be remembered also that green material is more pliable and more easily steamed and bent to shape than seasoned material.

Present methods of preservation:

Individual scow owners have exercised considerable ingenuity in attempting to preserve their scows from rot by various economical methods. Most of the methods used involve the use of common salt in some form or another. The use of salt in scows, barges, in fact, all wooden sea-going craft, is world-wide, and has been for centuries. It has been proved that salt has a certain measure of efficacy in preserving wood, probably by retarding the rate of decay, since common salt has a very low toxic value, and even a concentrated

solution is not strong enough to kill wood-destroying organisms. The hygroscopic or moisture absorbent qualities of salt may also help to explain its apparently preservative effect.

In steam tugs, salt is frequently packed between the skin and the lining of the hull as a measure of preservation. A tug, 21 years old, which was being repaired, was recently examined. At the stern, rock salt pockets had been built around the hull; at the bow end no salt had been used. The bow, deck and sides were rotten and were being pulled out and replaced, but the stern end was as sound as when originally built. Under such conditions as these, salt gives good preservation. In the interior of scows, however, where conditions are so favourable for the development of decay, and the distribution of salt can only be limited, the application of salt as a means of preservation can be at best only a palliative.

The preservative action of salt is exemplified by the fact that scows used for river purposes have a life several years shorter than those used in salt water, in spite of the fact that marine organisms such as teredos and limnoria are entirely absent in river water. In addition, several operators have observed that a leaky scow is less subject to rot than a water-tight scow.

A method of preservation once commonly used was to take a scow out to deep water, pull out the plugs, and submerge her. She would be left there for a week or so, then towed in, pulled on a mud flat or a grid, and when high and dry the plugs were re-inserted. This is seldom done, nowadays, because of the time and labour involved. It is considered also that the amount of salt present in sea water is insufficient to give lasting preservation.

Another old method which has been used for years is the use of salt shelves. These are shelves, or boxes, about a foot wide, attached at an acute angle along the tops of the solid keelsons (not the skeleton keelsons). Upon them rock salt is placed. The salt absorbs moisture gradually and the salt solution formed thereby slowly drips down the sides of the timbers, coating them to some extent with salt.

A method now much in vogue amongst scow operators is "brining" of the interior through a force pump or spray. Salt is added to cold water in a tank, and mixed until a potato floats in it, when the solution is assumed to have reached the highest concentration which can be obtained in cold water. The saturated salt solution is then sprayed upon the walls and deck of the interior, using a nozzle pressure of 150 or more pounds. The salt crystallises on the surface of the wood, and to some extent penetrates the surface layers. This method is said to add at least two years to the life of a scow. From 2000 to 3000 pounds of salt are used upon a standard scow, and the total cost of spraying, or "brining," as it is called, is about \$35.00 per scow. The Board of Marine Underwriters (of San Francisco), in Vancouver, recom-

mends the use of salt shelves, together with either sinking in salt water or bringing, at least once every ten months. The "white" (mycelium) must be removed and scraped off thoroughly before the salt treatment is given.

One large firm which operates 60 scows in normal times uses salt in the following way: about 25 tons of rought sack salt (cost \$7.50 per ton) are placed in the scow, at its moorings alongside their wharf. Water is poured through the hatches, and in about eleven hours the scow has sunk to water level. It is thus left for two weeks. The brine is then pumped out and poured into another scow, where it is again left for two weeks, and so on. They say this method is superior to the use of the brine pump. It is applied once a year.

Salt treatments of these various kinds are generally used by scow owners, but they give at best an uncertain measure of protection, and their efficacy is very limited.

Creosote treatments, applied superficially by brush or spray, have been tried by various operators, with no retardation of the rate of decay. The negative results by this method have, unfortunately, produced a reaction against the use of creosote in any form, ignoring the fact that when properly injected into the wood under pressure, creosote gives an excellent form of preservation for these craft. It has not been sufficiently understood that a surface application of creosote, tar, or paint to the interior of scows simply prevents the passage of moisture through the wood, and retains it inside the wood, where it is able to do its maximum damage by stimulating decay.

