Wood preservation manual

FAO FORESTRY PAPER
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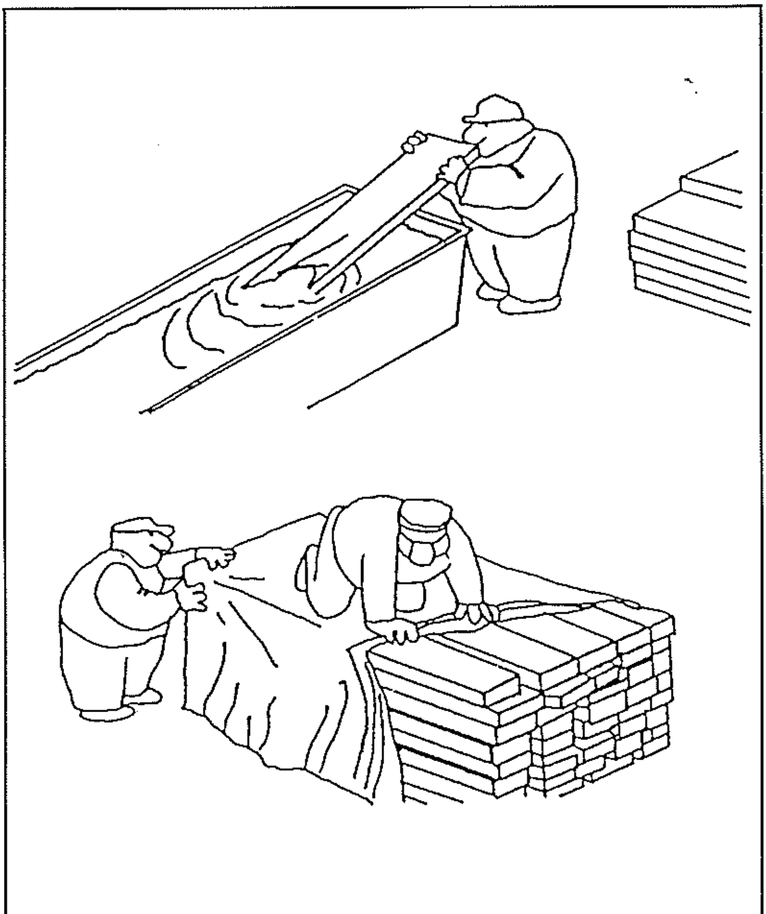

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Wood preservation manual

Mechanical Wood Products Branch
Forest Industries Division
FAO Forestry Department

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Chapter 1

INTRODUCTION

Wood is one of earth's most valuable resources and it conforms to the most varied requirements. It is easily worked with tools and machines and it has a very high strength to weight ratio. Despite its strength, it is so elastic that steam can be used to make it into complex shapes. Wood is resistant to mild chemicals and it does not corrode.

All these considerations - and they are by no means exhaustive - leave no room for doubt that wood protection is an economic necessity. It is a gift of nature and is the only working material that is self generating. Some timbers have excellent resistance to various agents of deterioration and are therefore highly valued for this property - usually summed up as durability. Many others have only moderate resistance or hardly any resistance and it is in these cases, which are very numerous, that wood preservation becomes a necessity.

Present day wood preservation techniques enable us to extend the life span of wood almost indefinitely depending on the preservative and the method used. The efficacy of the preservative treatment depends upon the correct choice of the preservative chemical and the treatment method which ensures the required absorption and penetration of the preservative. A number of chemicals and treatment methods are available which give varying degrees of protection against deterioration from fungal and insect attack. This manual gives a guide to the selection of appropriate preservatives and methods of application.

FAO wishes to express its appreciation to Mr. D. Lionel Jayanetti on whose work this manual is based.

Chapter 2

WHAT IS PRESERVATION?

Importance, benefits and economics of wood preservation

Wood preservation, in its widest sense implies the protection of wood against any factor whatsoever that may damage and ultimately destroy it. However, timber preservation in a practical sense refers to the improvement of woods' natural durability by treatment with chemicals that are toxic to insects, fungi and other decaying agents. Despite the marked extension in the use of competitive materials, wood is still a leading building material. It will continue to maintain this position so long as an adequate supply is available at a reasonable cost. In view of the limited availability of naturally durable species, it is imperative that supplies of less durable timbers which when suitably treated would give an increased life under service conditions. Preservative treatment of timber therefore forms a very important part of the national effort to conserve the material resources of the country.

The primary objective of the preservative treatment of wood is to increase the life of the material in service, thus decreasing the ultimate cost of the product and avoiding the need for frequent replacements. Outstanding examples of increased permanence through such treatment are afforded by products which are exposed to the most severe attacks of wood destroying agencies. Thus for example, in a telegraph or electricity pole in the ground where the temperature and the moisture conditions are especially favourable for the development of decay, the average life of untreated wood may be a couple of years (unless it is a naturally durable timber) whereas creosoted poles have survived for many decades. This itself demonstrates the benefits of preservative treatment in extending the life of timber in exposed situations. Experience has shown that the prolonged life obtained from adequately treated timber especially used in exposed situations invariably results in a distinct financial saving, despite the fact that treated material has a higher initial cost. In certain types of construction, (as in the case of rural telephone lines in some developing countries), the costs for preserving the timber may so decidedly increase the cost of the completed installation that it may only be warranted if the life of treated wood is considerably greater than that of the untreated material. However, in bridges, jetties and in fact most timber structures, the cost of preservation constitutes only a relatively small proportion of the total investment, with even a slight increase in the serviceable life of the wood more than justifying the added expense. This is notably the case in large buildings and other forms of construction in which only a small amount of the wood used needs to be treated to safeguard the structure from deterioration by decay or other destructive agencies.

The economy resulting from the use of treated wood in any form of timber construction is affected primarily through the reduction in maintenance costs. With some products, such as fence posts, the labour and other charges incidental to making frequent replacements may not be significant, but with others, such as bridge timbers and poles in a city electricity distribution line, these replacements are extremely important. In addition to the direct charges for labour and materials, replacements in electricity power lines, railway tracks and other structures may also entail inconvenience and rather expensive interruptions in service.

The extension of the service life of timber by the application of appropriate preservatives has another significant effect in the field of wood utilization. It has made available for use a large number of species which previously had been considered inferior solely or primarily because they lacked the durability and gave only a short service life when exposed. Preservative treatment of woods that are naturally non durable, but otherwise acceptable to the consumer or to the industry, has not only increased the supply of timber available for construction purposes but has also brought about certain other benefits. This applies especially to secondary timber species found in many developing countries.

In addition, preservation contributes to the reduction of the demand for replacement wood, thus conserving the forests. On the other hand, wood importing countries could adopt preservation in order to conserve foreign currency by reducing wood imports whilst wood exporting countries could reduce the home demand for replacement, thus leaving the maximum possible volume for export.

Protective measures

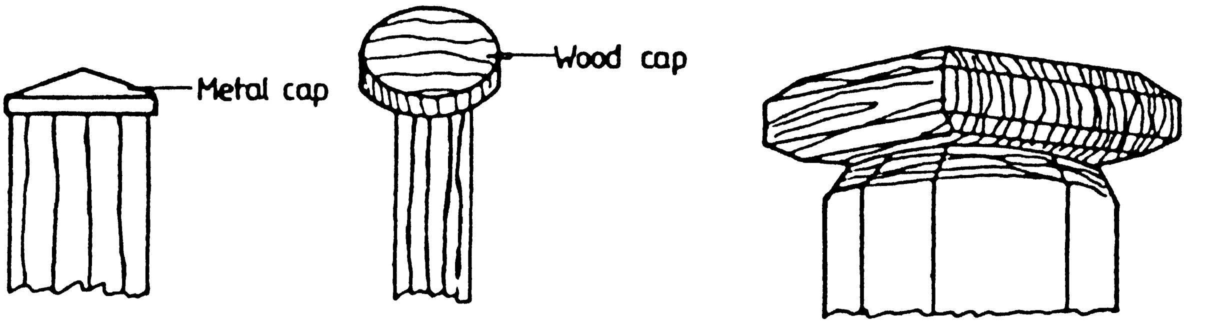
In the past, prejudice against the use of timber has been connected with its deterioration in service. Today inherent durability is not an essential feature since there are preservative treatments which will prolong the life of inherently non durable timbers. In addition to preservative treatment with chemicals, there are two other ways which will enhance the protection; they are protection by specification and protection by design.

Protection by specification

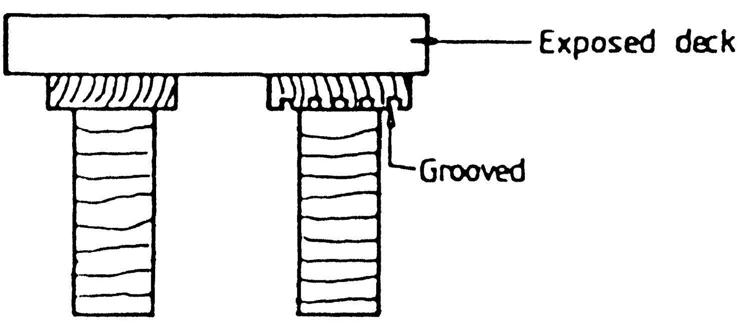
Protection by specification (or simply by selection) implies firstly that the risks involved be correctly assessed and secondly that the properties of the materials be known. These hazards can to some extent be controlled by specifying or selecting a particular timber species such as a species very resistant to attack by insects and fungi and by specifying the absence of sapwood, etc. However, even the most durable of woods do not have the decay resistance of wood fully impregnated with an effective preservative. Heartwood of durable species is increasingly difficult to obtain, however where a preservative treated timber is not available for use, it is a good practice to select timber containing only heartwood. Furthermore, having a higher safety factor and therefore having larger dimensions leads to longer service life. For example, if untreated poles are to be used, the effective diameter should be taken as the diameter exclusive of sapwood, as sapwood is liable to decay. Even with treated poles, their durability will depend upon the preservative retention of the annulus of the treated wood. Therefore care should be taken not to cut through, machine, drill or otherwise remove the treated wood. A most important specification for indoor use, is the use of well seasoned timber.

Protection by design detailing

Good detailing in design, such as the elimination of all pockets of water, provision of ventilation etc., minimises most of these hazards. Timber structures should always be designed so that they shed water and timber should always be located so that the ends are not directly exposed to rain, since the end grain is a good access for water (Figure 2.1). In the same way, ventilation should be provided to ensure that any moisture which enters into the wood dries out before any decaying



Protecting end grain
Figure 2·1



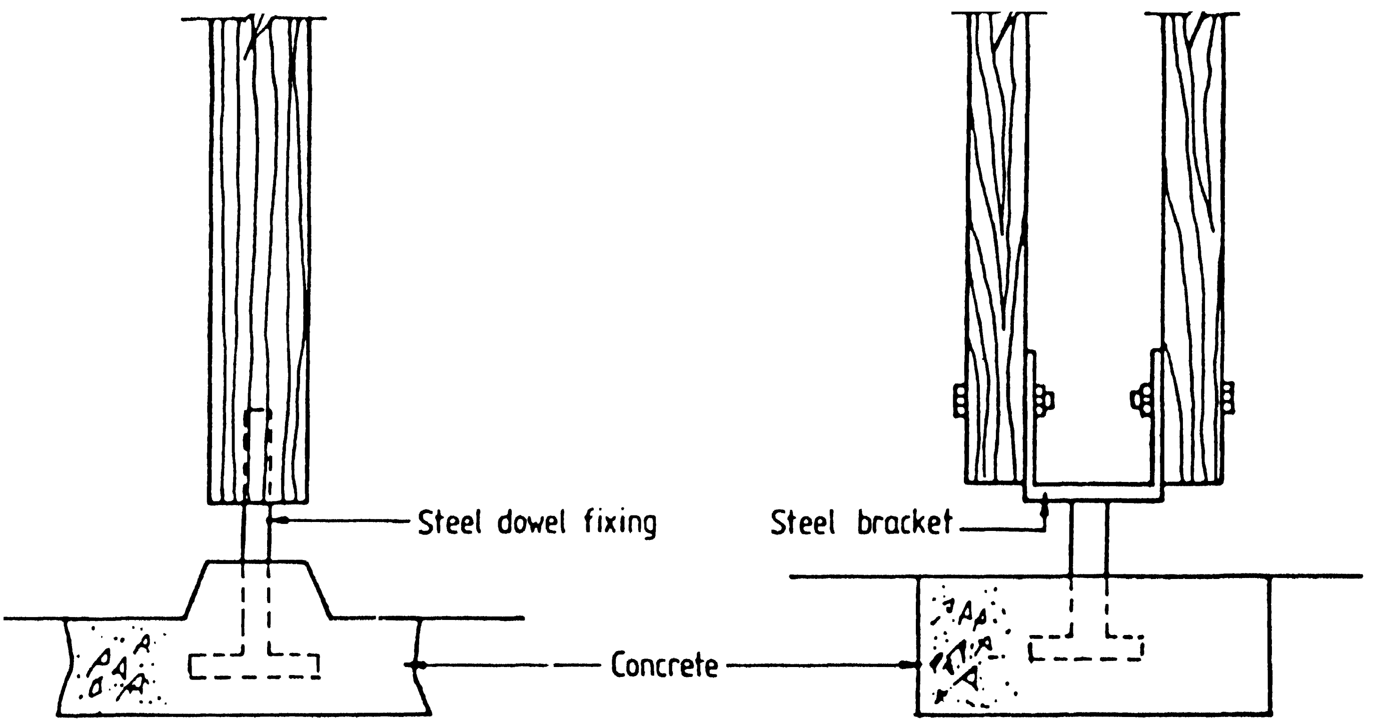
Use of capping to deflect water
Figure 2·2

organism can develop. When timber components are joined together or brought into contact with other structural members or materials, care must be taken to avoid trapping water in the joint. Shaping, caulking and flashing of timber members can encourage drainage of water away from joints and also inhibit the entry of water. Grooving and drilling the faces of members can also allow drainage of water from inside joints where leakage may be present. The transfer of moisture from another porous medium (such as soil or concrete) to timber should be prevented. Joints should be designed to allow easy access for the application of maintenance treatments, especially on end grain surfaces. Where metal shoes or fittings are used to support the ends of members they should not enclose the member or encourage trapping of water (Figure 2.3). The best time to provide for protection against decay is during the design and construction of a structure. This has been learned through research on the habits and behaviour of the insects and other decaying organisms and through experience in their control.

There is often a severe decay hazard at the junction between exposed wooden decking and the supporting beams. This can be much reduced by the use of capping over the beams to deflect water from them (see Figure 2.2). If the capping is drip throated and grooved, it will be more effective. The capping timber should be of a durable species or pressure treated with preservative.

Foundations in Building

The most important need for protection in timber construction arises at the point of ground support. A ground level problem peculiar to the tropics and sub-tropics is the probability of attack by subterranean termites. The design must effectively isolate wood from the ground so that termite activity can be readily seen; it must also incorporate physical barriers such as termite shields. When constructing a building in an area where termites are a problem all foundations should be made as impervious as possible to prevent hidden attack on wood work alone. This is one of the most important protective measures which should be considered very carefully in all construction work. In the case of a permanent timber structure, it should as far as possible be isolated from the ground. This will most usually be done with a steel shoe, steel plate, steel posts or bars or with a concrete base (Figure 2.3).



Isolation of wood columns
from entrapping water
Figure 2.3

Some of the measures taken to establish resistance to penetration by termites in foundation construction in buildings are:

(a) by having concrete foundations properly reinforced to prevent large shrinkage or settlement cracks;

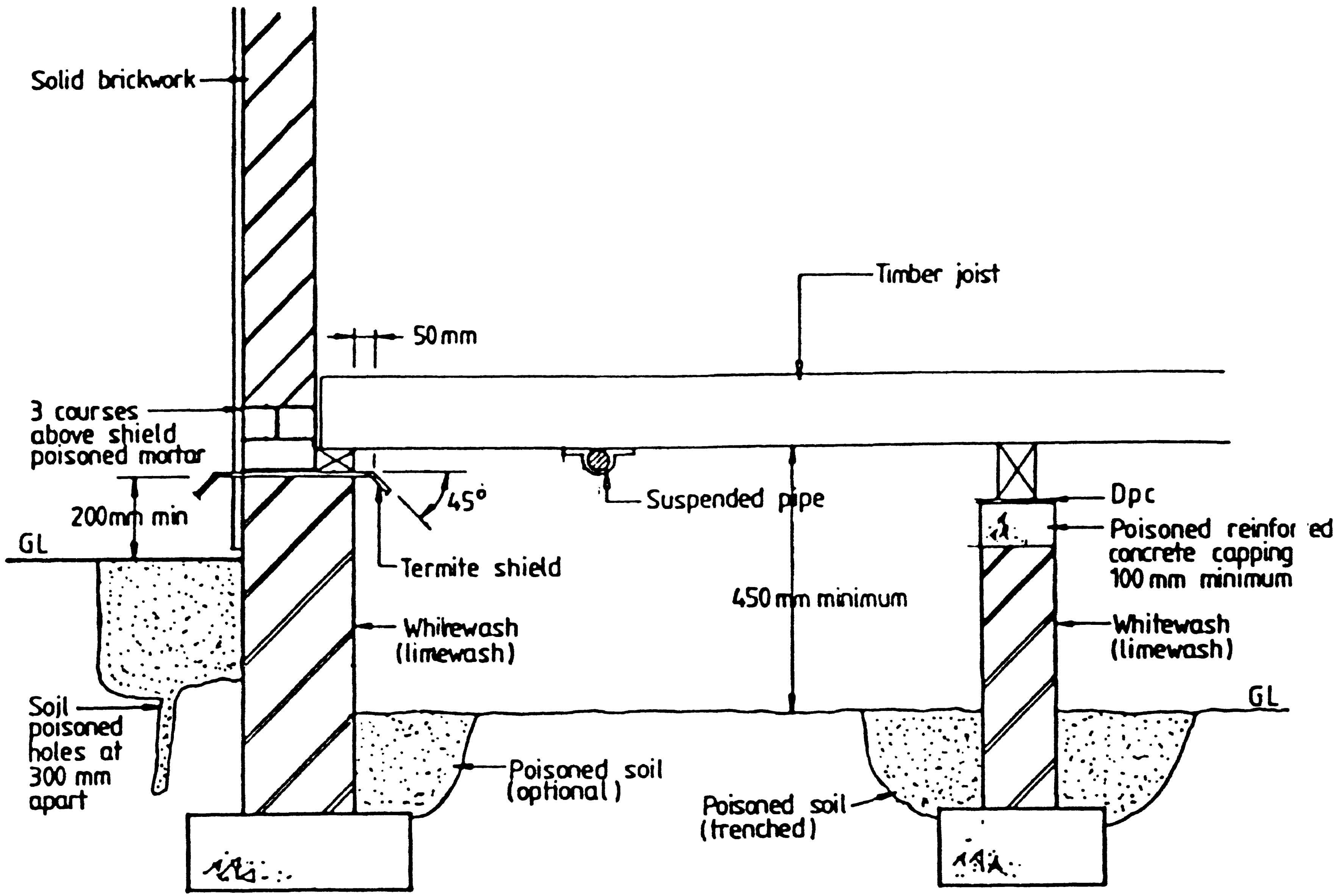
(b) by capping with a minimum of 100 mm of reinforced concrete on block or brick foundation or piers (Figure 2.4A);

(c) by having metal shields or caps where appropriate (Figure 2.4B). In the humid tropics termite shields are of copper sheet which also acts as a damp proof course. In less corrosive conditions galvanised steel or zinc sheet may be used with a conventional damp proof course below it to prevent corrosion. The mechanical barriers will prevent subterranean or soil termites from entering the building but they will not prevent attack by free flying pests such as powder post beetles and drywood termites. Infestation by such pests should be prevented either by using naturally resistant timbers or by pre-treating the timber with wood preservative.

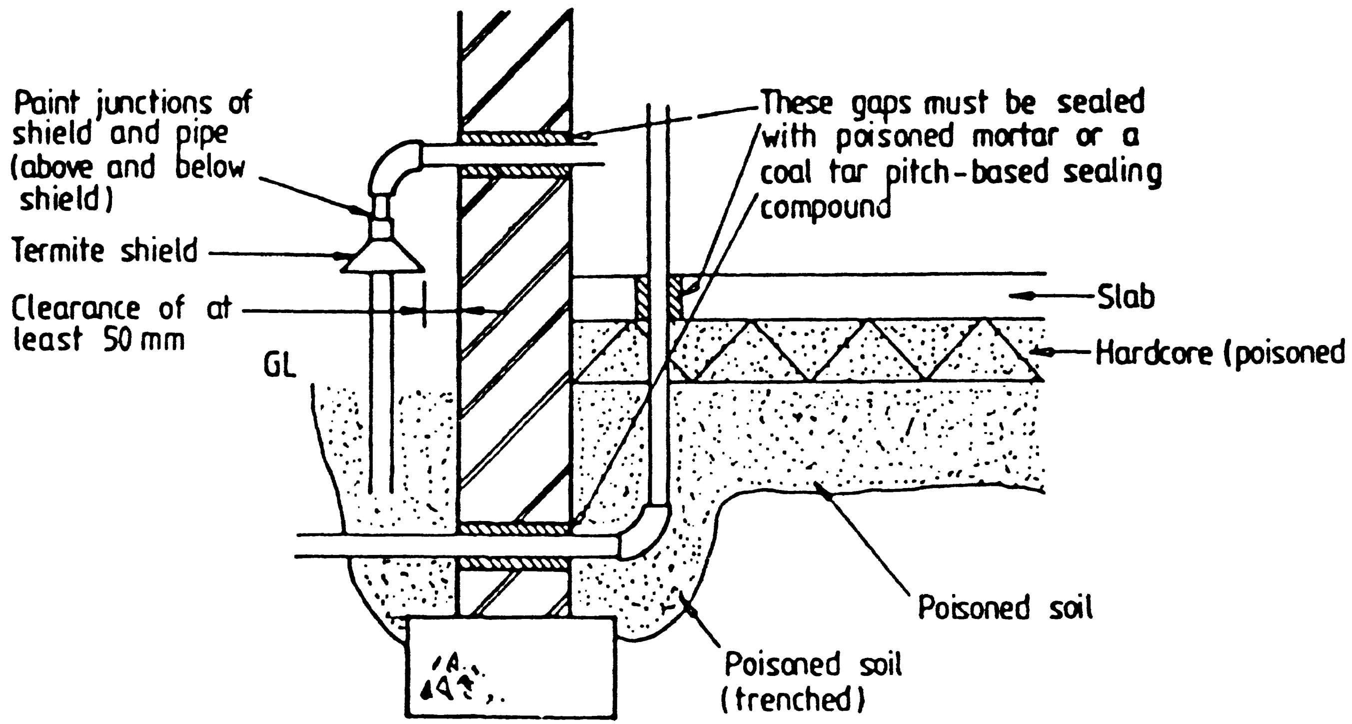
Contact of wood with soil

The houses built well above the ground is the safest in avoiding most of the decaying problems in wood. Ventilation openings in foundation walls beneath buildings of the above type should provide crawl spaces large enough and so distributed as to prevent dead-air pockets forming. These pockets give rise to humid conditions which favour termite activity and fungus formation.

Embedding wood in concrete near the soil is an invitation to decay. Wood posts resting on concrete floors should be protected from floor moisture by placing them on raised concrete bases (Figure 2.3) or by using treated or naturally durable wood. However use of such material is again a supplement to good construction practices. If a wooden floor is laid on a concrete slab, there should be a damp proof membrane on the slab (Figure 2.4A).


Solid brickwork
Timber joist
50mm
3 courses above shield poisoned mortar
200mm min
GL
45°
Suspended pipe
Dpc
Poisoned reinfor ed concrete capping 100 mm minimum
Termite shield
450 mm minimum
Whitewash (limewash)
Whitewash (limewash)
GL
Soil poisoned holes at 300 mm apart
Poisoned soil (optional)
Poisoned soil (trenched)

gure 2.4A



The use of metal barriers and poisoning techniques to prevent the entry of subterranean termites.
Figure 2.4B

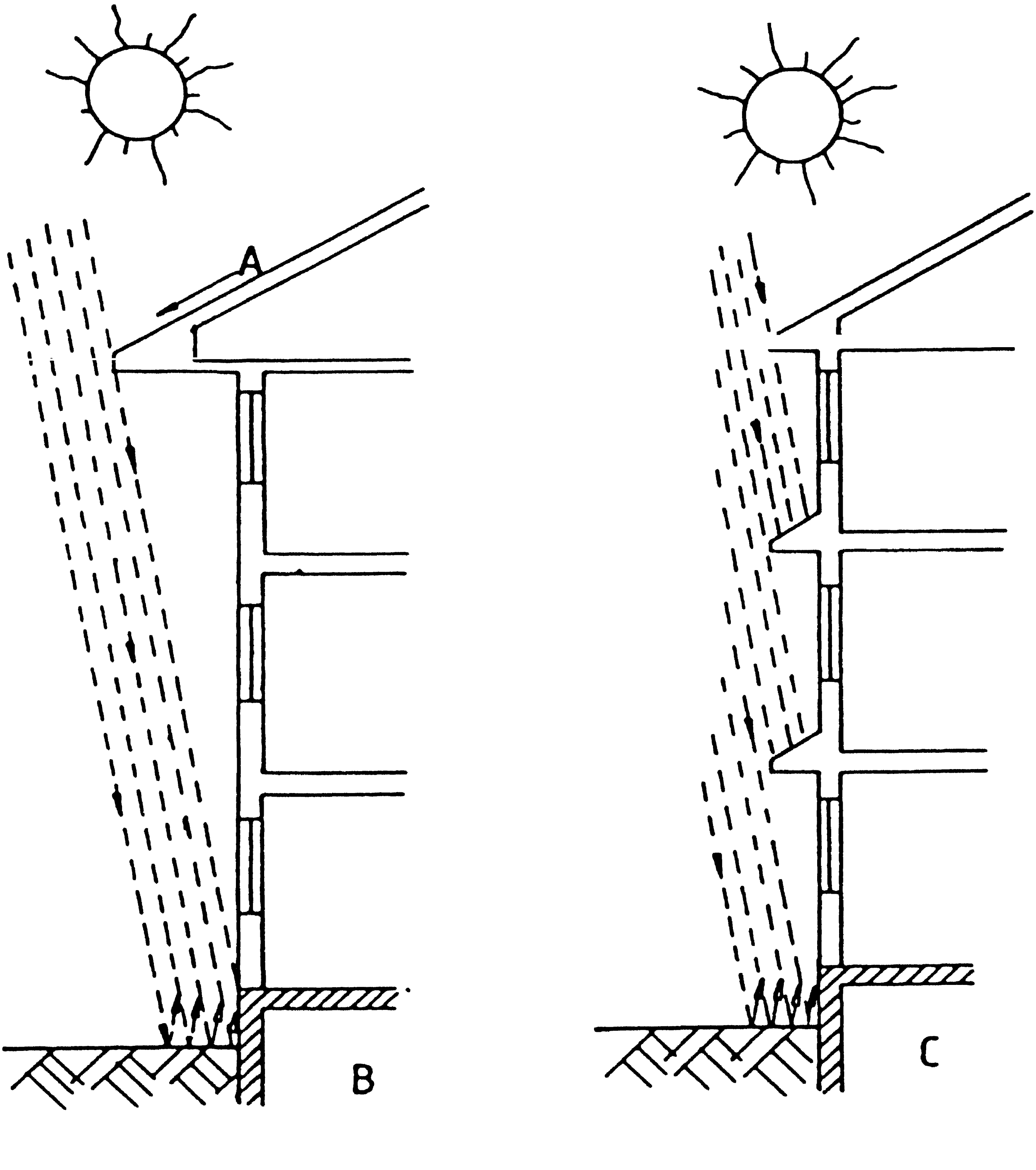
(Reproduced from Overseas Building Notes No. 170-BRE, UK)

Protection of new buildings

Whatever form of construction is adopted, it is essential that a building site is well drained; otherwise it would favour decaying organisms (such as termites, fungi, etc.). It is also advisable to clear the site of all wood, leaves and debris that could provide food for termites. Care should also be taken to ensure that none of the temporary timber used in construction is buried in the soil adjacent to the building. Soil poisoning is one way of producing a barrier through which it is difficult for termites to penetrate.

Eave overhang

Probably the most important example of protection by design is a large roof overhang or eaves. Roofs with considerable overhang, both at eaves and gable ends, give more protection to the rest of the house than those with narrow overhangs. In fact, a good roof overhang can markedly reduce decay hazards in external cladding and around windows and doors (Figure 2.5). In most climates, it virtually eliminates the flow of rain water over the wall, thus considerably reducing the decay in external joinery. Of greater consequence in the tropics is the shading from the direct sunlight which is afforded, thus avoiding high surface temperatures which may cause splitting and ultimately trapping of water. Roof overhand is not usually appropriate for buildings over two storeys high. It should however, still be possible to protect doors and windows to some extent by having a canopy above them. In high rainfall areas of the tropics, metal flashings may be used to protect woodwork when eaves and canopies are not considered appropriate. Direct nailing of metal flashings to wood should be avoided since there will be unequal expansion and contraction with consequent splitting and possibly the entrapment of water.



Protecting from sun and rain
Figure 2.5

Chapter 3

THE NATURE OF WOOD

Structure of Wood

Wood is derived from the boles or trunks of trees. It is formed in the growing tree by the accretion of rings of growth around the stem, which thus becomes thicker and thicker as it ages. These rings are more or less concentric layers, conspicuous in some timbers, known as growth rings or annual rings. In the temperate zone there is, as a rule, one such wood layer added during each season of growth. In tropical species growth rings are not always distinct.

In most species, growth rings can easily be distinguished from one another between earlywood and latewood, sometimes known as springwood and summerwood respectively.

Examined under the microscope, wood is seen to have a cellular structure, and to be composed of cells of various shapes and sizes which perform different functions in the tree.

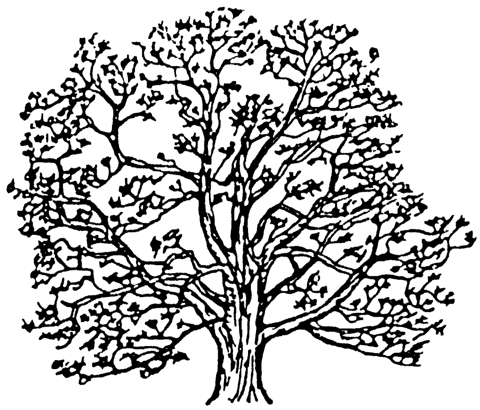
Classes of Wood

All woods can be grouped into two general classes and they are:

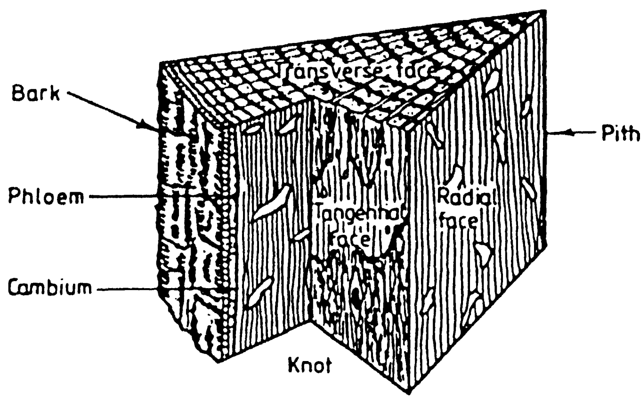
(a) hardwoods, which come from broad leaved trees (Fig. 3.1) and
(b) softwoods, or conifers (Fig. 3.2) which come from trees with needle-like leaves.

The terms hardwood and softwood are not descriptively exact, since some of the softwoods are harder than some of the hardwoods and the structure of the two classes of wood is fundamentally different. In softwoods the bulk of the wood is composed of small, regular fibrous cells called tracheids. These serve the combined purpose of conducting sap from the roots to the leaves and giving strength to the wood. Where these are in contact with each other they are provided with small perforations, known as pits, which can act like valves controlling the flow of the sap.

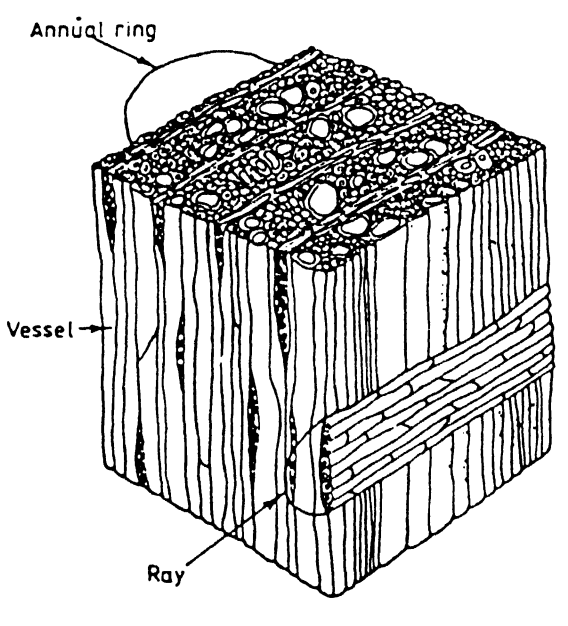
HARDWOODS

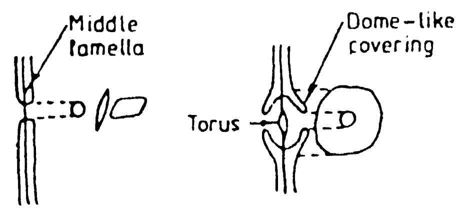


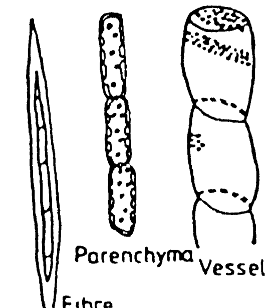
Trees with broad leaves



Wedge shaped segment







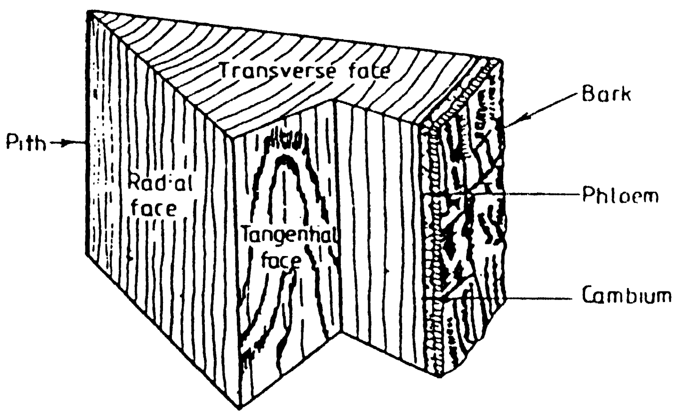
Hardwood cells

Simplified structure of a hardwood (magnified)

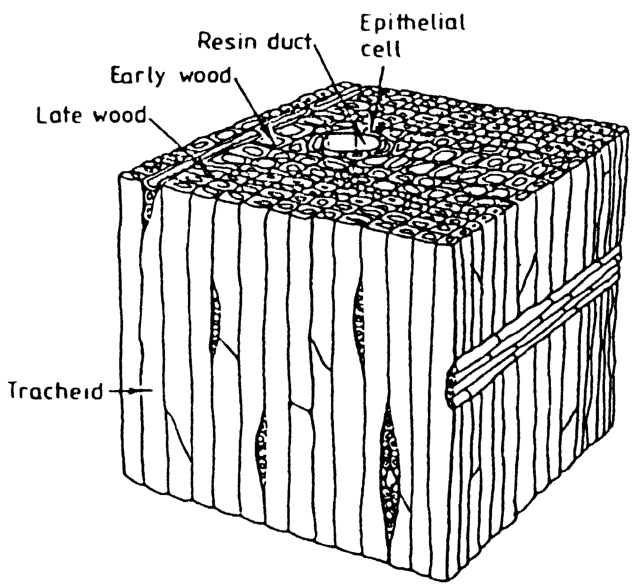
Figure 3.1

SOFTWOODS

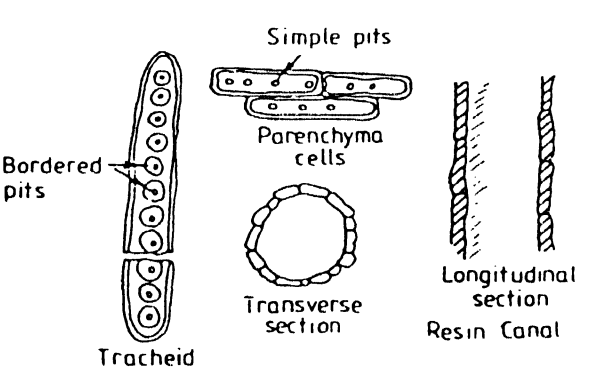
Conifers



Wedge shaped segment



Simplified structure of softwood (magnified)



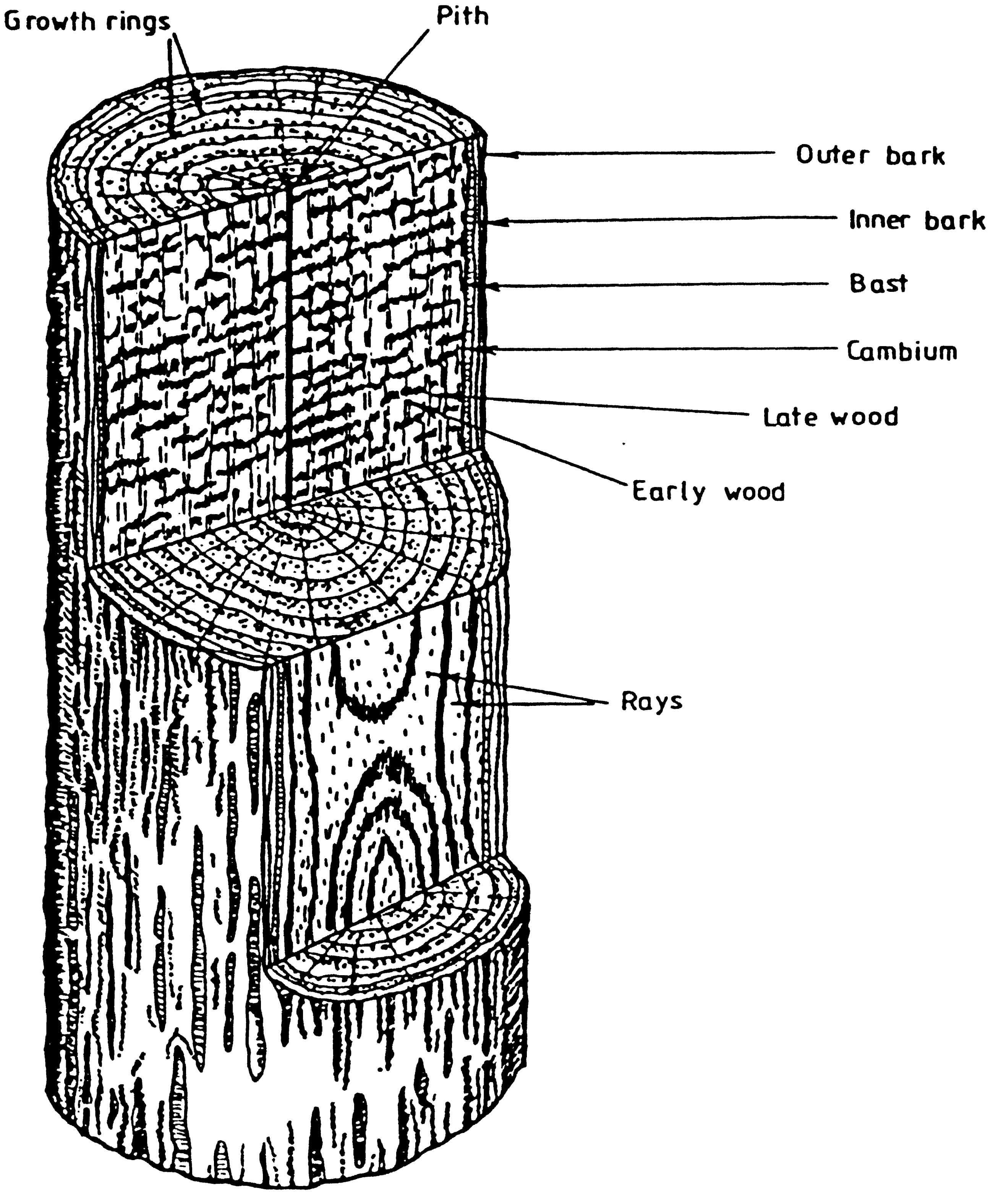
Softwood cells

Figure 3·2

Hardwoods differ from softwoods in having larger cells as pores scattered among small ones which are mostly strength giving fibres. The latter are so small that they cannot be readily distinguished individually without a hand lens. In many hardwoods the pores can be distinctly seen without magnification, as small holes on smoothly cut cross sections and as fine lines on planed longitudinal surfaces.

In both classes of timber reserves of food are stored in the so-called rays which consist of lines or "walls" of brick shaped cells that form ribbons of tissue running from the centre to the bark. A transverse or cross section of a stem is shown in Figure 3.3. The outermost layer is the bark which serves to protect the tree from injury, drying, etc. Between the bark and the wood is the cambium in which the cells actually grow and divide. The outer cylinder of wood is the sapwood which takes part in food storage and conduction of sap. Depending on various factors such as the species and the rate of growth of the tree the sapwood may be from a few millimeters to several centimeters wide. The central core of the trunk is the heartwood which is normally dark coloured. In the centre of the heartwood cylinder is the pith. As new rings of growth are added onto the outside rim of the sapwood the inner rings of the sapwood change into heartwood. As the living cells of the sapwood die, they are converted into substances such as tannins which usually lead to a darkening in colour of the wood, and generally increase its resistance to fungal and insect attack.

The presence and amount of sapwood is of great importance in relation to the need for wood preservation for two reasons: Firstly, sapwood of practically all trees is readily attacked by fungal decay and wood boring insects. Secondly, sapwood, which in the living tree provides the path for the flow of sap, remains permeable to liquids even after the timber has been seasoned. This means that in practice, sapwood can easily be impregnated with a preservative. The cells of the heartwood of many trees become so choked with gummy materials, and the vessels so blocked with the outgrowths which are called tyloses that no liquid can pass through them.



Section of a tree stem

Figure 3·3

Moisture Content

The moisture content of wood is the amount of water present in it expressed as a percentage of its oven dry weight. This means that a piece of wood which is one-half dry wood fibre and one-half moisture, has a moisture content of 100 percent. Green timber therefore can have moisture content well over 100 percent. It may be determined in several ways but two methods have become established as standard practice. They are the oven drying method and the moisture meter method. The oven drying method involves cutting samples from the wood to be tested, weighing the cut samples, drying them at a temperature of 101 - 105 degrees C and reweighing (Fig. 3.4). The moisture content is then calculated from the formula:

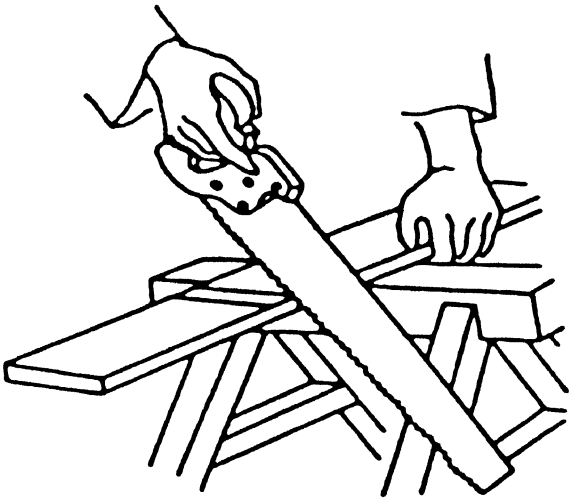
$$\frac{\text{Initial weight} - \text{Final weight}}{\text{Final weight}} \times 100 = \text{Moisture content (\%)}$$

A moisture meter uses variations in electrical resistance to measure moisture content.

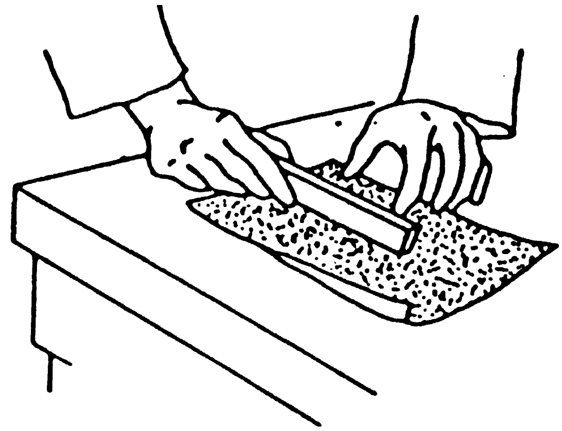
In the sapwood of a healthy tree all the cells are full of sap and the wood may contain more than its own weight of water. If the timber is to be impregnated with a preservative solution, it is absolutely essential that the timber should be seasoned so as to remove all the water in the cells to make room for the preservative. The best way of treating green, unseasoned timber with preservative is by one of the diffusion or sap replacement methods which will be dealt with later. Many of the failures through premature decay of treated timber can be attributed to the fact that the timber was not sufficiently seasoned before it was treated. A moisture content of around 25 percent is quite suitable for treatment by impregnation, while a somewhat lower moisture content may be desirable for timber that is to be treated by surface applications of preservative.