Tar has also been used as a surface coating in the interior of scows, but has proved no more effective than creosote. Tar is frequently used for the surfaces of decks and the upper portions of the outside of a scow. In the few instances where creosote is still used, tar is generally mixed in varying proportions with the creosote to give it the necessary body and "tack" it to the wood. The mixture is then sprayed or brushed on when hot. The workman doing the spraying is protected by a rubberised costume, similar to a diving suit, with special boots attached, and a gas mask.

The common use of tar is ill advised. Its utility is confined to a water-proofing effect. It is well known that tar will often accelerate rather than retard decay when applied in a surface treatment. If a brush treatment is desired, it is better to use straight creosote. In any case, if infection is already present in the wood, no surface treatment can prevent progress of decay below the outside skin.

Consideration of other methods of experimentation:

Above has been given a description of the commoner methods in vogue to increase the durability of wooden scows. There remain to be considered certain other possible methods of preservation as yet largely untried.

Consideration was given to the use of antiseptic vapours inside the scow, such as acetic acid and the vapours from creosote. It was thought that tanks containing glacial acetic acid could be installed in scows, so that the vapour arising therefrom could be expected to sterilise the surface of the wood without sealing it up and preventing the passage of its moisture therefrom by evaporation. The vapour would be expected also to poison the air supply and render difficult the growth of wood-destroying fungi. Several factors, however, rendered the use of this method impracticable. They were:—

1. The fact that there is a certain seepage of air through the walls of the scows, not only through uncaulked crevices, but through the wood itself.

2. The presence of bilge water would lower the vapour pressure of the acetic acid, thus preventing saturation of the air in the scow. The surface area of the acetic acid being small compared to the area of the water surface, the molecules of the acetic acid would diffuse slowly through the air and then would be absorbed by the water more quickly than evaporation would take place from the acid containers.

It has been reported from Czecho-Slovakia that mining props in that country have been satisfactorily protected from decay by coating them with a mixture of common salt and cement. A strong solution of common salt is made up and then sufficient cement is added to form a thick liquid. The mixture is applied to the surface of the timber with a brush.

A promising procedure in the case of scows would be to use salt boxes in the usual manner, and then to cover all other timbers which cannot be protected by drippings from the salt boxes with a brushed coat of the salt-cement mixture. Renewal of salt in the boxes and brushing with the mixture should be done twice a year.

Creosote treatment:

Once the wood of a scow has begun to decay, it is of little use to attempt treatment of any kind. Application of a surface coat of creosote, brine, tar, cement or other antiseptics or palliatives has simply the effect of sealing in any wood-destroying organisms present and possibly accelerating the rate of decay.

Negative results from surface applications of creosote have prejudiced the scow owner against the use of creosote in any form, which is unfortunate, since a pressure treatment of creosote is the most durable and economical method at present known of coping with the problem of decay in scows. During treatment the timbers are effectively sterilised, that is, wood-destroying organisms which may be present in the wood at the time of treatment are killed. Furthermore, since the wood is impregnated with creosote, no infection from outside can take place. The bottom and sides are immune to teredo and limnoria attack, as well as decay, during the life of the scow.

The creosoted scow has a very low annual maintenance cost. Since the timbers are protected from decay for an indefinite period, the fastenings remain tight, and there is no loosening of bolts, drifts, etc. No painting of any kind is required during the life of the scow, and the caulking remains firm for long periods.