Natural durability

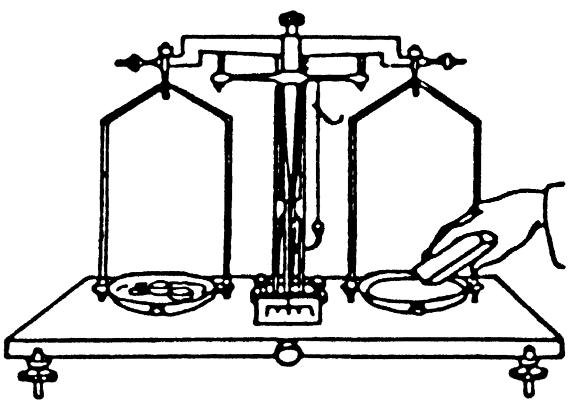
Durability or natural resistance to decay, is extremely variable. Certain kinds of timber are noted for their resistance to fungus attack and are commonly recommended for use where untreated material is to be placed in contact with the ground or in other exposed situations. Some species are considered more or less



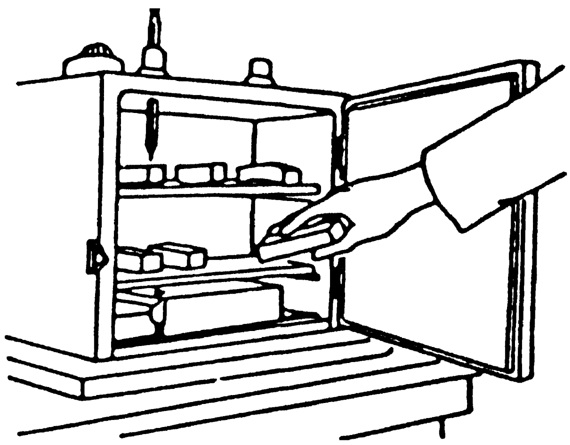
1. Cut a section



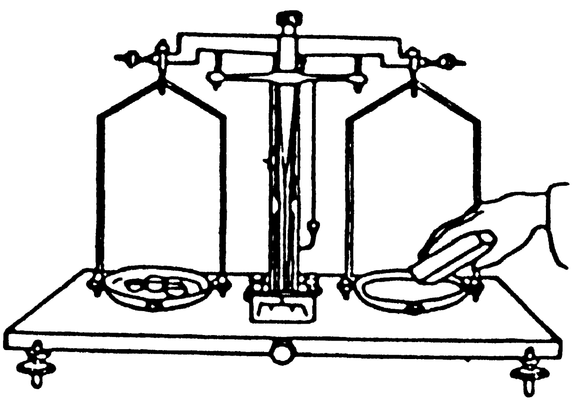
2. Scrape the section



3. Weigh the section



4. Place section in oven



5. Reweigh after 24 hours and repeat at four hour intervals till a constant weight is obtained

Determination of moisture content

Figure 3·4

intermediate in durability while others are readily susceptible to deterioration. However even with a given species of wood, there is likely to be a marked diversity in decay resistance. The factors responsible for the differences in durability are numerous and diverse, some of them relating to conditions within the wood itself, others with circumstances attending its use.

The sapwood of almost all woods is readily susceptible to decay where as the heartwood of many woods is resistant to such deterioration. The greater natural durability of heartwood over sapwood is attributed primarily to certain chemical changes that take place when and after the sapwood is transferred to heartwood. During this transformation, it is considered that tannins and other coloured substances are deposited in the food storing and distributing cells (called parenchyma cells). Generally the higher the proportion of extractives, the greater the durability and darker the colour of the heartwood. However, light coloured heartwood does not necessarily denote a lack of durability. It is clear from what has been said earlier, that precise comparison of the durability of timbers is difficult. Classification of timbers on the basis of durability relies on the knowledge of their service performance and the results of scientific tests. Appendix 1 lists the durability rating of a wide range of timbers, both softwoods and hardwoods.

Chapter 4

DECAY HAZARDS

The main causes of timber deterioration are fungi, insects, mechanical failure, fire and weathering.

Fungi

In order to understand the need for timber preservation one must know something about the nature of the fungi responsible for wood decay and the conditions under which they flourish. It is important to realise that fungal decay may be proceeding quite rapidly in timber on which no signs of fungal growth are visible. Fungi are a form of plant life characterised by the fact that unlike other plants they do not possess Chlorophyll and hence cannot produce their own food. This means that they must live on the food produced by other plants or animals either living or dead, wood destroying fungi belong to the latter group. Fungi reproduce by means of very minute spores and air contains quite a number of fungal spores and if wood is in a condition favouring colonisation by fungi, it will almost certainly be colonised in a very short time. The spores of fungi, which fulfil the function of seeds, are extremely minute, and are individually invisible to the naked eye. On germination these spores give rise to extremely fine threads, known as hyphae, which permeate the wood and can easily be seen under the microscope. Under very damp conditions, as in an unventilated cellar, these hyphae may proliferate on the surface of the decaying wood, and give rise to a visible mass of growth which is known as mycelium. After a fungus has been growing in the wood for a considerable time, it usually forms, on the surface of wood, a fruiting body which bears the reproduction cells or spores. There are very many species of fungi which cause decay in wood or wood products. The differences in the nature of the damage are usually due to the action of different species of fungi, so the species responsible may be identified from the type of damage caused.

Advanced stages of fungal decay are recognised by a brittle nature and a colour change in the decayed wood. In the early stages decay is not easy to recognise. Even incipient decay causes loss of strength and is usually accompanied by change of colour. As decay proceeds wood substance is used up by the fungi and the wood becomes lighter in weight and begins to shrink. Timber where decay has started is softer than normal wood and this can be tested with a pen knife. The point of the pen knife should be inserted into the wood and a splinter prised up. A long splinter can never be prised up in decayed wood and if this does not happen it is positive evidence that the timber is sound. However, there are some short fibred trees with interlocked grain where it is not possible to prise up a splinter even in sound wood.

Closely allied to the wood destroying fungi, there are other fungi which give rise to definite discolourations in wood without noticeably affecting the strength and the texture of the material. There are a number of wood staining fungi producing a wide range of colour effects but by far the most important is the blue stain or sapstain. In general, it may be said that blue stain should not be considered as a serious defect in material used for ordinary construction purposes.

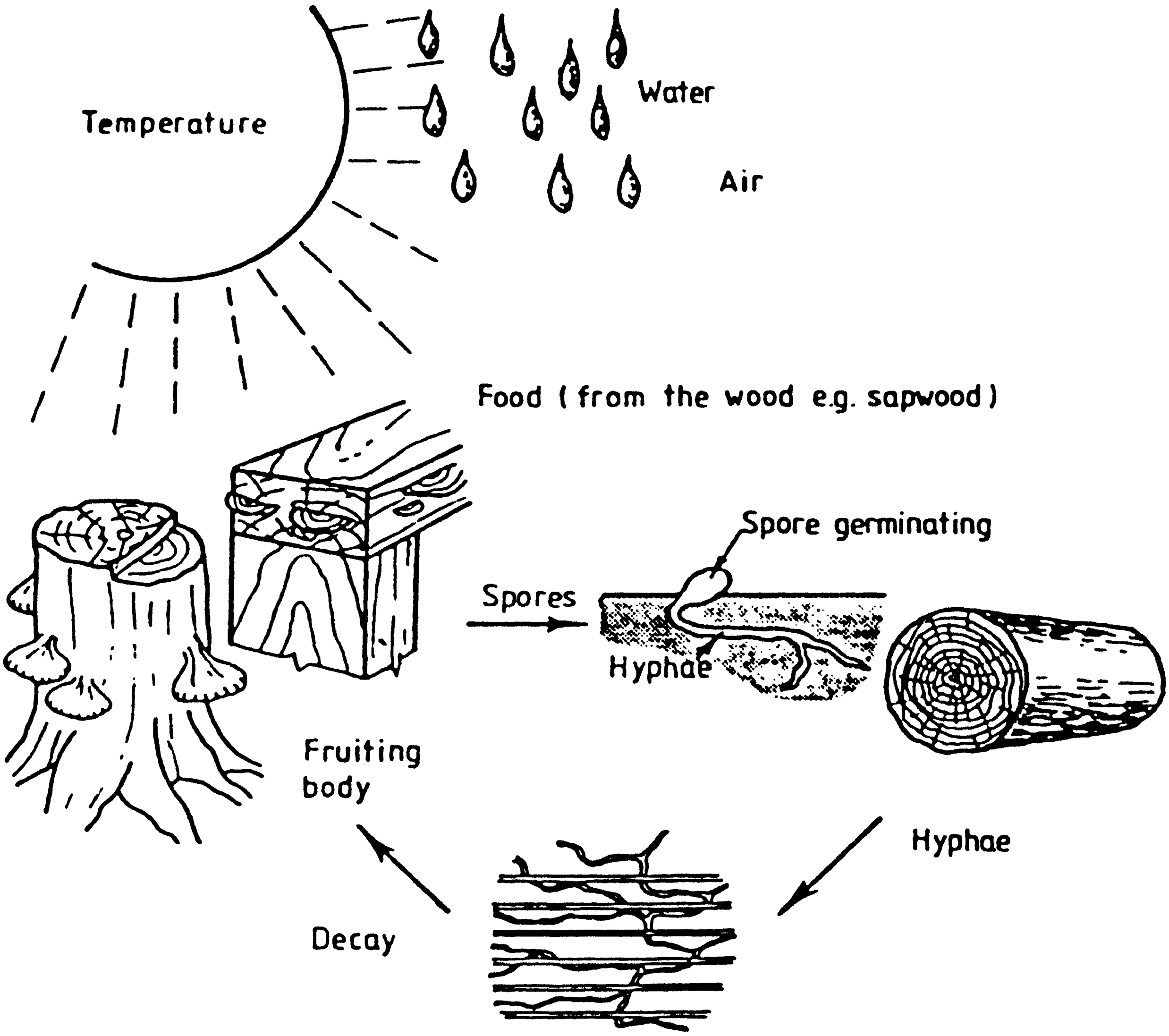
Decay Requirements

The conditions necessary for the development of decay producing fungi in wood are (Fig. 4.1):

- a suitable substrate or a suitable supply of food
- adequate moisture
- a favourable temperature
- adequate supply of air or oxygen

A deficiency in any of these requirements will inhibit the growth of a fungus, even though it may already be well established in the wood. The food required for the nourishment of a wood destroying fungus is supplied chiefly by the actual wood substance. Few, if any, of the decay producing fungi are able to attack all kinds of wood indiscriminately, presumably because of dissimilarities in the chemical composition of different woods.

A supply of air is necessary for the growth of wood destroying fungi, but their demands in this respect are very moderate and under ordinary conditions the amount within and surrounding wood in service or in storage is ample. Wood, therefore, can be kept in a sound condition for a long time if it is submerged under water or immersed in an impermeable clay.



Fungi in wood (growth requirements)

Figure 4·1

Temperature has an important effect on the growth of fungi, the optimum temperatures reported being between 20 and 32 degrees C.. While cold temperatures check the growth of all fungi in wood, freezing does not actually kill fungi in wood, and they soon become active again when the wood thaws out. On the other hand, most of them are soon killed by exposure to high temperatures, and a convenient way of sterilising infected timber is to heat it in a timber drying kiln.

One of the conditions necessary for the development of fungi which are responsible for wood decay is the availability of a sufficient degree of moisture in the wood. While the individual fungi show considerable variation in their precise moisture requirements, it is recognized that a moisture content above the fibre saturation point of wood is required for the development of most of them. At that point, which occurs within the limits of 25 and 30 percent moisture content in most woods, fungal growth is greatly retarded, and below 20 percent it is completely inhibited. Consequently, sound wood that has been kiln dried or thoroughly air dried is immune to decay unless subjected to wetting or to dampness sufficient to raise its moisture content above the required minimum. Moreover, if wood in which decay is already established is dried to a moisture content below 20 percent, the development of the fungus will be arrested. There is also an upper limit to the moisture in wood beyond which fungi will not grow. The upper limit unlike the lower limit is variable and may be as high as 150 to 200 percent. Decay is usually found in wood that is in direct contact with damp ground or in locations where moisture collects and cannot readily evaporate. The ground line of posts and poles, sills placed on the ground, the ends of beams built into masonry piers or exterior walls are examples of locations where decay normally starts.

Insects

Several different groups of insects attack timber and without knowledge of the biology of these groups of insects effective measures for protection cannot be undertaken. Therefore in this manual a brief discussion of the life styles of the most important insects is undertaken. One could classify the insects in a number of different ways such as:

by the natural orders (scientific) to which they belong, beetles, termites, moths, etc.

- according to the stage at which they attack the wood - as trees, logs, timber in service, etc.

- according to their mode of nutrition - such as starch feeders, fungus feeders, etc.

Nearly all the insects that cause serious damage to timber belong to one or the other of the two orders or classes:

Coleoptera - the beetles and
Isoptera - the termites

From the aspect of wood preservation it is most convenient to consider insects according to the stage at which they attack the wood, however protection against termites presents many special problems as they are able to attack the timber at any stage. In many tropical countries, they cause untold damage to all kinds of timber structures.

Ambrosia beetles

Of the insects which attack freshly felled logs, the pin hole borers or Ambrosia beetles are a more serious problem in the tropics than they are in temperate countries. They are characterised by their peculiar form of feeding. They do not derive any nourishment from the wood itself but feed on certain moulds which grow on the walls of the tunnels which they make in the wood. Since these moulds can grow only in unseasoned timber, it follows that the beetles themselves cannot breed or survive for long in seasoned timber. What is of importance in the life history of Ambrosia beetles is that neither the adults nor the larvae eat the wood. Therefore the preservative chemical required to control these beetles should be of a contact poison and not of a stomach type.

When the beetles are active, their attack may be recognised by the fact that only fresh logs are attacked, by the roundness of the hole, by the size ('pin hole') and by the powdery frass that is ejected from the tunnels, sometimes in short strings. In dry or converted timber, damage by Ambrosia beetles is recognised by the black staining of the tunnels which is caused by the fungus. The fungus does not destroy the wood but only lives on the starch and sugars of the sapwood.

Power Post Beetles

These beetles are so named because of the powdery frass caused by the adults boring into the wood. They are capable of attacking comparatively dry timber but the attack is confined to the sapwood because starch appears to be an essential element in their diet. Well air seasoned timber is not attacked by by these beetles. There are a number of insects that produce so called "powder post" defects in wood. The larvae or grubs of these insects bore through the wood for food and shelter, leaving the undigested parts of the material in the form of a fine powder. When an infected piece is moved around, this powdery residue falls out of holes made in the wood surface by winged adults as they emerged to spread the infestation. The most important of the powder post beetles are the LYCTUS beetles and the BOSTRYCHIDS. For Lyctus larvae, starch is the principal food substance and therefore the liability of wood to attack is determined by its starch content. These beetles attack only those hardwoods in which the pores (vessels) are of sufficient diameter to receive their eggs. The females lay their eggs within the pores and the larvae bore tunnels freely in the sapwood and may eventually reduce it to powder. However they usually leave a thin surface skin of wood intact which means that infestation may not be detected until mature beetles make their exit holes. Heartwood is not normally attacked though mature beetles may tunnel through it. The bore dust made by these beetles is extremely fine, almost like flour, and is left on the surface of wood in which larvae are actively working.

In the case of the Bostrychids, the female lays her eggs on the rough surfaces of timber or in short tunnels bored into the timber. Some of the Bostrychids bore extensive tunnel systems at the time of egg laying and frass is ejected as a fine powder. Considerable damage can be done to the wood in this way even before the lavae hatch out. When the eggs hatch out, the larvae bore into the wood, making galleries parallel to the axis of the wood. The larvae pupate at the ends of the galleries and the adults emerge by boring out an emergence hole and this may be through heartwood. Emerging adults cause holes to appear in the wood long after it is too dry for new colonisation.

Carpenter Bees

These are not a very common type of pest in buildings but when they do occur they continue for generations in the same timber and complete destruction may be caused. Generally attack is confined to exposed timber hence attack is noticed as soon as it starts. The carpenter bees construct tunnels of which partitions with cells are made of wood dust mixed with saliva. In each cell an egg is laid and provided with a pollen or bee-bread. The larva feeds on this bee-bread for about three weeks and pupates in the cell. After three further weeks the adult bee emerges by gnawing its way out of the wood. With such a short life cycle, severe damage can occur in a short time.

Common Furniture Beetles

This beetle which is called "Anobium punctatum" is normally found in temperate climates. They are small, dark brown beetles which emerge during the summer months and fly quite actively, particularly on warm days. After mating, the female beetle lays her eggs on exposed rough surfaces of wood. After four to five weeks, the eggs hatch and the young larvae penetrate into the wood. There they may spend three years or longer, tunnelling and growing in size, until they pupate and finally emerge as adult beetles through exit holes. Each of the holes that can be seen on infected wood indicates the place a beetle has emerged. These beetles do not bore again into the wood.

The Death Watch Beetle

These beetles are normally found in temperate climates. It is primarily a pest of timbers in old buildings in which damp has been allowed to reach the woodwork. The tapping sound which the adults make in spring and early summer is probably a mating call. The eggs are laid in cracks and crevices on exposed wooden surfaces and the larvae make tunnels in the wood where they remain for a number of years depending on how favourable conditions are for their development. Their final size is similar to or slighly larger than that of the adult beetles. After pupation the beetles emerge through exit holes. Prevention of attack by these beetles depends primarily then, on adequate protection of the timber against the woodwork becoming damp.

Longhorn Beetles

In most cases these beetles commence their attack on living trees. Eggs are laid in the bark and larvae bore tunnels into wood parallel to the long axis of the tree. These larvae may persist in the wood after the tree is felled because they are tolerant to dry conditions. One or two of the species in this group of beetles are capable of initiating attack on seasoned wood but they do not usually do so. Attack by longhorn beetles can usually be recognised by the fact that their larval tunnels are much larger and elliptical in cross section, instead of circular as from other beetles. Longhorn beetles are usually larger than other wood borers.

Termites

Termites are social insects living in large colonies and they are classed into two main groups - ground dwelling (subterranean) termites and drywood termites.

Ground Dwelling Termites

Ground dwelling or subterranean termites are, by nature, soil inhabiting and enter wood from the ground. They require a constant supply of moisture for their existence and provide access to the soil by their internal workings in the wood or by means of covered surface runaways or shelter tubes. The runaways and towers, are constructed of tiny fragments of earth and partly digested wood cemented together by insect secretions. These enable the termites to establish suitable moisture conditions in wood that would otherwise be so dry as to be immune to their attacks. They can severely damage timbers in contact with the ground and may extend attack to the roof timbers of high buildings. To reach such timbers they may travel through cracks in cement or brickwork or build runaways over the surface of various materials. These termites always avoid the light and conceal themselves in the wood or their runaways. The presence of subterranean termites in a building or other structure may not be discovered until the more seriously attacked pieces of wood begin to show definite evidence of failure. On the other hand, there are certain signs, such as the occurence of the earthlike runaways over brick, stone and concrete foundations. Certain characteristics of the galleries of these insects serve to distinguish them from the workings of the dry-wood termites. These are the oval discoloured spots made on the gallery walls by the deposition of drops of liquid feces and the peculiar frass with which the insects wall up some of their cavities or plug up unused passages. Damage by subterranean species above ground level may be prevented by ensuring that all means of access are eliminated. It should also be noted that ground dwelling termites will die if they are denied access to their underground home. Thus, if these termites have entered a building through outside galleries it is sufficient to break the galleries and prevent their reformation to kill all the termites in the building.

Drywood Termites

The insects of this group are distinct from the subterranean termites in that they are entirely wood inhabiting, never entering the ground. At the time of swarming, they gain entrance to sound dry wood directly from the air. They look for a check, crack or other small natural opening in the wood, or a crevice in the building and begin to make tunnels into the timber quickly plugging up the entrance with particles of chewed wood. In excavating their galleries, the drywood termites form tiny fecal pellets, which are occasionally discharged through holes temporarily opened up for the purpose in the protective outer shell of wood. The accumulation of these charateristic pellets at the base of, or under, the structures in which the insects are working, provides a definite indication of the presence of termites. Drywood termites are able to work in wood of fairly low moisture content, consequently may be found in thoroughly seasoned timbers and the woodwork in upper parts of buildings as well as in more moist material. The drywood termite is a much more insidious operator. Since it does not leave the wood except to swarm, external evidence of its presence is only the small, hard pellets which are excreted by it. If this cannot be seen for any reason, its activities may continue unsuspected till virtual destruction of the timber. The colonies are, however, much smaller than those of subterranean termites and hence the process of destruction is slower.

Marine Borers

The destruction of wood in the sea is mainly due to the activity of marine borers which are widely distributed throughout most parts of the world although more prevalent and destructive in the warm regions rather than the cold ones.

Marine borers are of two types - **SHIPWORMS** (bivalve molluscus) and **GRIBBLE** (small crustaceans). Although there are a number of marine fungi which can cause slow superficial decay of timber, these are of minor importance, except in so far as they pave the way for the borer attack.

Shipworms

The shipworms known as Teredo are the most destructive of the marine borers. They start life as tiny free swimming larvae which appear to be attracted to wood on which they soon settle down and begin to bore. The larvae soon change into the adult form, the shell altering to become an efficient cutting tool, instead of a protective coating, and the body becoming long and wormlike - hence the name shipworm. Two tubes through which the animal can circulate water around its body, project a short way out in the water from a small hole in the wood. It can withdraw these tubes and thus close the opening, thereby retaining water in the burrow and enabling it to survive quite long exposures to air. As it grows, the diameter of the burrow enlarges. The tunnels twist and turn (never actually crossing) until finally the wood may become riddled with holes, although the surface remains practically intact. The damage they cause is somewhat sporadic and its intensity seems to depend mainly on the temperature of the water. In warm water they can cause surprisingly rapid damage. They cannot live in fresh water but they can survive in blackish water if it is saltish.

Gribble

Gribble is the crustacean type of wood borer. It makes its burrows on the surface of the wood so that the damage it causes is always obvious. Its attack is most severe about low water level. The damage done by this group of marine borers is less spectacular and serious than that caused by the shipworms, not only because it is more evident to inspection but also owing to the fact that the excavation of wood proceeds less rapidly.

Weathering

Any unprotected wood exposed to alternate wetting and rapid drying will soon suffer deterioration at the affected surfaces, which swell and shrink in response to moisture changes and develop case hardening, checking, and lifting of the grain. Exposed surfaces absorb moisture very quickly in a damp atmosphere or during wet weather,and they swell up before the corresponding change takes place in the interior of the wood. Thus stress developed between the surface layers and the deep layers lead to splits and checks and eventually to the disintegration of the whole surface. Freezing of water in the pores of the wood will also assist in this breaking up of the surface layers, and so will the abrasive action of windblown sand and chemical changes induced by ultraviolet radiation.

Woods vary considerably in their susceptibility to weathering influences. Close grained dense woods containing a fair proportion of resin, or gummy materials that check the absorption and loss of water, resist weathering much better than porous open grained wood.

Fire

Timbers vary greatly in the ease with which they can be ignited, and in the rate at which they will burn. Despite its combustibility, wood posseses excellent fire resistance. In general, dense, heavy hardwoods are more resistant to burning than light, resinous softwoods. While wood is combustible, the rate of combustion of different timbers varies greatly. Combustion cannot occur in the absence of oxygen (or air) so that wooden members of large section, burn only slowly at their surface, which then progressively charrs to form charcoal on the surface, inhibiting the lower layers and demanding on extra heat supply for burning to continue. This insulating effect helps to explain why heavy timber posts and beams survive in fire. Fire resistance in many instances could be achieved in a building by using an adequate thickness of wood in construction and taking precautions which will stop the fire penetrating through a partition or a fire barrier. The resistance to fire of wood and wood products can be greatly increased by treatment with certain chemicals. Fire retardant chemicals and their method of application are discussed later in this manual.

Chapter 5

WOOD PRESERVATIVES

Wood preservatives are chemical substances which, when initially applied to wood, make it resistant to attack by decaying agents. The protective effect is achieved by making the wood poisonous or repellent to the organisms that would otherwise attack it. Preservatives vary widely in character, cost, effectiveness and suitability for use under different conditions of service.

Among the requirements of an effective wood preservative, the following characteristics are the most important:

- high toxicity towards wood destroying organisms;
- permanance in the treated wood (non leachable);
- ability to penetrate deeply into the wood;
- harmless to wood;
- non corrosive to metals which come into contact with the treated wood;
- odourless, colourless, paintable, glueable, non smelling and moisture repelling;
- cheap and plentiful.

There is no one ideal preservative suitable for use on every kind of wood in every sort of situation. For any particular purpose the choice is often limited and sometimes there is only one that is wholly suitable for a particular job. The effectiveness of a preservative depends primarily upon its toxicity, or its ability to make the wood poisonous to the organisms that feed upon it or enter it to obtain shelter.

In deciding what preservative to apply, thought must be given to any special requirements imposed by the situation in which the treated wood will be used. For instance, resistance of the preservative to leaching will be of prime importance on timber used in the open where it will be exposed to the rain. For timber to be used in the vicinity of food stuffs the absence of any odour will be essential. Where the fire risk is serious a non flammable preservative that can be combined with a fire retardant is desirable and so on.

Wood preservatives are commonly classified into four main groups:

(a) the oily type such as creosote
(b) the organic solvent type
(c) the non-fixed water soluble type
(d) the fixed water soluble type

<u>Tar Oils</u>

Coal tar, a product of the distillation of coal, was originally used as a wood preservative, but the lighter creosote fraction of coal tar was adopted with the introduction of pressure impregnation as its lower viscosity improved penetration. Creosote is a brownish-black, oily liquid that comes from the tar produced during the distillation or the carbonisation of bituminous coal. The oils produced vary somewhat in composition, but variations are allowable without loss of value for preservation processes.

Provided that creosote oil is deeply and evenly introduced into the wood in sufficient quantity, there is an assurance of good protection from borers, termites, decay and marine organisms. It is convenient to use in a number of processes, its depth of penetration is clearly visible, it does not easily leach out or evaporate from the wood. Resistance to leaching is mainly due to the insolubility of creosote in water. In addition impregnation with creosote provides extra protection against moisture content changes, so that treated wood is stable and very resistant to splitting. It is not normally corrosive to metals and has a high electrical resistance. Creosote possesses a variety of advantageous properties, which are not readily present in alternative preservatives. However, it has its single disadvantage that treatments are relatively dirty. This happens especially when bleeding of creosote from the treated wood occurs. Therefore, there are some applications where creosote treatment is not desirable, for example, in containers and packages where food stuffs are stored. Creosote is unsuitable for timbers which are to be painted. Wood freshly treated with creosote is more flammable than when untreated, but after the more volatile fractions have evaporated, it is more difficult to ignite than untreated wood. Once a fire is established, creosoted wood burns more strongly and gives off more smoke than untreated wood.

Creosote Mixtures

In order to economize where the cost of creosote is high, or where absorption is heavy and cannot be satisfactorily controlled, it is diluted with a cheap petroleum oil. This often allows better distribution of creosote without unduly increasing the initial cost. Addition of 2% pentachlorophenol to creosote treatment eliminates the problem of decay due to the fungus called Lentinus lepedeus in creosoted wood. It has been found that one way to protect creosoted wood from termite attack in some parts of the world is the addition of a small amount of arsenic trioxide.

Choice of Method of Application

Creosote oils are usually applied using pressure treatment processes (which are discussed in Chapter 8) such as the empty-cell process or full-cell process. After treatment, surplus creosote comes out onto the surface of the treated wood, especially when exposed to the rain. This phenomenon is called bleeding.

Pressure creosoting is recommended where timber comes into contact with the ground, water or sea. If pressure treatment is not possible the next best method is the open touch or the hot and cold method.

Surface application of a suitable grade of creosote by thorough brushing or spraying will give a fair degree of protection to thin material which is not in contact with the ground such as weather boarding and palings. It is also a convenient way of treating timbers which can be retreated by further applications after a certain number of years.

Wall plates and the ends of joists and rafters are often brushed with creosote before being built into a house. This certainly gives them some protection against infection during the critical period when there is still moisture in the new brickwork. However, such superficial treatment cannot be relied upon to give really permanent protection, especially as it is impossible to repeat the treatment on such timbers, which once built into the walls become inaccessible.

Water Borne Preservatives

Water borne preservatives are the soluble salts of some metallic salts. There are two types of water borne preservatives; salts which do not get fixed and leach out of the treated wood and salts which get fixed and do not leach out of the treated wood.

The Non Fixed Water Soluble Type

Among the water soluble non fixed wood preservatives are borax and boric acid, sodium pentachlorophenate, copper sulphate, mercuric chloride, sodium flouride and zinc sulphate. However, most commonly used are the boron compounds, which are applied by the dip diffusion method. Although they are highly effective against fungi and insects, boron preservatives are not fixed, hence wood treated with boron salts cannot be used in contact with the ground or in other wet conditions. The preservatives are, however, well suited to the treatment of timber for use above ground in buildings.

The Fixed Water Soluble Type

The fixed water soluble type intended mainly for external use contains salts which service to fix the preservative chemicals in the wood and render them non leachable. The most prolonged and effective protection has been achieved by the use of carefully balanced mixtures of copper, chromium and arsenic salts, commonly called CCA. Wood treated with these salts (CCA) has been shown to remain unaffected by fungal decay or insect attack over long periods, even under very severe conditions of exposure, such as slats in water cooling towers. CCA salts are available in different forms as dry mixtures of crystalline powders, pastes of liquid concentrates. This variety of products has arisen from differences in the raw materials available in various manufacturing countries, safety considerations and transport requirements. Pastes and concentrates have several advantages over dry mixtures. It is far easier to make up a working strength solution from them at the treatment plant. During the mixing of powders, dust can be produced which may be a health hazard to plant operators. Pastes with their high viscosity, also have the characteristic that cracks or other container faults do not lead to widespread leakage. Unlike dry mixtures, they do not harden and become solid blocks. CCA salts are diluted with water to make up to the required concentration; these solutions are odourless and normally non corrosive to metals; it normally comes into contact with and are chemically stable at normal temperatures. However, they should be protected from temperatures above 50 degrees C. for prolonged periods, as this could produce insoluble precipitates.

Specifications for CCA preservatives vary from country to country. Normally preservative mixtures are defined by the proportions of active elements, namely the relative amounts of copper, chrome and arsenic expressed as percentages of the total. It should be emphasized again that the CCA preservatives are highly effective and are chemically fixed in the wood by the formation of insoluble salts which are not leached out by water.

In addition to CCA, there are other formulations such as:

Copper/Chrome/Boron	CCB
Copper/Chrome/Fluorine	CCF
Copper/Chrome/Phosphorous	CCP
Fluorine/Chrome/Arsenic	FCA
Fluorine/Chrome/Arsenic/Phenol	FCAP
Boron/Fluorine/Chromium/Arsenic	BFCA
Chromated Zinc Chloride	CZC
Copperised Chromated Zinc Chloride	CCZC
Zinc Meta Arsenate	ZMA
Ammoniacal Copper Arsenate	ACA
Acid Copper Chromate	ACC

The biggest criticism of most of these salts is their poisonous nature specially those containing arsenic. Hazards of these and other preservative chemicals are discussed later in this manual.

Advantages of Water Borne Preservatives

- These preservatives can be transported in solid or concentrated form.

- They are to be used with the cheapest of all solvents - water.

- They are very effective against both fungi and insects.

- They leave the wood in a clean condition which is not unpleasant to handle.

- The treated wood can be painted and glued once the water has dried off.

- They can readily be combined with fire retardant chemicals.

Disadvantages of Water-Borne Preservatives

- Most of these salts are poisonous though the dried treated wood is usually safe to handle.

- When applied to seasoned timber, it re-wets the wood, causes it to swell and has to be re-dried again.

Organic Solvent Type

Solvent type preservatives consist of active chemicals which are toxic to decaying agents, dissolved in an organic solvent such as a petroleum distillate. These organic solvents have low viscosities and are able to penetrate rapidly into dry wood, so that they are particularly suitable for use in preservative formulations that are designed for superficial application by brush, spray and immersion. It should be noted that the preservative action depends solely upon the toxic deposit and the solvent has no preservative action. As these solvents are normally expensive, the use of such solvents can be justified only when other types of preservative chemicals are unacceptable.

The most important fungicide for organic solvent preservatives is pentachlorophenol, while the most effective are lindane and dieldrin. Other important organic solvent type preservatives are tributyl tin oxide (TBTO), copper 8-quinolinolate and copper napthenate. It should be remembered that in several countries, the use of dieldrin and other organochlorines such as DDT is banned.

Organic solvent type preservatives are applied by brush, spray, dipping or low pressure processes such as double vacuum.

Advantages of Solvent Type Preservatives

- They leave the wood in a clean condition.
- They penetrate well into permeable timber.
- They do not leach out.

- Treated timber can be painted and glued soon after the solvent has evaporated.
- They do not cause swelling or distortion of the wood as they do not contain any water.
- They are very useful in remedial treatment of wood in buildings which have been attacked by insects or fungi as they are easily absorbed by most building timbers when applied by brush or spray.

Disadvantages of Solvent Type Preservatives

- Solvent type preservatives are relatively very expensive.
- They increase the flammability of the wood for a short time after the preservative has been applied.
- Certain foodstuffs can become tainted except in the case of copper 8-quinolinolate.

Fire Retardants

Application of fire retardant treatments should reduce surface spread of flame, rate of degrade and charring. It should also reduce ignitability and prevent after glow and the sustained combustion when the heat is removed. As for wood preservatives, fire retardants should be easily applied, inexpensive, permanent and have no degrade effect on physical and mechanical characteristics of the treated wood. In addition, these should not have any effect on gluing and finishing properties.

There are two principal types of fire retardant systems and they are surface coating and pressure impregnation. Many surface coatings are essentially decorative paints to which fire retardants have been added. Normally flame retardant coatings are applied by brush, spray or by other mechanical process such as curtain coating.

Flame retardant coatings are of two types:

- Intumescent coatings are those, when exposed to fire, produces non flammable gases and an insulating layer by foaming, thus reducing the rate of temperature rise of the protected wood.

- Non intumescent coatings are those when exposed to fire, interfere chemically with the process of burning.

However intumescent type is proved to be more effective and is mostly used.

The chemicals used for fire retardant treatments are based on mixtures of ammonium sulphate and phosphates with additional flame retardant salts such as boric acid and zinc chloride.

Chapter 6

LOG PROTECTION/PRESERVATION

As long as a tree is healthy and stands with its bark intact, it is certain that it will be free from decay. Decay will probably start if the tree or the branches are injured. The protection of standing trees are beyond the scope of this manual and will not be discussed.

As soon as a tree is felled and cross-cut into logs the ends of the logs are exposed. These logs have a moisture content which may vary from 60 - 200 percent or more. Depending on the kind of timber species, the surrounding climate and the presence of fungi and insects in the vicinity, these decaying agents could start attacking the logs. It is possible at first for the sapwood to discolour and for the wood rotting fungi to attack. The most common attack by fungus is one which produces blue stain. At the same time the logs may be attacked by bark boring beetles and possibly pinhole borers.

In the temperate zones, the possibility of insect attack is minimal during the winter months, but in the tropics, the logs may be attacked immediately or within a few days after felling.

Insects that Attack Logs

Ambrosia beetles

Of the insects which attack freshly felled logs, the pinhole borers or Ambrosia beetles are a more serious problem in the tropics than they are in temperate countries. They are characterised by their peculiar form of feeding. They do not derive any nourishment from the wood itself but feed on certain moulds which grow on the walls of the tunnels which they make in the wood. Since these moulds can grow only in unseasoned timber, it follows that the beetles themselves cannot breed or survive for long in seasoned timber. Of importance in the life history of Ambrosia beetles is that neither the adults nor the larvae eat the wood. The preservative chemical required to control these beetles should therefore be of a contact poison and not of a stomach type.

When the beetles are active, their attack may be recognised by the fact that only fresh logs are attacked, by the roundness of the hole, by the size ('pin hole') and by the powdery frass that is ejected from the tunnels, sometimes in short strings. In dry or converted timber, damage by Ambrosia beetles is recognized by the black staining of the tunnels which is caused by the fungus. The fungus does not destroy the wood but only lives on the starch and sugars of the sapwood.

Longhorn beetles

In most cases these beetles commence their attack on living trees. Eggs are laid in the bark and larvae bore tunnels into the wood parallel to the long axis of the tree. These larvae may persist in the wood after the tree is felled because they are tolerant to dry conditions. Some species in this group of beetles are capable of initiating attack on seasoned wood but they do not normally do so. Attack by longhorn beetles can usually be recognised by the fact that their larval tunnels are much larger and elliptical in cross section instead of circular as with other beetles. Longhorn beetles are usually larger than other wood borers.

Fungi That Attack Logs

Fungi can attack not only logs but also standing trees. Although the very high moisture content in the living sapwood tissue generally prevents attack by fungi and insects, any physical damage to the bark and the cambium may allow the wood to dry out to a level where decay could start, eventually fungal infection could spread progressively through the heart of the tree. These heart rots are generally known as dote and punk and they fall into a category called Armillaria mellea. This infection will be destroyed by kiln drying at high temperatures. However, if the infection is not fully destroyed, it will become reactivated if the moisture content reaches the required level for the fungus. This could easily be seen in logs, stacked in the open, by the fluffing white hyphae. Sometimes there is an odd small characteristic to the particular fungus involved.

There are two main types of fungi namely sap-staining fungi and rotting fungi.

The sap-staining fungi live on the sapwood cells and their presence is normally confined to sapwood cells. The most normal discolouration is due to blue stain fungi which does not destroy the timber.

Sapstain

Sapstain which is also known as blue stain, is a discolouration of wood caused by fungal attack. Depending on the particular fungus, it may be blue-black or blue-grey or sometimes even brownish or purple. The sapstaining fungi do not live on the wood substance itself but on the contents of the sapwood cells. That means their action is restricted to the sapwood, except when wood species without differentiated heartwood are concerned. These fungi attack as soon as a tree is felled and develop very quickly, depending on the surrounding conditions. Therefore, any preventive treatment should be carried out as soon as possible. Spraying with a chemical or preferably a chemical dip is found to be the simplest solution.

Sapstain does not normally affect the strength of the wood but it spoils the appearance. Also it could mask the presence of any other fungi which could weaken the wood.

Log Protection

In temperate climates, where the winter is cold and temperatures below freezing point persist for months, logs of perishable species can be felled and left in the woods with no risk of deterioration until the warm weather returns. However, they should be removed from the forest before the end of the cold weather and should be sawn without delay and then piled for seasoning either by air or using a kiln.

Water storage

The best way to protect logs awaiting conversion is to submerge them under water. As long as they are completely submerged, they will remain free from insect attack and fungal decay. In addition, ponding will avoid any risk of the ends drying out causing end splitting. However, if any portion of a log is above the water level, it is possible to get decayed. Therefore some device has to be installed to keep the logs completely submerged. If ponding is not possible, spraying the logs continuously with water, could be used. It is not necessary to use large volumes of water but continuous rather than intermittent spraying is likely to give better protection. However, spraying with water may be costly in most developing countries.

Protection using chemicals

If ponding of logs is not possible and delay in conversion is unavoidable, exposed wood such as the cut ends, should be brushed or preferably sprayed with a preservative. This should be done immediately after felling and cross cutting as it is useless to apply any superficial treatment once infection has penetrated into the wood. The chemicals which are now used, simply form a thin layer on the surface and do not penetrate enough onto the bark or into the wood itself. Quite a number of preservatives applied with full success in temperate climates, where both biological and climatic conditions are far less severe, may fail completely when applied in the tropics. The most common preservatives used are organic compounds such as pentachlorophenol, benzene hexachloride, dieldrin, etc.. Protection of logs using chemicals will be discussed in the latter part of this manual.

Chapter 7

PREPARATION OF MATERIAL

Factors Affecting Penetration and Absorption

The amount of preservative necessary for adequate protection is mainly governed by the end use of the timber. For instance, timber to be used in ground contact would need a higher absorption of the preservative than for a roof timber. However, absorption in itself is not a complete measure of the treatment, as it is important to have a complete and uniform penetration to a depth as deep as possible. Inadequately penetrated wood may be subjected to an early failure as a result of an extension of a check or a split beyond the treated zone. The main factors affecting penetration and absorption are:

(a) the anatomy of wood
(b) the treating procedure
(c) the preparation of material

The anatomy of wood was earlier discussed in Chapter 3 while the treating procedures are given in Chapter 8.

Preparation of Material

If satisfactory results are to be obtained in the treatment of wood, it is essential that the material be suitably prepared for the subsequent impregnation of preservatives. Only very few processes give best results when applied to green timber such as the diffusion and Boucherie processes, the latter even requiring the bark to be retained. However, other treatment methods can only be effective if the wood is correctly prepared and it is extremely important that any cutting, boring or machining operations should be carried out before preservative treatment is given. There are two reasons for this. Firstly, any cutting into the wood after it has been treated may expose untreated wood in the core of the piece to decay, and secondly, any holes that are made in the wood before it is treated provide useful ports of entry through which the preservative can enter the wood. If for any reason it becomes necessary to do any cutting or boring after the wood has been treated, the unprotected wood thereby exposed should be given a thorough brushing with preservative. End cuts can be treated in this way fairly effectively, but it is very difficult to obtain adequate penetration on side cut surfaces by any superficial treatment.

Debarking

Removal of bark is a very essential step in the preparation of round timbers for treatment, as bark is virtually impermeable to liquids. As mentioned earlier, this does not apply to sap displacement processes such as the Boucherie method.

Before conversion, logs are sometimes debarked or bark is sawn off and discarded along with some outer sapwood. There are several ways of removing the bark. Though mechanised peeling gives a smooth, even roundwood, it has the disadvantage of removing too much wood from uneven logs. Therefore in the case of poles, care must be taken to avoid removing too much wood as this reduces the thickness of the treatable sapwood. The easiest method of debarking in developing countries in adzing and the use of high pressure water jets is common to peel the logs before pulping.

Drying

Except for treatment processes such as diffusion, where green wood is used, the presence of water in cell cavities will retard or even prevent the absorption of the preservative. Thus the surface application of preservatives such as brushing will have no worthwhile effect. Even with pressure processes, it is impossible to impregnate green wood. Therefore it is absolutely important that the timber should be dried so as to remove all the water in the cells and make room for the preservative. A moisture content of less than 30 percent is recommended for wood to be treated with a pressure process. A much lower moisture content is desirable for wood to be treated by surface applications of preservative. The process of drying wood under more or less controlled conditions is called seasoning. Controlled conditions are necessary to avoid rapid drying which is responsible for developing defects in wood. It is very important that once the wood is seasoned, it should be stored under cover to protect it from both sun and rain. The two common methods of seasoning wood are air seasoning and kiln seasoning. Other methods such as vapour drying, chemical seasoning, etc. are not generally used as they are costly, although they are used in special cases. It is fairly common to use air seasoning to bring down the moisture content to the fibre saturation point followed by kiln seasoning.

Air Seasoning

Unseasoned wood exposed to the open air but protected from rain will gradually dry out until it achieves a moisture content which is in equilibrium with the surrounding air. Air seasoning is done by stacking the timber exposed to the atmosphere either in the open or in a shed. In air drying, there are two essentials which control the final condition and dried quality of timber that has been stacked for drying. The first of these is to maintain sufficient air movement throughout the yard and through individual stacks to ensure uniform drying. The second is to use stacking techniques which will ensure that degrade due to warping, twisting, checking, etc. is kept to a minimum.