Within three to four years, the cost of pressure treatment is balanced by the elimination of maintenance charges during that time. In addition, the treated scow has a life of maximum effectiveness of 35 to 50 years, as against a life of maximum effectiveness of 10 to 15 years with the untreated scow. Furthermore, after the first 5 years the cost of maintenance of an untreated scow increases with the age of the scow, whereas the only items of maintenance necessary during the entire life of the treated scow are repairs due to mechanical wear or damage, usually confined to repair or renewal of a cheap grade of untreated sheathing used for protection of the decking from mechanical abrasion, periodical inspection, and attention to caulking of side seams between light and load water lines. The frequency of such maintenance depends largely upon the character of service. If a scow is loaded frequently during the year, the side seams will give very little trouble. When a scow remains idle, light, for a year or longer, slight leakage through side seams may be expected during the first loading thereafter. The best practice is to "make in" the oakum prior to such loading, as a precaution rather than a necessity, as within a short time after loading all leakage through the side seams will stop.

With the pressure-treated, creosoted scow, all timbers are framed and most of the holes bored before creosoting, and the scow erected after treatment. Where parts are in contact with each other attack by wood-destroying organisms (fungi) can be expected to be most severe, and by this method all such parts are protected from decay.

To give the best results, for the bottom, rake, and side planks, a treatment of 12 pounds of creosote oil (Grade No. 1, A.R.E.A.) per cubic foot of wood, rendering these timbers immune from teredo and limnoria attack, is recommended. For deck planks, inside keelsons and stanchions a treatment of 7 to 8 pounds of the same oil per cubic foot of wood, thus preventing all forms of decay, is recommended. This applies to scows to be used in coastal waters. For scows and other similar structures which are to be put in service in inland lakes and waterways, it is necessary only to use 7 to 8 pounds per cubic foot throughout.

The pressure-creosoted scow has been used very extensively in inland and coastal waters of the United States, but not as yet extensively in Canada. There are numbers of scows on the Mississippi river which have been in operation for thirty or more years, and ten or more years of effective life is anticipated. At the end of this period it may be necessary to use them for

lighter duties, due to mechanical abrasion and structural weakness, but not because of rot or marine borer attacks.*

The Public Works Department of the Dominion Government has built and put into service on the interior British Columbia lakes of recent years seven or eight pressure-creosoted Douglas fir dump barges and scows. Their experience has been that the treated type of barge is far more economical than the untreated type, and they have adopted the treated type of floating structure as standard.

Statements have been made that the pressure-treated scow is difficult to caulk. Investigations made fail to substantiate such statements.

It has been stated that pressure-treated, creosoted scows ride lower in the water. Investigation fails to substantiate this statement, and creosoted scows float just as high, if not higher, than untreated scows.

The only argument which is of sufficient importance to detract from the advantages of the pressure-treated scow is that of extra initial cost. When creosoted timbers are used, the cost of the material is about doubled, and the gross cost of labour, material, etc., is increased about one-third. The actual additional cost of creosoting in 1933 at Vancouver, B. C., was about \$20.00 per thousand feet b.m. As already pointed out, this extra cost is readily balanced within a few years by the cost of maintenance of the same scow if untreated.

SUMMARY:

1. The cost of maintenance of wooden scows in the region under consideration is extremely high, chiefly due to the rapid development of decay in the interiors.

2. The present methods of preservation of interiors are entirely based on the use of common salt in various ways.

Common salt has an extremely low toxic value, and, at best, its use can simply decrease a little the rate of decay.

3. Where cutting of initial costs to an absolute minimum is required, and pressure treatment with creosote cannot be afforded, a mixture of (a) a saturated solution of salt in water, and (b) cement may be brushed on all inside timbers which cannot be reached by drippings from salt boxes.

4. If it is at all possible for an extra additional initial cost to be met, a pressure-treated creosoted scow, with timbers framed before treatment, gives the best possible results at present known, producing a fully effective life of 35 to 40 years, or more, with almost negligible maintenance charges.

5. The use of surface applications of creosote, tar, or any other antiseptic or waterproofing must be expected to be unproductive of good results, and in some cases may do more harm than good.

* See Proceedings of American Wood Preservers' Assn., 1928: p. 188.