Stacking for air drying of timber is done in several ways. The most common method is to stack horizontally although sometimes vertical and triangular stacking are used (see Figure 7.1). In horizontal stacking, the whole stack is built up on a platform and covered with a roof. The platform is constructed in such a way that the transverse members are spaced at appropriate intervals depending on the thickness of the timber to be dried and the drying behaviour of the particular timber species. Stickers (which are about 20 mm thick and 40 mm wide) are placed in line with the transverse members of the platform. Within limits it is possible to control the rate of drying by varying the thickness of the stickers. Each stack should consist of only one thickness of timber. Heavy weights may be placed evenly on the top of the stacks to prevent the pieces at the top from warping. Warping and twisting can largely be prevented by close attention to the construction of suitable stack foundations, by care in the choice and placing of stickers and by the adoption of other procedures such as stack weighting. Checking caused by uneven or excessively rapid drying of part or all of a stack (or a charge) can be controlled by the use of suitable sticker thickness, stack covers, end coatings, etc.. It is also essential to understand the factors which control air movement in a stack and in a yard since air movement is mainly responsible for uniform drying. Air within a stack of timber under average conditions has at any moment the ability to dry only an infinitesimal amount of water from the timber. Unless the air is replaced when

AIR SEASONING

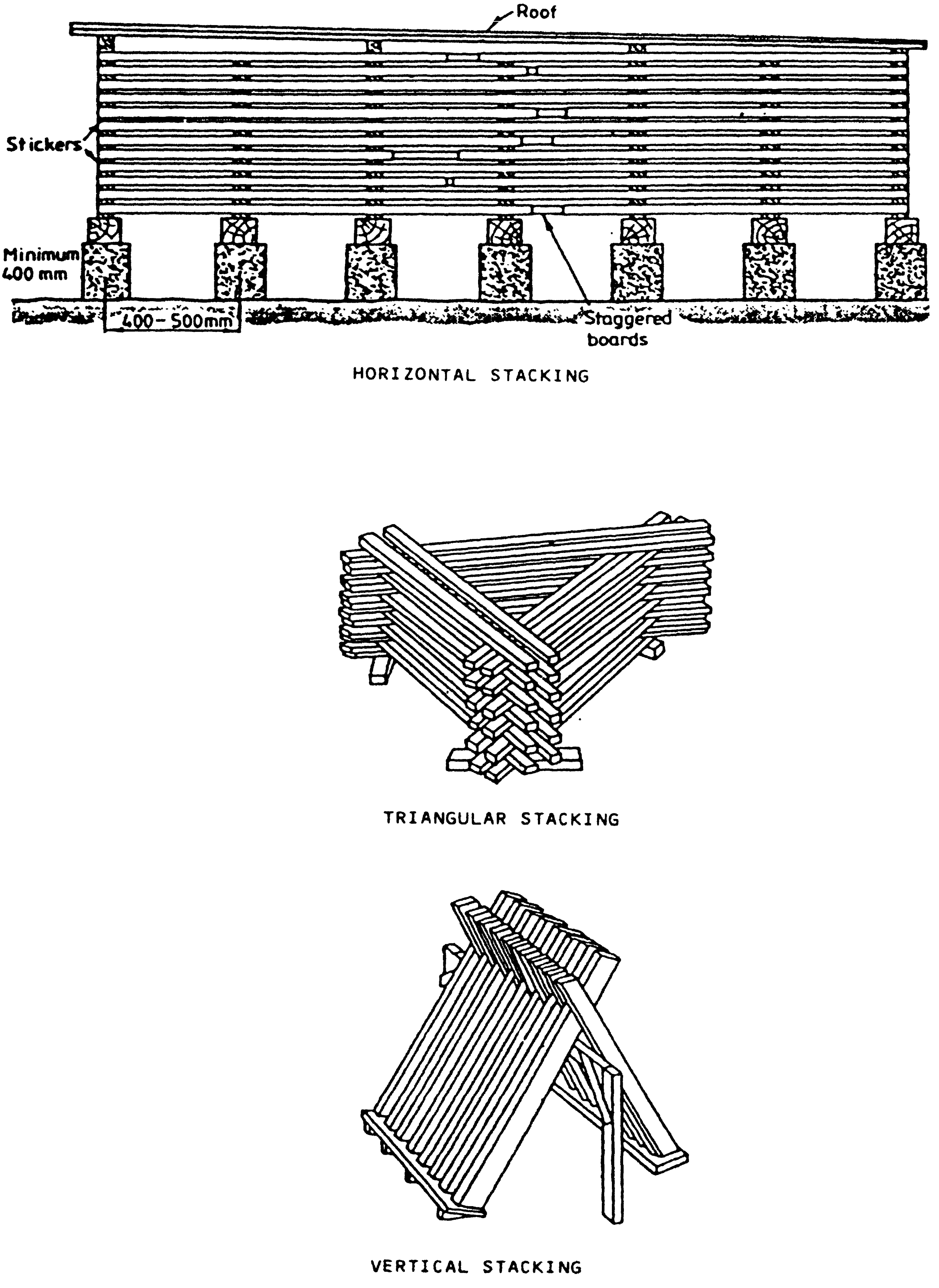


Figure 7-1

it has evaporated this negligible amount, drying ceases. Therefore it is necessary to obtain a good circulation throughout all parts of a timber stack for drying to proceed and uniform drying to be achieved. When erecting a number of stacks in a timber yard, considerable attention should be given to the layout of the stacks in the yard to ensure that adequate uniform circulation is provided for all the stacks.

It is also important that there must be good drainage in the vicinity of the yard to keep the damp air to a minimum. Other important points are reasonable spacing of stacks, strong foundations having concrete or masonry piers which could support the load of timber without deflection and proper covering of stacks to avoid direct sun and rain. The progress of seasoning in a stack is found by using sample boards placed in different places of the stack. These boards are removed and checked for moisture content at regular intervals.

Kiln Seasoning

The basic principle of seasoning which is the removal of moisture from wood remains the same whether in air seasoning or kiln seasoning. In this case the drying process is increased by high temperatures, low relative humidity and fast movement of air within the timber stack. This is achieved by having the timber stack in a chamber designed so that the temperature, humidity and air movement can be controlled. Thus any kiln must be provided with means of heating, humidifying and controlling the flow of air. The principles of stacking are similar to those mentioned for air drying.

Other Conditioning Methods

Even when properly seasoned, some species of wood remain impermeable to preservatives. There are a few other methods which sometimes increase the permeability of wood. The most common methods are ponding, steam conditioning and incising.

Ponding or Water Spraying

Ponding or water spraying not only helps to protect logs in storage but also it could make use of the natural biological processes to give wood exceptional permeability. The action of bacteria growing within the cells is responsible for this extra permeability.

However, this does not affect the strength of the wood. The only problem encountered with ponding is that it sometimes creates unusually high absorption of preservatives.

The two common methods available for achieving high permeability is by ponding logs in lakes, tanks or rivers where bacterial water is available and by sprinkling stacks of logs in a timber yard with water rich in bacteria.

Steam Conditioning

Steam conditioning is a method which could significantly increase the natural permeability of wood. This process uses steam at temperatures of about 125°C for one to 24 hours. The duration of the treatment depends on its initial moisture content, the species, and the thickness of the timber. Steam conditioning of timber is done in a treating cylinder under pressure. Steam is produced either directly in the cylinder or externally and then introduced into the cylinder. The permeability of all timbers cannot be increased by steam conditioning, however, the permeability of some timbers which would otherwise be untreatable has been increased by this process. Its disadvantages are the cost of treatment and the tendency to reduce the strength and distort the timber to be treated.

Chapter 8

WOOD PRESERVING PROCESSES

The objective of wood preservation is to introduce the preservative into the wood so that a deep continuous layer of treated wood contains sufficient preservative to prevent decay and insect attack. Various treatment methods may be used depending on the timber species and the end use. Most of the preserving processes may be grouped into either pressure processes or non-pressure processes. Non pressure processes are carried out without the use of artificial pressure while pressure processes are in which the wood is placed in a treating cylinder and impregnated with preservative by applying pressure or vacuum and pressure. There is also a third group of miscellaneous processes in which the wood is treated in one way or another with slight to moderate pressure but not in a closed cylinder.

Pressure Processes

The most successful method of preservative treatment of wood is the use of pressure impregnation of the wood. This is done in specially constructed plants where the timber is treated under pressure in a closed steel cylinder. Depending on the actual process to be used, the timber may be subjected to a preliminary vacuum. After the preliminary treatment, if used, the cylinder is filled with the preservative solution at a specified temperature and then pressure applied to it. The amount of pressure applied and the duration of the pressure period depend on the species, penetration required and the usual pressure applied is between 800 to 1400 kPa.

High Pressure Processes

There are several types of high pressure processes some using only pressure and others using vacuum and pressure.

The Full Cell Process

In the full cell process the aim of the treatment is to retain as much as possible of the preservative by making the cells full of preservative solution. This is the normal process used when treating with water borne solutions. Where high retentions of creosote is required in very hazardous environments, as is the case in marine piles, full cell is often employed. In the case of creosote, it has to be heated to temperatures about 65 to 100 °C during the pressure period to lower the viscosity, to enable the liquid to penetrate.

The main steps in the full cell process are (see Figure 8.1):

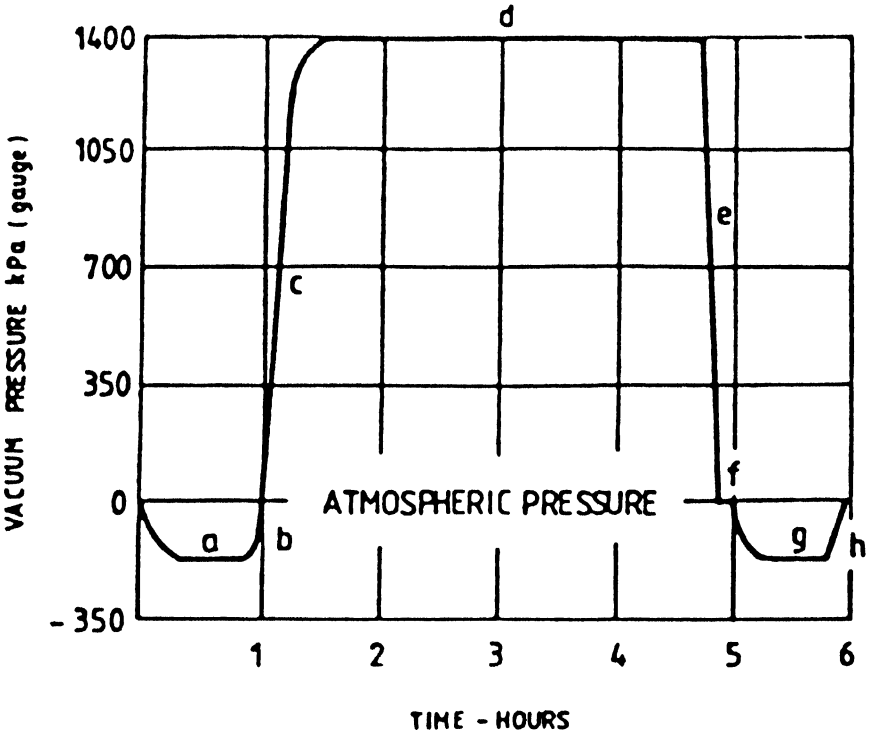
(a) preliminary vacuum period
(b) fill cylinder with preservative
(c) build up pressure
(d) maximum pressure held
(e) release pressure
(f) empty cylinder of preservative
(g) final vacuum period
(h) release vacuum

The amount of pressure and vacuum applied and also their period of application vary with the species, the retention required, etc.. Details of the operation are normally supplied by the manufacturer of the treatment plant.

The Empty Cell Processes

There are two main types of empty cell processes, which are called Rueping and Lowry processes. In both processes, there is no initial vacuum applied, the preservative is forced into the wood under pressure and subsequently a vacuum is applied to remove the excess of the preservative. Empty cell processes are applicable when it is required as deep penetration as possible with a limited final retention. This process is normally used with tar oil preservatives. The main steps in the Rueping process are (see Figure 8.3):

(a) preliminary air pressure applied
(b) fill cylinder/hold air pressure
(c) build-up pressure
(d) maximum pressure held
(e) release pressure
(f) empty cylinder of preservative
(g) final vacuum period
(h) release vacuum



a Preliminary Vacuum Period
b Fill Cylinder with Preservative
c Build up Pressure
d Maximum Pressure held
e Release Pressure
f Empty Cylinder of Preservative
g Final Vacuum Period
h Release Vacuum

FIGURE 8.1 FULL CELL PROCESS

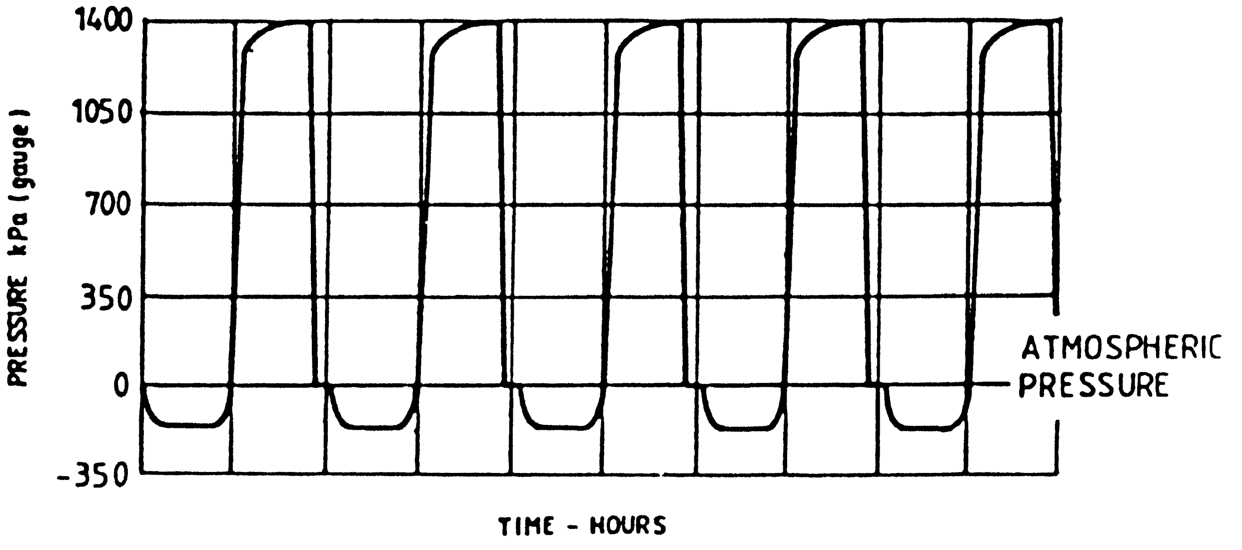


FIGURE 8.2 OSCILLATING PRESSURE PROCESS

And the main steps in the Lowry process are (see Figure 8.4):

(a) fill cylinder with preservative at atmospheric pressure
(b) build up pressure
(c) maximum pressure held
(d) release pressure
(e) empty cylinder of preservative
(f) final vacuum period
(g) release vacuum

Oscillating Pressure Process

This is a variation of full cell process for the treatment of timber of high moisture content with water borne preservatives. As the name applies, this process utilises repeated applications of high and low pressure (Figure 8.2), the high pressure being over 1000 kPa, and the low pressure generally being in the vacuum range. The timber to be treated should normally be steam conditioned at temperatures around 125°C. After removing from the steam cylinder, it is allowed to cool for sometime after which the timber is subjected to a brief pressure in a pressure cylinder. This is followed by cycles of vacuum and pressure which are of predetermined intensity and duration, depending on the size and species of material to be treated.

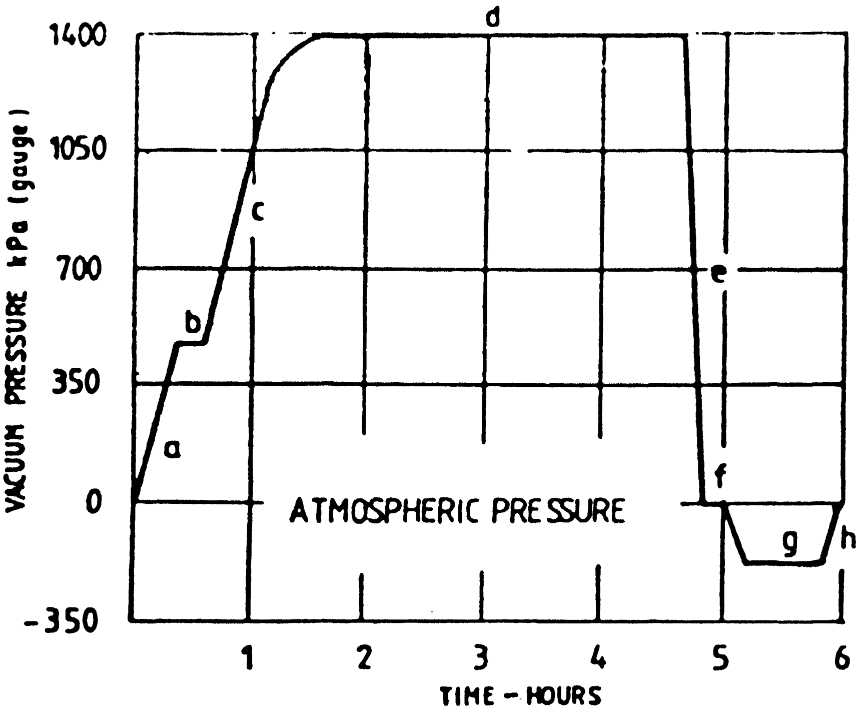
The plant required is more complex than that used for other pressure processes, and high standards of operational and technical control are necessary.

Low Pressure Processes

There are few processes where low external pressures are used to treat the wood, most important being the double vacuum process.

Double vacuum process

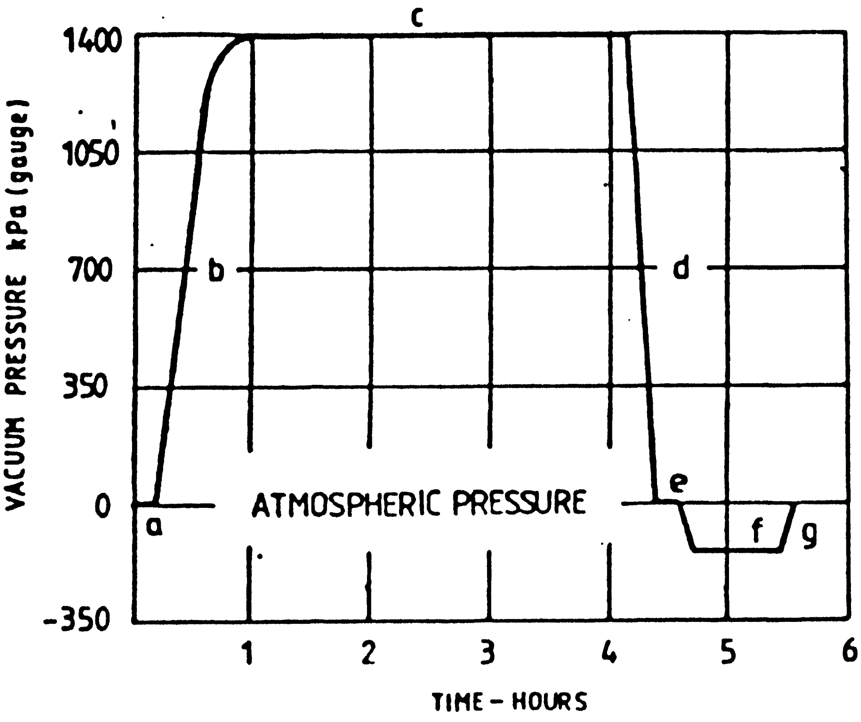
Double vacuum process uses about one-tenth of the pressures involved in Full Cell process and is widely employed in developed countries mainly for treating timber joinery components with organic solvents. The main steps of this process are:



a	Preliminary Air Pressure Applied	e	Release Pressure
b	Fill Cylinder Hold Air Pressure	f	Empty Cylinder of Preservative
c	Build up Pressure	g	Final Vacuum Period
d	Maximum Pressure Held	h	Release Vacuum

RUEPING TREATMENT

FIGURE 8.3 EMPTY CELL PROCESS



a	Fill Cylinder with Preservative at Atmospheric Pressure	d	Release Pressure
		e	Empty Cylinder of Preservative
b	Build up Pressure	f	Final Vacuum Period
c	Maximum Pressure Held	g	Release Vacuum

LOWRY TREATMENT

FIGURE 8.4 EMPTY CELL PROCESS

(a) application of an initial vacuum
(b) flooding with preservative
(c) application of pressure
(d) release of pressure
(e) application of final vacuum

The above steps are very similar to the steps employed in the Full Cell process except the pressure applied is much less.

Solvent Recovery Process

These processes use an organic solvent preservative with a solvent where the solvent could be recovered after carrying the preservative into the wood. The treating solution is usually butane or isobutane together with isopropyl or polyethylene glycol containing 2% to 4% PCP. The timber treated in this way is dry at the end of the process and could be used immediately. However, the solvents are expensive and involves high operational costs and extreme care is required in handling highly flammable solvents.

Non Pressure Processes

There are a number of non pressure processes of treating wood which are quite varied in their procedure. Some of the important methods are listed below.

Brush Treatment or Brushing

The simplest method of applying a preservative is brushing and is normally used for preserving small individual items and also when it is required to apply to a timber already installed in a building, brushing may be the only way possible. Brush treatment is used to ends of any timbers which have been cut to size after they have already been pressure impregnated. In order to have an appreciable effect, the preservative should be flooded on the surface by brushing to get the maximum amount absorbed. An important factor is the timber to be treated should be dry. Tar oils if they are too viscose, should be heated before applying. Brushing can be repeated at regular intervals depending on the environment to which it is exposed. Care should be taken to brush any exposed grain with sufficient preservative.

Spraying

Spraying offers a more liberal and effective covering of the timber than brushing. The possibility of the preservative penetrating into holes, cracks, splits, etc. is more in spraying. This method is often employed when it is required to apply the preservative to large areas and also to roof members with wood worm which enables the preservative to reach the timber which is inaccessible to brushing.

Immersion or Dipping

Immersion or dipping involves immersing the timber in the preservative for a short time and the same treatment is known as steeping or soaking when immersion extends to several hours or days. Immersion gives a better chance of the preservative reaching the holes, cracks and splits.

The degree of penetration depends on the duration of immersion, the timber species and also on the type of preservative. Absorption is rapid during the first few hours only and it takes a long time to get an appreciable penetration. Steeping is important where other methods of treatment are not available. In any case, it is more expensive than brushing as it requires large tanks and more preservative.

Hot and Cold Method

This process is sometimes known as open tank process or thermal process. Next to the pressure treatment this offers a very satisfactory method of impregnation. In this process seasoned timber is immersed in a bath or preservative which is heated for few hours and allowed to cool while the timber is still submerged in the liquid. Sometimes the cooling is done by transferring quickly the timber from the hot bath to a cool bath of the preservative. During the heating period the air in the cells expands and much of it is expelled as bubbles. During the cooling period the remaining air in the cells contracts creating a vacuum and the preservative is drawn into the wood. Therefore, practically whole of the absorption takes place during the cooling period.

The temperature of the hot bath is normally between 80 to 95°C in the case when creosote is used as the preservative. The duration of submerging in the hot bath depends on the size of the timber and the species of timber. If the absorption of the preservative is too much, the duration of the cooling period can be reduced or the timber can be reheated in the preservative and removed while it is still hot. It is also sometimes possible to increase the penetration by increasing the duration of heating.

This process is effective for treating permeable timbers or timbers which are moderately resistant to impregnation and normally used to treat fence posts and other farm timbers.

Sap Displacement Method

Sap displacement method can only be applied to round timbers in green condition and uses the hydrostatic pressure due to gravity to force the preservative from the butt end of the round timber. This method which is commonly known as Boucherie process which originally used copper sulphate as the preservative. However, it is possible to use other water soluble salts such as CCA salts.

In this method, a cap is fitted to the butt end of a freshly sawn pole or round timber and then one end of a flexible tube is connected to the cap and the other end to a tank containing the preservative at a place as high as possible (see Figure 9.12). The caps mentioned above are sometimes modified from old tubes of vehicle tyres.

There are modifications to this process such as the application of a vacuum from the top end. A major problem is the difficulty in having air tight caps at the ends. This method gives a greater concentration of the preservative at the butt end and this is welcome specially in the case of poles going into the ground which are most vulnerable to decay.

With sap displacement, it may be assumed that logs of almost any species can have preservative solution forced through them if they have been freshly felled and are still full of sap. However, by inspecting a log, it is possible to find whether it is generally suitable for sap displacement treatment. The two most important criteria are the sapwood thickness and wood structure (in hardwoods).

(i) Sapwood thickness

Unless the heartwood is sufficiently durable to last the required length of time without treatment, complete reliance is placed on the treated sapwood shell. The treated sapwood layer should be strong enough to perform the task of the post or the pole if and when the centre decays. A rule of thumb for minimal strength loss is that the sapwood thickness should not be less than one-third of the radius of the log.

(ii) Wood structure (in hardwoods)

In hardwoods, flow will only be through the vessels, and preservative movement from these to the fibres must be by diffusion. As preservatives of CCA type will diffuse only a very short distance, it follows that vessels must be fairly uniformly distributed and close together. This immediately rules out fast grown ring porous species, and a quick examination of a cleanly cut surface with a hand lens will soon identify such species.

Diffusion processes

Diffusion processes can only be applied to very green timber and normally carried out at sawmills soon after the logs have been converted to sawn timber. The treatment has to be carried out at least within seven days and in some cases within two to three days. The preservatives used in the diffusion treatment are highly soluble in water and most commonly used salts are mixtures of Borax and Boric acid or polyborates and also Borofluoride/Chrome/Arsenic (BFCA). The process involves dipping freshly sawn timber in a concentrated treating solution which is heated upto a temperature of 30 to 65^{o}C. The concentration of the treating solution depends upon the thickness of the timber. The timber just after immersion is closed piled (block stacked) and completely covered with a tarpaulin or polythene sheet so that drying is prevented as much as possible. The time for the diffusion of the preservative into the wood to take place is between 4 weeks for 25 mm thick material to 15 weeks for 75 mm thick material. The duration varies with different species when the penetration is complete, the timber is removed and restacked for normal seasoning. The main advantage of this method is that some timbers which are very resistant to impregnation can be treated this way. Furthermore, the cost of capital investment as well as the cost of the preservatives are not so high.

There are two main disadvantages, first being the non fixing nature of these preservatives and secondly the treatment can be applied only to freshly sawn timber. However, using the double diffusion process, it is possible to fix the preservative in the timber. One method is to immerse the freshly sawn timber in a solution of copper sulphate for several days and then transfer the timbers to a solution of sodium dichromate and sodium arsenate. These two chemicals react together within the wood, forming a product which is insoluble. Although it gives a good fixation of the preservative, the control over the treatment is hardly possible.

Remedial Treatments

Remedial treatment for termite control is of two types; removal of living termites and the other treatment of timber as well as the removal of living termites and inhibiting termite activity.

One way of removing the living termites is fumigation. The method is to cover the building to be fumigated with special tarpaulins or other suitable material such as PVC coated nylon which is impervious to the passage of the fumigants. All seals are made with the cover properly secured to the base with sand bags or other convenient method. The fumigants normally used are sulphuryl fluoride or methly bromide. It is released from a cylinder through tubes which are connected to a number of points in the building. In order to disperse the gas uniformly inside the building, a blower or an electric fan is used. If fumigation is not possible, the infested timber should be removed and replaced by treated material and the rest of the woodwork can be brushed or sprayed at frequent intervals with an insecticide such as lindane or dieldrin.

Dessicant Dusts

Dessicant dusts are normally applied to all surfaces of building structures as a uniform film of the dust. These dusts to be effective, must remain on the surface of the timber and must not be absorbed by it. The most commonly used dessicant dusts are fluorinated aerogel or boric acid. They are applied by the use of an electric blower and blown into attics, roof spaces and any hidden accessible area. Termites in their galleries are not affected by the dust but as the larvae leave the timber they are destroyed by the dust. The dessicant dusts are used in buildings which are under construction as well as to prevent reinfestation by drywood termites after a building has been fumigated.

Powder Treatment

This method consists of toxic dust such as arsenic trioxide into the termite tunnel system. The powder or the dust is applied using a blower and great care has to be taken not to block or damage the termite tunnel. If the tunnels are blocked, the termites find their way through another route.

Soil Treatment

Ground Dwelling Termites

In the case of ground dwelling termites, it is necessary to find out where the termites are entering into the building or the structure in question. The link between the origin of the termites and the building should be removed and if possible a barrier either mechanical or chemical or both should be inserted (Figure 2.4A).

Slab on Ground Construction

The soil around the perimeter of the building should be poisoned, taking care to ensure not to affect the foundation. A trench about 300 mm is dug around the perimeter of the building and the preservative is sprayed at the rate of six litres per metre run. Excavated soil is replaced and treated with an additional six litres of preservative solution per metre run. It is important to carry out the soil poisoning when the soil is dry and when rain is not imminent. Where pipes, drains and other services penetrate the ground floor slab and if there are cracks or gaps between the pipes and the slabs, poison should be introduced into the cracks until the ground underneath is well soaked.

Ground Floor with Crawl Spaces

If there is adequate crawl space in a house with suspended floors, trenches are dug around the foundations, porches, verandahs and staircases. As in the earlier case, soil poisoning is carried out. If there is any doubt about the completeness of the treatment and soil poisoning, it is advisable to treat as much as possible of the timber near the ground level with an organic solvent type of preservative, such as pentachlorophenol.

It is very important to note that termite control should be carried out giving due regard to the health hazards. Health and safety aspects are discussed in Chapter 12 of this manual.

Remedial Treatment of Joinery

This section deals with the decay of mainly SOFTWOOD joinery which is a major problem in the temperate climates. Longer lifespan could be expected using components either pretreated or of naturally durable timber. However, with untreated softwoods, the decay is very probable and if decay is detected after installation, insitu remedial treatments are necessary. There are several types of remedial treatments which are being used for softwood joinery in temperate climates. Some of them are:

(a) Oil based bodied mayonnaise type emulsion treatment

The form of treatment consists of an oil based bodied mayonnaise emulsion containing pentachlorophenol and dieldrin preservatives. It can be trowelled or brushed. It is effective against wood boring insects and wet and dry rot fungi leaving a persistent deposit in the wood to prevent further attack. This can be used on new or old timber, also before, during or after installation and is particularly useful for timber which are in contact with masonry.

(b) Boron rods

These rods are made of boron salts and they are inserted into predrilled holes in the problem area of the joinery. If the wood is dry, the rods will remain inactive until moisture is present. Once dissolved in water, the preservative in solution is distributed with water, but remains in the wood when it dries out. These rods can be applied to painted joinery and can be repainted after the timber becomes dry.

Pressure injection of organic solvents

This operation involves drilling holes of about 10 mm in diameter to a depth of at least 40 mm to accommodate the injector. Then the organic solvent is injected through these holes. It does not take more than three minutes for one operation. Timbers are treated with an organic solvent containing a fungicide. The minimum size of the timber which can be treated this way is 50 mm x 25 mm (to take a small injector). The injection treatment is desirable to stop further decay in affected areas. Repainting of injected areas can be done without any difficulty.

Poles in Service

Preservatives in the form of a paste can be applied at the ground level to poles in service. The soil is dug away from the pole in question to a depth of 0.5 metres and the decayed wood is removed as completely as possible. The paste is then applied and covered with a protective wrapping or bandage after which the soil is backfilled. This is normally carried out once in every five years.

Chapter 9

TREATMENT METHODS

Selection of Method and Equipment

Before the most suitable method and equipment can be selected, the deterioration risk involved with the end use of the timber (or the timber product) must be clearly defined. It is easy to define situations such as marine piles where severe hazardous conditions are present and require protection against marine borers while building timbers in the tropics would require protection against termites. The marine condition would demand a pressure treatment with a non leachable type of preservative, while for building timbers a leachable type of preservative would serve the purpose if the timber were to be kept dry during its service life.

The effectiveness of any preservative treatment depends not only on the chemical composition of the preservative itself but also on the depth of penetration and absorption. The preservative must be adequately present in the wood as well as to such a depth that the area of treated wood on the outside effectively protects any untreated wood in the core. While it may be sufficient to enclose the wood with a superficial envelope of preservative treatment, it should be borne in mind that splits or accidental damage may occur through the superficial treatment permitting internal decay to develop. The retention of water borne preservative salts are expressed as either the amount of active ingredient as a percentage of the oven dry weight of wood, or as net dry salt retention. Retentions determined from charge volumes apply to the charge as a whole. However, if retentions of individual pieces are required, it can be found by weighing the pieces before and after treatment.

The amount of preservative required to protect a unit volume of wood against any particular type of decay is called the toxic limit or the threshold value. This value is normally used to compare the toxic effect of different preservatives and acts as a guide to the retention required when treating wood.

Table 9.1 (extracted from Overseas Building Notes - no. 183 - Preservation of Timber for Tropical Building by C.H. Tack of Building Research Establishment, UK) lists

Table 9.1

(Reproduced from Overseas Building Notes No. 183 - Building Research Establishment, UK)

Table 1 Preservation treatments appropriate to various degrees of risk

Situation	Major Hazard (assuming design protection)	Appropriate Treatments: Pressure	Open Tank	Double Vacuum	Diffusion	Sap Displacement	Immersion
1. In the sea (marine piling jetties)	Marine borers						
2. In fresh water, or partially or intermittently immersed (jetties, piling, bridge piers)	Fungal decay					Note: Leaching may reduce efficacy	
3. Structural timber in ground contact	Subterranean termites, fungal decay						
4. Structural or joinery timber not in ground contact in certain islands and water regions.	Drywood termites						
Structural timber not in ground contact in inland regions	Wood-boring beetles						
5. External joinery (except as in 4)	Fungal decay						
6. Interior timbers, high humidity or heavy condensation (e.g. cold stores)	Fungal decay						
7. Interior timbers generally	Wood-boring beetles						
8. Fence posts, transmission poles, verandah posts	Subterranean termite						

Note: Double-vacuum treatment is unlikely to be available in less-developed countries. It is included here because it may be offered in pre-fabricated buildings or components imported from elsewhere.

The protection afforded by the treatment should preferably be reinforced by a paint system.

preservative treatments applicable to various degrees of risk. Table 9.2 (extracted from Overseas Building Notes - no. 170 - Termites and Tropical Building published by Building Research Establishment, UK) lists the diagnosis of damage and control measures to be taken. Table 9.3 gives the recommended retentions and concentrations required for different types of preservatives. The natural durability and treatability of some timbers are given in Appendix 1.

Solution Concentration

When treating timber, it is essential to be familiar with solution concentrations or strengths and the necessary calculations involving their adjustments. With water borne salts it is possible to vary the solution concentration to control the uptake; a small volume of concentrated solution has as much chemical as a large volume of a dilute solution.

Solution concentrations are expressed as the weight of solid per unit volume of solution in percentage form. Thus 5 kg of salt dissolved in water to make 100 litres of solution has a strength of:

$$\frac{5}{100} \times 100 = 5\%$$

When making solutions with salts, an allowance should be made for the volume of the salt and then water is added in this case to make up to the required volume. The most important relationship which should be remembered is:

$$\text{Solution strength} = \frac{\text{Weight of salt}}{\text{Volume of solution}}$$

$$\text{or Weight of salt} = \text{Volume of solution} \times \text{solution strength}$$

$$\text{or Volume of solution} = \frac{\text{Weight of salt}}{\text{Solution strength}}$$

An example of the method of making a required solution strength is as follows:

It is required to make 250 litres of 5% solution.

Table 9.2 Diagnosis of damage and control measures

	Diagnostic features				Significance			
Type of pest	Timber attacked	Exit holes	Tunnels	Bore-dust	Origin	Persis-tence	Pre-treatment	Insitu remedial treatment
Ambrosia beetles (pin-hole, shot-hole borer needleworm) (Platypodidae & Scolytidae)	Sapwood and heart wood of all timbers	Circular 0.5 to 3.00 mm diameter	Across grain; walls darkly stained	None in tunnels may be seen on surface	Logs and baulk timber in forest or sawmill; sometimes in standing trees	Dies out after conver-sion and drying of wood	Damage should be minimised by spraying insecticide and early conversion	None require
Woodwasps (Urocerus spp.)	Sapwood and heart-wood of soft-woods	Circular 0.4 to 6.0 mm diameter	Few, widely spaced	Tightly packed chips	Standing trees and logs	Dies out after conver-sion of timber	None required	None required
Forest long-horn and jewel beetles (Cerambicidae & Buprestidae)	Sapwood of all timbers	Oval. Size according to species	Oval section, few, widely spaced	Mixture of pel-lets and splinters	Standing trees and logs	Dies out after conver-sion of timber	None required N.B. There may be long-horn borers locally important as pests, e.g Oemida gahani i Kenya	None required
Shipworm (marine borer) (Teredo, Martesia & Bankia spp.)	Sapwood of all & heartwood of most timbers	None	Circular, up to 12mm dia-meter chalk lined	None	In logs floated in sea or brackish water. In timber in marine work	Dies out when re-moved from water	For marine construction only - pressure impregnated with creo-sote or CCA - see foot-notes 1 & 2	In buildings none require In marine construction removal and replacement with resis-tant or pre-treated timber
Powder-post beetles (Lyctidae and Bostrychidae)	Sapwood of hard-woods	Circular 1.6 to to 6.0 mm diameter	Numerous, close	Floury powder	Logs and newly converted timber in saw-mills and timber yards	Can con-tinue until sapwood comple-tely disinte-grated	Spray logs and stacked timber with insecticide. Building timber-treat as footnote 1.6 or re-move sapwood during processing	Usually necessary to remove all affected sapwood

Table 9.2 (cont.)

Type of pest	Diagnostic features: Timber attacked	Exit holes	Tunnels	Bore-dust	Significance: Origin	Persis-tence	Pre-treatment	Insitu remedial treatment
Drywood termites (Kalotermi-tidae)	Sapwood of nearly all and heart-wood of many timbers	Round, 1 to 2mm dia, usually occluded	Galleries and voids of vari-able size with clean surface	Hard striated pellets like small seeds or coarse sand	Woodwork in ser-vice, furni-ture, shipping crates, dunnage, etc.	Continues till wood largely destroyed except for thin skin	See foot-notes 1,2, 3,5 and 6	Fumigation followed by applica-tion of insecti-cides - see Section 2.3
Subterranean or soil ter-mites (Hodotermi-tidae, Rhinotermi-tidae, Thermitidae)	Sapwood of all and heart-wood of most timbers	Sometimes present, with extruded soil	Tunnels or voids under thin skin or soil cover	Soil or faecal spotting on gal-lery walls	Ground surround-ing or beneath the building	Continues till wood comple-tely des-troyed	Soil poison-ing of site. Preservative treatment - see foot-notes 1,2, 3,5 & 6. Install termite barriers	Detect method of entry. Limited soil poisoning. Spraying of preservative or insecti-cide (see section 2.3). Install or repair ter-mite barriers
Wood-rotting fungi (decay)	Sapwood of all and heartwood of many building timbers	Not appli-cable Early stages detected by marked softening of wood when probed by bradawl. In later stages cubical cracking of surface and wood crumbly	Not appli-cable	Not appli-cable	Will only occur when wood is wet (above 20% mc) for lengthy periods	Will con-tinue until all damp wood is destroyed	See foot-notes 1,2, 3 and 4	Removal of affected wood and replacement with pre-treated wood, repair of defect inducing damp

Notes: Preservative treatments for tropical conditions

1. Pressure creosoting in accordance with BS 913:1972
2. Pressure impregnation with water borne copper-chrome-arsenate (CCA) preservative in accordance with BS 4072:1966
3. Hot and cold open tank process using creosote or CCA preservative as described in PRL Technical Note No. 42
4. Double-vacuum treatment with organic solvent preservative.
5. Double-vacuum treatment with organic solvent preservative containing persistent insecticide such as lindane or dieldrin.
6. Immersion for not less than 10 minutes in organic solvent preservative containing not less than 1% by weight of persistent insecticide such as lindane or dieldrin.

TABLE 9.3

TYPICAL OVERALL AVERAGE PRESERVATIVE RETENTIONS

Situation/Hazard	Timber Product	Retention (kg/m^3)	
		Creosote	CCA salts
Interior timbers	Roofing timbers joinery, etc.	50	6
Exterior timbers not in ground contact	Exterior building, timbers, cladding, bridge, railings, etc.	60	8
Timber in ground contact	Transmission poles, railway sleepers, fenceposts, etc.	100	12
Timbers frequently or permanently immersed in fresh water	Bridge piling, cooling towers, etc.	120	16
Timbers frequently or permanently immersed in sea water	Groynes, jetties, boat building timbers	150	24

$$\text{Weight of salt needed} = \frac{5}{100} \times 250 = 12.5 \text{ kg}$$

First, 12.5 kg of salt is weighed and then dissolved in a volume of water less than 250 litres (this is to allow for the volume of solid) and later more water is added to make it upto 250 litres.

Change of Solution Strength

The following example shows how a solution strength can be reduced:

It is required to change 200 litres of 5% solution to 2% solution strength

Calculate the weight of salt in the 200 litres of solution.

Weight of salt = Solution strength x Volume

$$= \frac{5}{100} \times 200 = 10 \text{ kg}$$

This is the amount of salt in the 200 litres of the solution.

Then calculate the volume of water required to make up a solution of 2% strength with 10 kg of salt.

$$\text{Volume} = \frac{\text{Weight of salt}}{\text{Solution strength}}$$

$$= \frac{10 \times 100}{2} = 500 \text{ litres}$$

Therefore add 300 more litres of water to the 200 litres of solution which already exist to make the required 500 litres.

The following example shows how to increase the solution strength:

It is required to increase the 400 litres of 5% solution to 8% solution.

Calculate the amount of salt already in the solution.

Amount of salt = Solution strength x Volume

$$= \frac{5}{100} \times 400 = 20 \text{ kg}$$

Then calculate the amount of salt required to make 400 litres of 8% solution.

$$\text{Weight of salt} = \frac{8}{100} \times 400 = 32 \text{ kg}$$

Therefore additional amount of salt required is (32 - 20) = 12 kg.

Determination of Retention and Penetration

Retention

Retention is the amount of salt retained in a unit volume of wood expressed in kg per cubic metre or lbs per cubic foot. This can be calculated for a charge (i.e. a parcel of timber which has been treated) or for individual pieces.

Example:

Volume of the total timber = $1.52 m^3$
Solution strength = 4%
Volume of preservative solution = 550 litres
Therefore weight of salt contained in the absorbed solution

= Solution strength x Volume

$$= \frac{4}{100} \times 550 = 22 \text{ kg}$$

$$\text{Retention} = \frac{\text{Weight of salt}}{\text{Volume of timber}}$$

$$= \frac{22}{1.52} = 14.5 \text{ kg/m}^3$$

Penetration

As mentioned earlier not only the retention in the timber is important but also the penetration. Penetration is the depth to which the preservative has reached from the surface of the wood. The penetration of preservatives into the timber can easily be determined on site by using colour reagents. However, it could be done in a laboratory by chemical analysis of the wood at different depths to determine the concentration of the active preservative element such as copper chromium and arsenic in the case of CCA salts. When colour reagents are used to determine the depth of penetration, cross section samples are cut at least 500 mm away from the end of the timbers. This is to avoid the effect of longitudinal penetration. The other method is to use a boring device such as a core borer sometimes called an increment borer to extract a small core specimen. Alternatively, in hard timbers, a dowel plug cutter driven by an electric drill can be used to extract a core specimen. The holes made by the removal of a core should be plugged with treated wood dowels. When borings are taken, it is important to avoid knots, splits or other irregularities and the bore should also be of sufficient length to reach into the heartwood. Different colour reagents are used to detect different preservative elements, important ones are discussed later in this chapter.

Colour Reagents

Colour reagents for different preservatives are usually available from the manufacturers of wood preservatives.

Test for copper

The most widely used colour reagent to detect copper in CCA salts is called the Chrome azurol S test which is given below.

The reagent used is 0.5% chrome azurol S dye and 5% sodium acetate in distilled water. (This is prepared by dissolving five grams of chrome azurol dyestuff and 50 grams of sodium acetate in one litre of distilled water). Spray or dip treat specimen with the solution. Presence of copper gives a strong blue colour and the untreated areas show orange. Alternately Rubeanic acid test can be used to test copper. The reagents used are: (i) 5%

ammonia solution and (ii) 0.5% Rubeanic acid (Dithio-oxamide) in alcohol. (Solution (i) is made by diluting one part of ammonia of 0.880 specific gravity with six parts of distilled water and solution (ii) is made by dissolving five grams of rubeanic acid in a litre consisting of 90 parts of ethanol and 10 parts of acetone). Spray specimen with (i) followed by solution (ii). Presence of copper gives a greenish black to black colouration while untreated areas show natural wood colour.

Test for arsenic

The most common test for arsenic is the Molybdate test which consists of two separate reagents namely (i) sodium molybdate and (ii) stannous chloride. (Solution (i) is made by dissolving five grams of sodium molybdate in 100 ml of 10% hydrochloric acid and solution (ii) is made by dissolving five grams of stannous chloride in 100 ml of 10% hydrochloric acid). Spray specimen with solution (i) and allow to soak in. Then spray with (2). Presence of arsenic shows a royal blue colour.

Test of pentachlorophenol in oil

Cupric acetate which is used for testing pentachlorophenol is made up of two solutions. Four grams of Cupric acetate dissolved in 100 ml of water with a suitable wetting agent is mixed with an equal quantity of solution of 0.4 grams of silver acetate dissolved in 100 ml of water. When this is sprayed on the specimen, areas containing pentachlorophenol show a deep reddish-brown colour.

DETAILED PROCEDURES

Cold Soaking

This method is normally used only for round timbers such as fence posts. This treatment consists of placing the dry posts in a bath of unheated preservative. A two stage treatment giving the butt ends a heavier treatment than the top ends is preferable.

Preservatives recommended are:

(i) 5% pentachlorophenol in diesel oil, waste sump oil or other suitable oil.

or (ii) creosote with diesel oil (for every 100 litres of creosote add 10 litres of diesel oil)

or (iii) 1% copper napthenate solution

Use a 200 litre drum as the soaking tank and for draining a similar drum cut into half lengthwise and welded (see Figure 9.1).

Use dry posts for treatment.

Soak the butt ends of the posts, as shown in Figure 9.1, for several days.

Soak the top end for a few hours.

Keep the treated posts for draining.

Recover the drained preservative.

Alternatively a deeper tank can be used to treat the full length of the posts without treating the posts' butt end and top end separately.

Different arrangements for cold soaking on a larger scale are shown in Figures 9.2 to 9.5.

The method employed is:

Keep posts in the tank or the container with butt ends down in the case of vertical treatment.

Use a holding down device to prevent the posts from floating.

Fill the tank with preservative.

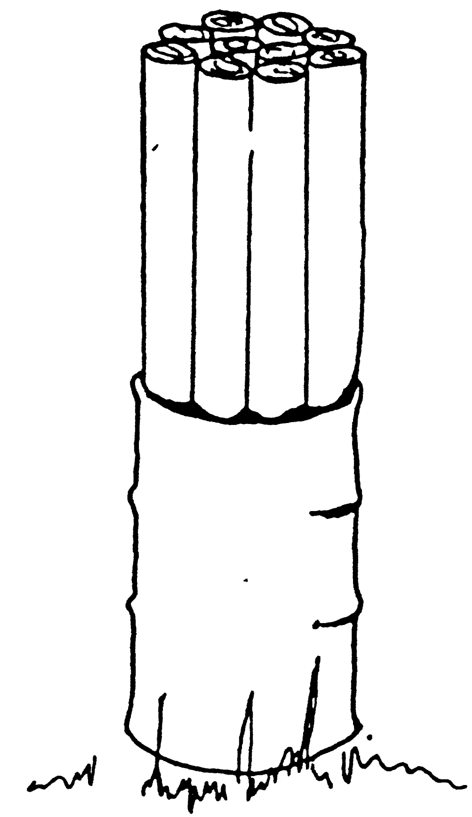
Ensure that the posts are fully submerged in the preservative.

In the case of vertical treatment of posts, preservative can be pumped out leaving (800 - 1000 mm) of preservative after a few hours.

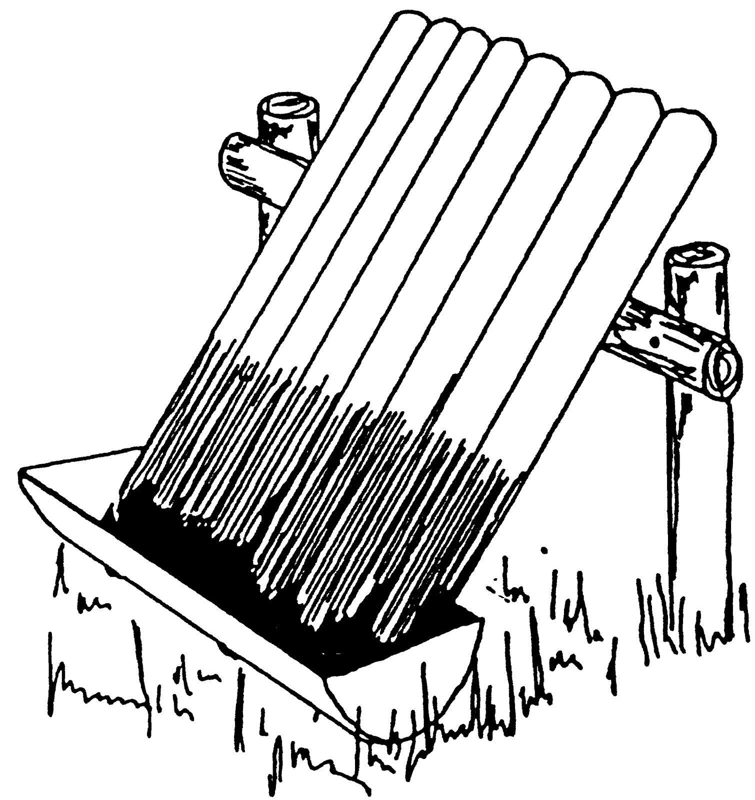
Keep the butt ends soaked for a few days.

Afterwards remove the remainder of the preservative.

Allow the posts to drain in the tank.



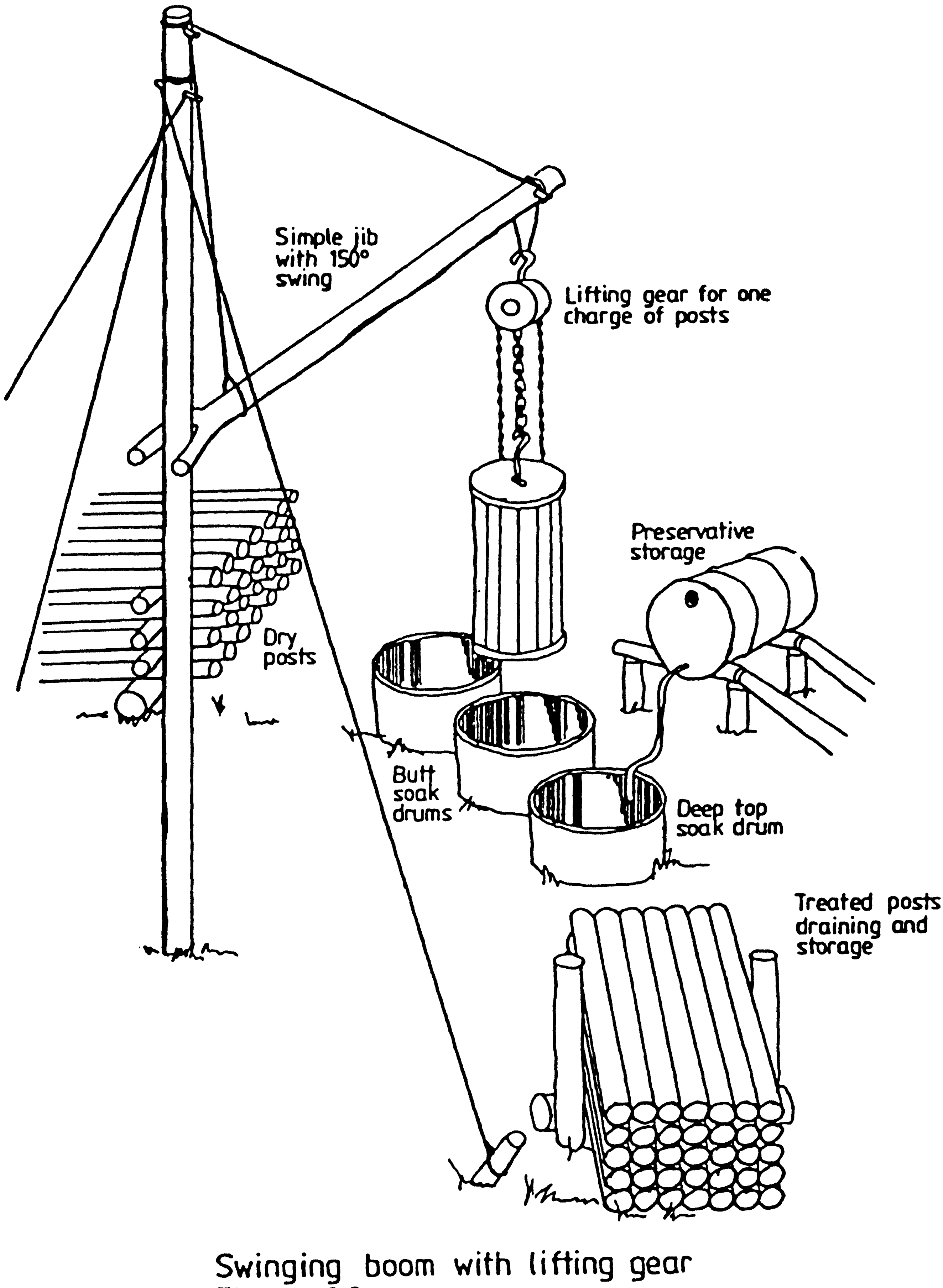
A 200 litre drum to hold about 10 posts



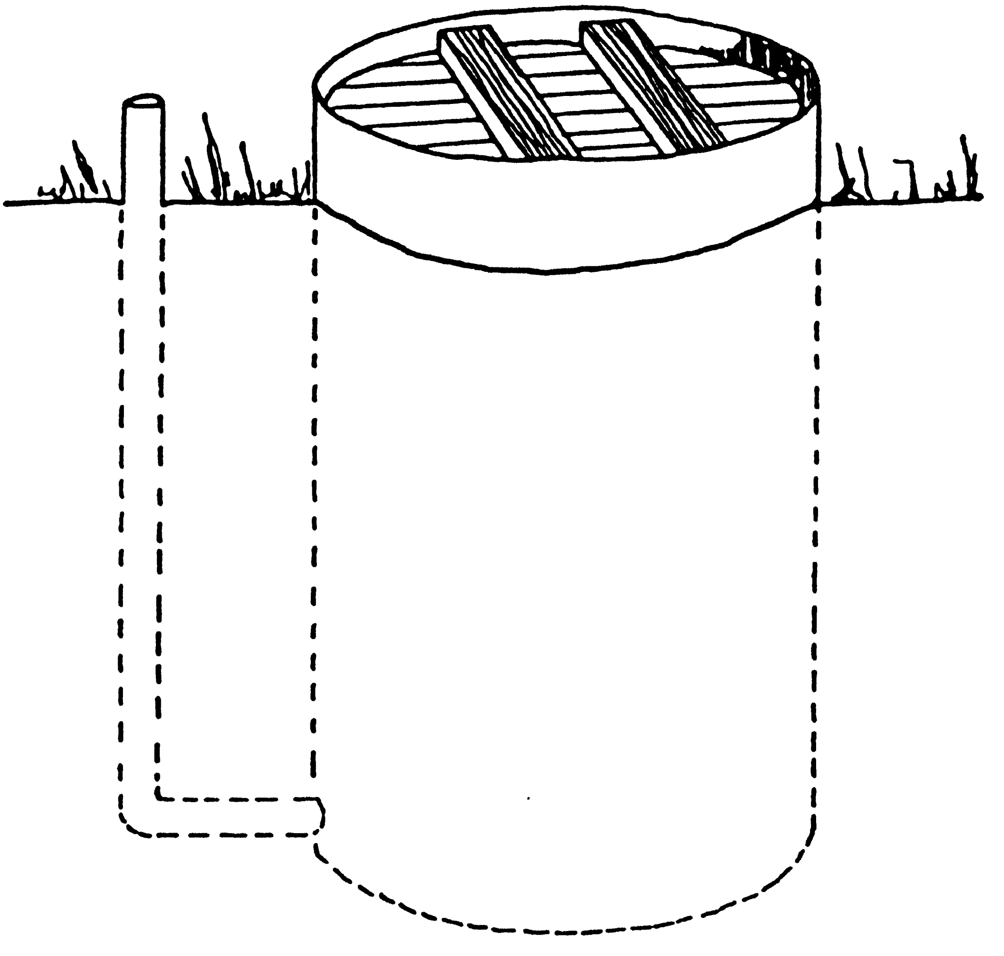
Split drum or trough for draining

Figure 9.1

(Reproduced from CSIRO (Australia) leaflet series No. 12)

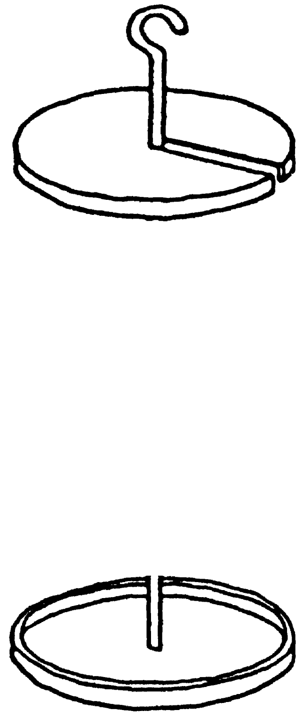


Swinging boom with lifting gear
Figure 9.2
(Reproduced from CSIRO (Australia) leaflet series No. 12)

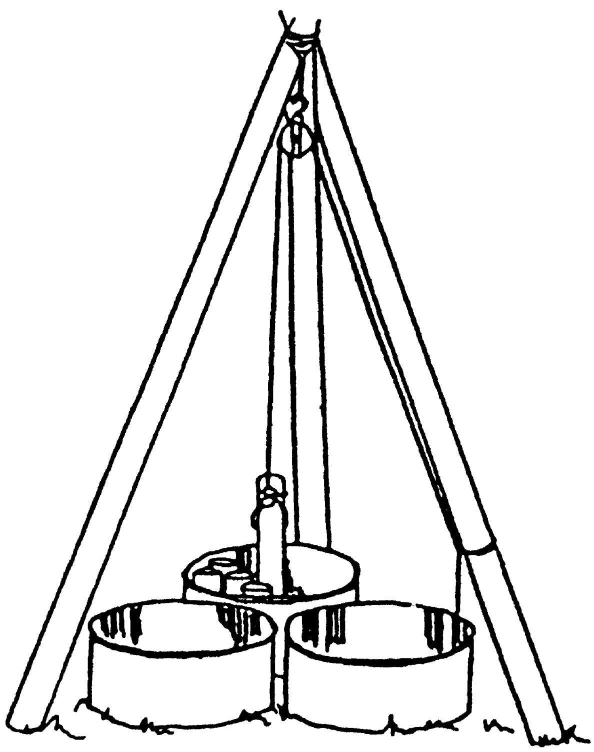


A 2000 litre fuel tank partly sunk in ground and fitted with a pipe for filling and emptying and a holding-down device to prevent posts from floating.

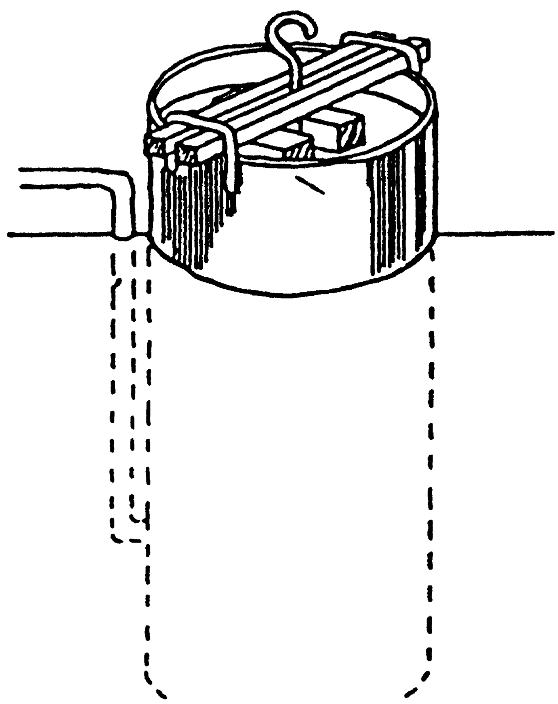
Method of handling posts
Figure 9.3
(Reproduced from CSIRO (Australia) leaflet series No. 12)



Cradle for holding posts



Lifting heavy posts by block and tackle

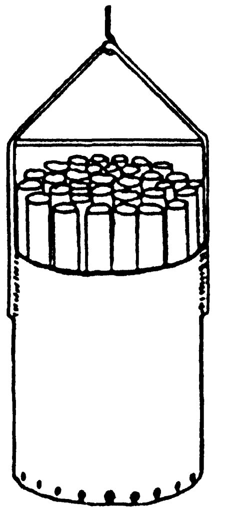


Full-length drum sunk in ground showing device for holding down the cradle

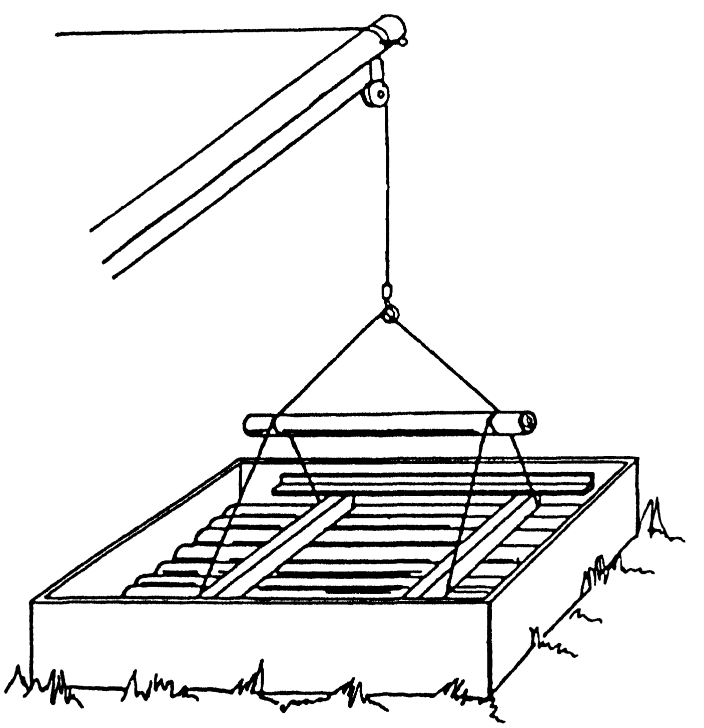
Method for handling posts

Figure 9.4

(Reproduced from CSIRO (Australia) leaflet series No. 12)



Cage for vertical treatment of posts



Tank and lifting gear for horizontal treatment of posts, with holding-down device

Method for handling posts
Figure 9.5
(Reproduced from CSIRO (Australia) leaflet series No. 12)

If the volume of the posts and the weights before and after treatment are known, the amount of preservative absorbed per unit volume (or the retention) could be estimated.

Low Pressure Soaking

Acknowledgement: The information on low pressure soaking was extracted from CSIRO (Council for Scientific and Industrial Research Organization) Forest Products Reprint no. 307: Low pressure soaking by P.J. Moglia.

This is an accelerated version of the cold soaking method and the pressure applied is around 100 kPa depending on the height of the header tank. Using this method, the duration of soak treatment can be reduced from one week to one day or a little less.

A cross section of the plant is shown in Figure 9.6. The main components are a pressure cylinder designed for a working pressure of 100 kPa, a storage tank and a hand pump. It can be mounted on a trailer chassis to make it portable. In addition there is an elevated tank, two 10 metre long plastic hoses and a 2 metre long suction hose. The particular cylinder shown in the figure is 1 metre in diameter and 2 metres long, welded from 4 mm thick steel plate. It can hold 40 to 50 small posts. At the open end two rings of flat bar are arranged to form a circular pocket and welded in place to register with the edge of the door. A length of 12 mm square pressed rubber or neoprene fitted into this pocket is used as a gasket. Four eyebolts and screw dogs, each registering with a pair of lugs on the door are equally spaced round the periphery of the cylinder; hand tightening is sufficient to effect a seal at the pressures used. An air bleed and a connection for the pressure line is provided at the top of the cylinder. The storage tank is welded from 14 gauge steel sheet and the capacity is around 850 litres. A double acting hand pump with a capacity about 100 litres per minute is employed. Three way cocks are fitted on both the suction and delivery sides of the pump and arranged so that the pump can draw from either the bottom of the pressure cylinder or through a flexible hose from a container of preservative and can deliver into either the storage tank or to the elevated tank. Another three way cock is fitted to the storage tank so that the preservative can be run by gravity into the cylinder or through the flexible hose into the container.

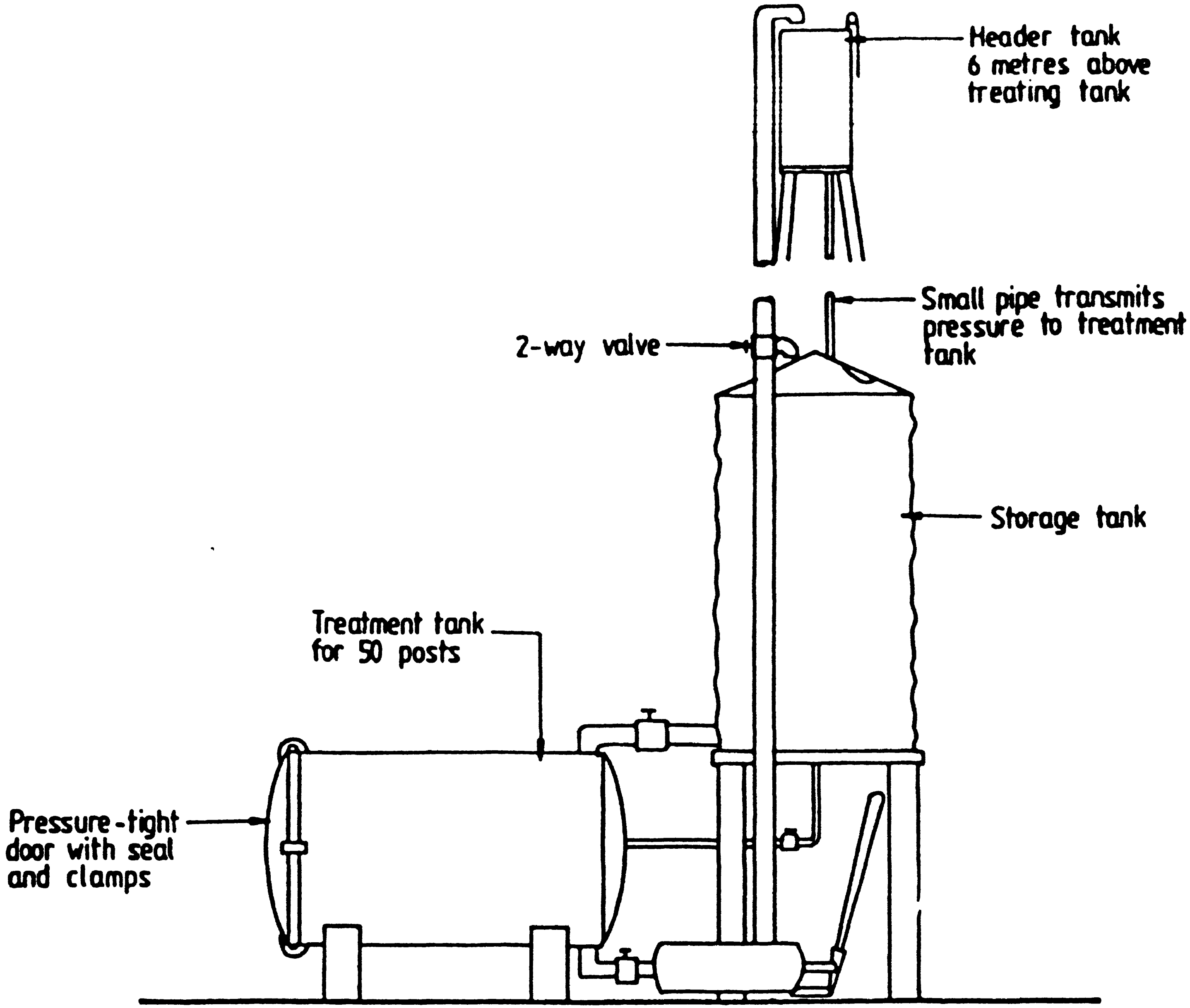


Figure 9.6 ow essure rea en an

The plant is set up on ground level with the cylinder sloping slightly downward from the door end. The pressure line is connected between the elevated tank and the cylinder. The site should be chosen near some structure which will enable the overhead tank to be raised to a height of at least 6 metres.

The operation of the plant is very simple. First the posts are loaded into the cylinder and the door sealed. With the air bleed open, preservative is run from the storage tank till it flows out of the air bleed line. The cylinder is then isolated and the pressure valve opened.

At the completion of the treatment, the pressure valve is closed and the contents of the cylinder are returned to the storage tank. The posts are removed and stacked to drain. Before starting the next treatment the elevated tank should be refilled and the storage tank topped up.

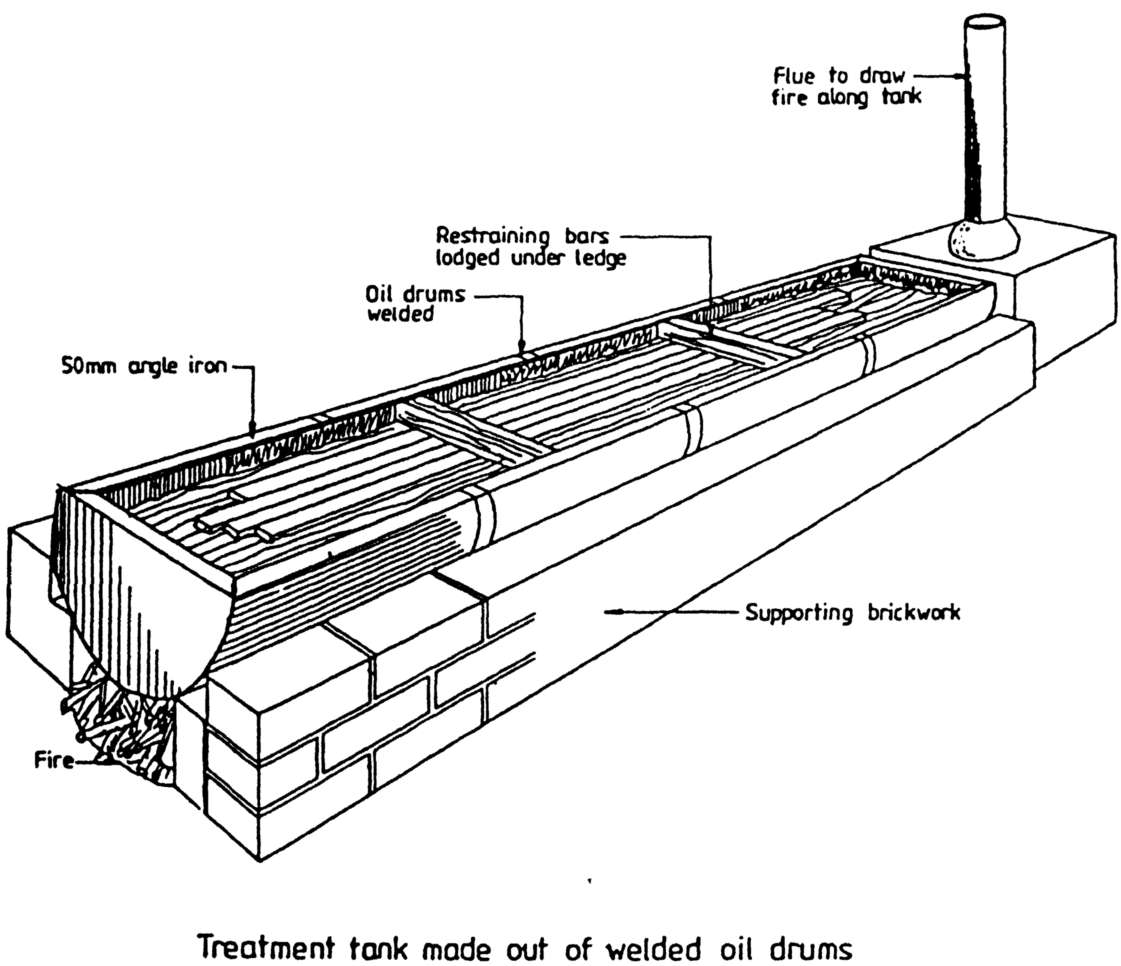
Hot and Cold Bath

As mentioned earlier in Chapter 8, hot and cold bath treatment can be carried out in two ways. One way is to heat the timber in the preservative in a container and let it cool in the same container. The other way is to transfer the timber from the heated preservative solution as soon as possible to a vessel containing the cold preservative. The latter procedure may be advantageous with some water borne preservatives which are liable to decompose when heated to temperatures usually employed in the hot and cold method.

The preservative recommended is creosote or creosote fuel oil mixture (50:50).

Equipment Required

Basic equipment required is a container capable of holding the timber and the preservative and which has the facility of heating. A convenient method is to construct a tank using 200 litre oil drums by cutting them into half and welding them lengthwise and then reinforcing them with angle iron (Figure 9.7). Make a brick foundation leaving space to have an external firing system whilst preventing the risk of the preservative catching fire.



Treatment tank made out of welded oil drums
Figure 9·7

Procedure

The timber to be treated should be dry and preferably having less than 20% moisture content.

Pour the cold preservative into the tank.

Weight a few marked samples and also find their volume.

Submerge the timber in the cold preservative.

Gradually heat it up to about 90°C. (Do not exceed this temperature).

Maintain this temperature for about one hour to three hours. This depends on the size and timber species, etc..

Allow it to cool or transfer the timber quickly into another vessel containing the cold preservative and keep it submerged.

Remove the timber after cooling and let the excess preservative drain.

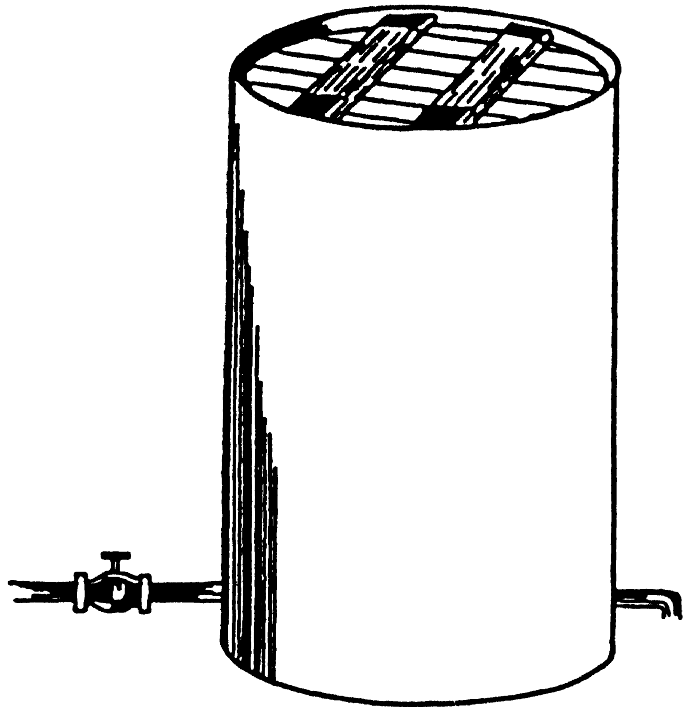
Reweigh the marked samples.

Calculate the preservative absorbed.

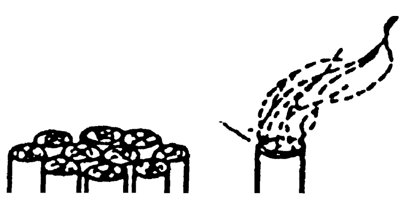
Adjust your heating period to obtain the required retention (Refer Table 9.3).

If too much preservative is absorbed by the wood, then some of the preservative could be expelled by reheating and removed while the timber is still hot. In this event the duration of the cooling period should be reduced in the next batch or the next charge. For less permeable timbers, it may be possible to increase the penetration by increasing the length of time of the heating period or by repeating the heating and cooling treatment.

A variation of this treatment which is often used to treat small numbers of fence posts is the butt treatment method. In this case dry fence posts are kept in a drum with their butt ends immersed in the preservative (creosote or creosote mixture) as shown in the Figures 9.8 and 9.9. The procedure is the same as that



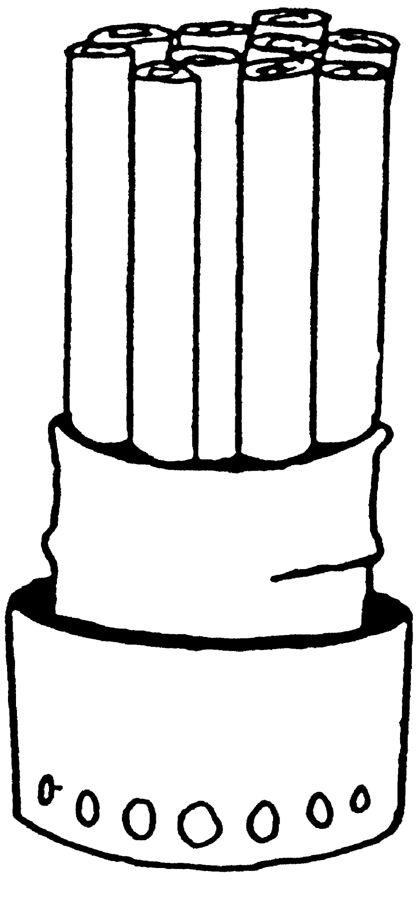
If steam is used for heating, a continuous coil in the bottom of the drum is connected to a steam inlet and outlet through the wall of the drum. A fixed stand above the coil to keep the posts off it is essential, as also is a simple steam trap on the outlet.



A covered fire-place into which the drum is set, and fitted with a flue, as illustrated is simple to construct and removes any likelihood of the preservative boiling over on to the fire. It also simplifies maintaining an even temperature.

Hot and cold method of treatment

Figure 9.8
(Reproduced from CSIRO (Australia) leaflet series No. 12)



Heating with kerosene pressure burner protected by sheet-iron wind shield.

Hot and cold treatment for fence posts

Figure 9.9

(Reproduced from CSIRO (Australia) leaflet series No. 12)

described previously. The top end can be treated by brushing with hot preservative or if the exterior conditions are hazardous, the treatment can be repeated with the top end immersed.

If the treatment is to be carried out on a large scale, then it is advisable to employ steam to heat the preservative. Figure 9.10 (reproduced by permission from the Forestry Commission, UK) shows a typical arrangement for creosoting fence posts.

Sap Displacement Method

As discussed earlier, this method could be applied only to freshly felled round timbers such as fence posts and poles. The most common method is the Boucherie process, but there are a few variations to this method.

Method 1

This method can be used only for young trees which are sometimes called saplings. These saplings are normally obtained from thinnings of forest plantations. However, these saplings should have a layer of sapwood at least 25 mm thick. The freshly cut saplings are debarked and stood up in a bucket of preservative solution for a few days.

The preservative used for this treatment is a solution of CCA salts.

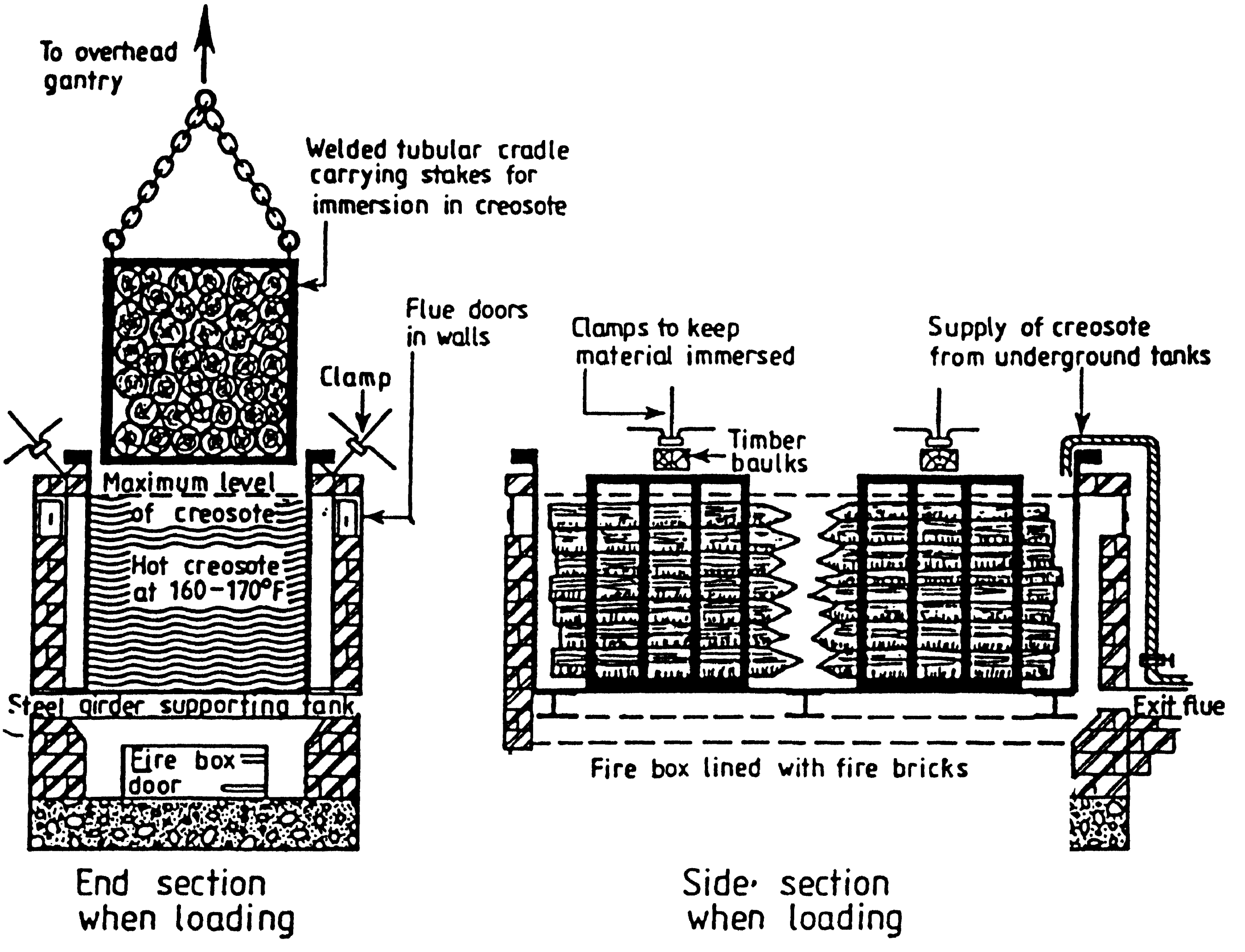
Important: CCA (Copper-Chrome-Arsenic) salts are very poisonous and great care should be taken when handling. To avoid any accidents the precautions given in Chapter 12 should be strictly adhered to.

Procedure

Make a 5% CCA solution. (CCA power is highly poisonous and you should not breath its dust. Respirators should be worn always when handling CCA salts.).

The posts should be treated as soon as they are felled.

First remove the bark of the freshly felled saplings. Care should be taken not to damage the surface of the posts.



Typical arrangement for creosoting of fence posts

Figure 9.10

(Crown copy right – reproduced by permission from Forestry Commission- Forest Record No. 44)

Cut the posts into lengths a little longer than the required length.

Keep the posts in a container, preferably a plastic bucket (one bucket for each post), with the butt end down. Rest the posts against a fence or a tree to prevent them falling over (see Figure 9.11).

Fill the buckets with the preservative solution.

Tie a piece of polythene or plastic sheet around the top of each bucket (Figure 9.11) to prevent rain water getting in and to avoid evaporation.

Turn the post halfway round in the bucket every day.

Make sure children or animals do not go near the treatment area.

Add more preservative solution to the bucket to replace the preservative absorbed by the post.

Remove the posts when the level of the solution stops going down which means that no preservative is being absorbed. Normally this takes around a week for a post of 100 mm diameter and 3 metres long.

Cut the posts to the required lengths.

Before using it is advisable to coat both ends with hot tar or hot bitumen.

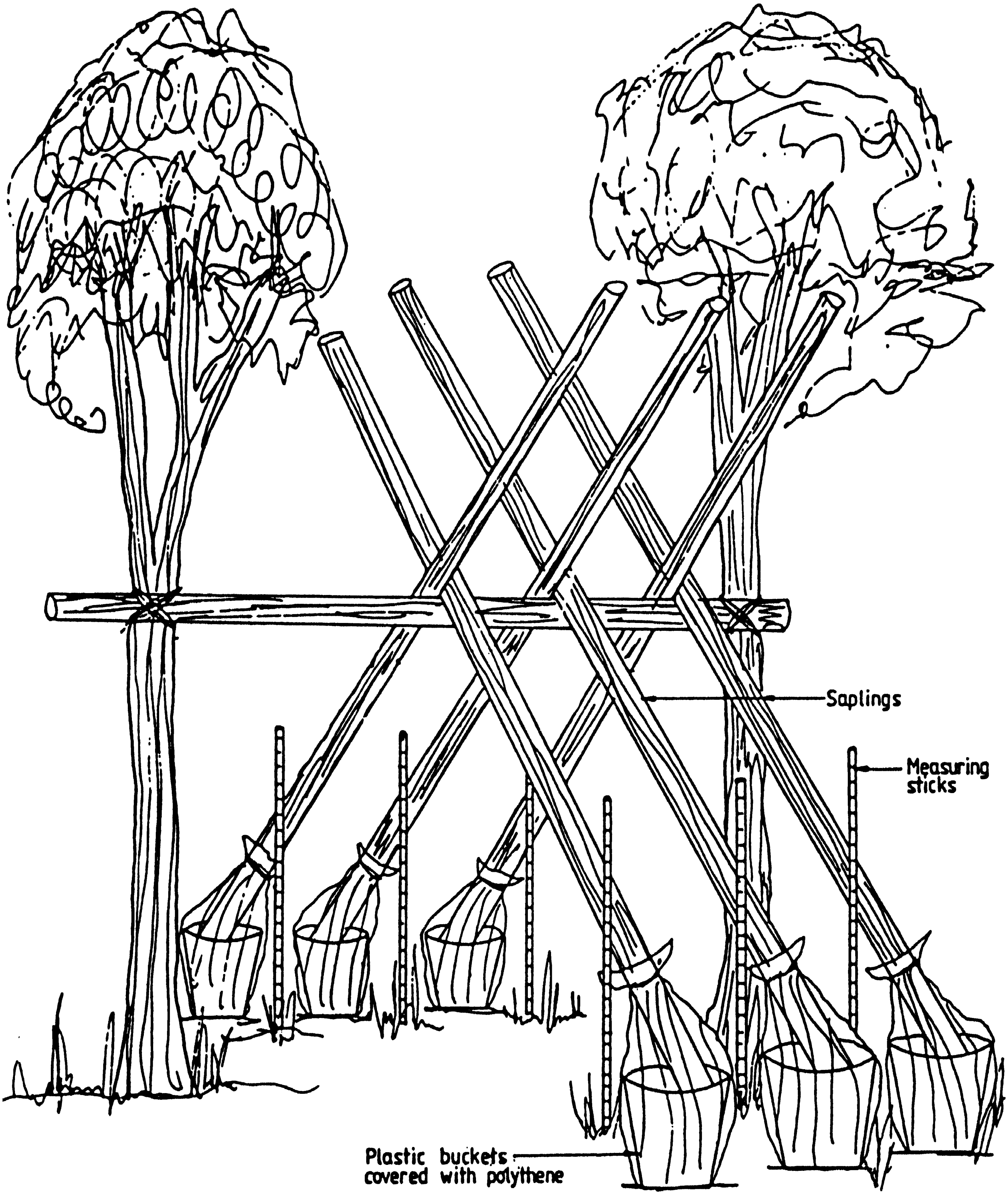
Method 2

This is the modified Boucherie process where freshly felled unpeeled logs are placed with their butt ends slightly higher than their top ends, and water tight caps are fitted to the butt ends.

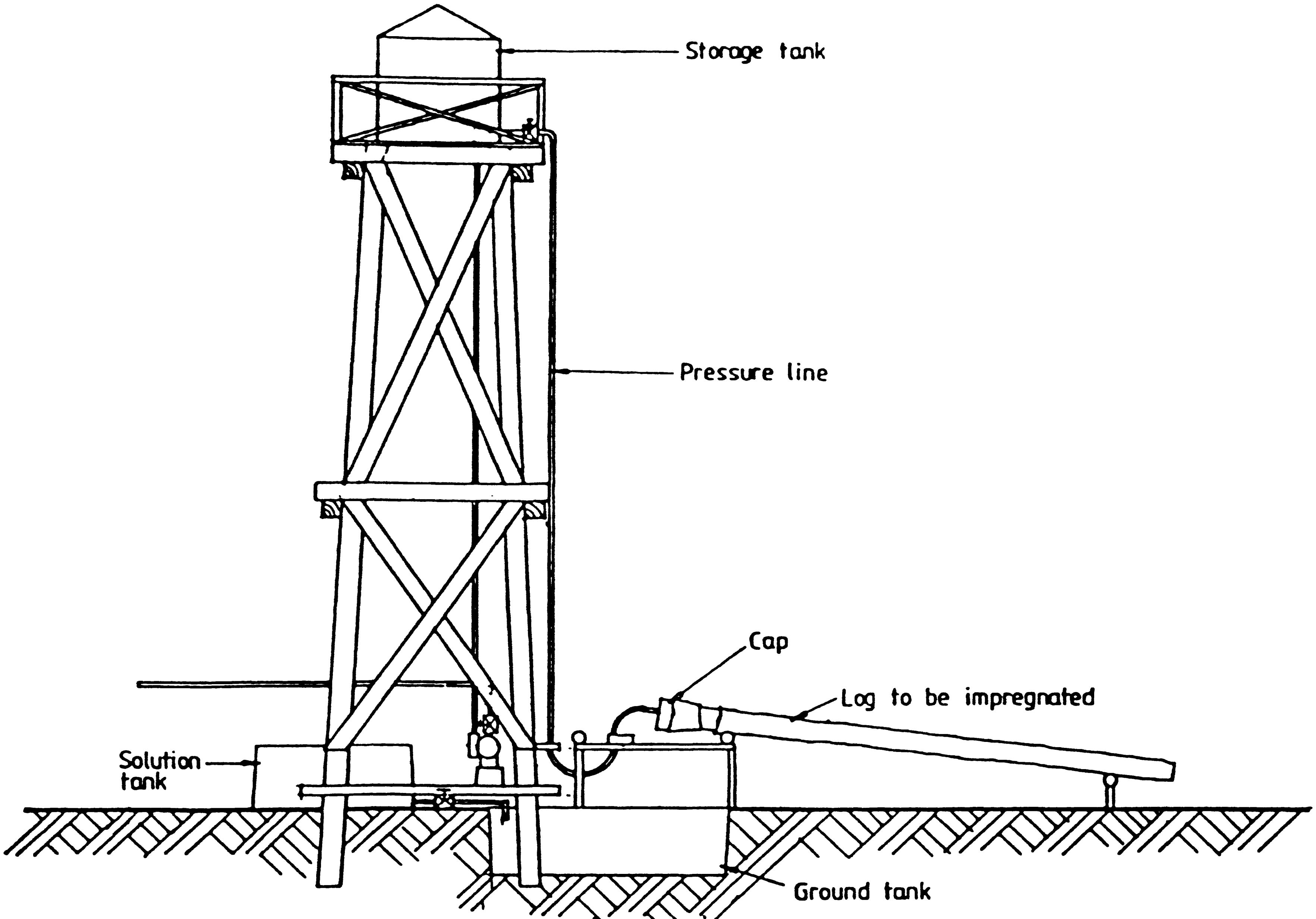
Fix the header tank (storage tank) as high as possible (Figure 9.12).

Remove the bark from the butt end of the freshly cut pole for about 100 mm to 150 mm leaving a smooth, clean surface so that a water tight seal can be made against the wood with rubber (tyre tube).

Connect a hose pipe from the header tank to the cap at the butt end of the freshly cut unpeeled poles. Caps can



Sap displacement method
Figure 9.11



Typical arrangement for Boucherie process
Figure 9.12

be made out of galvanised sheets and connected to the pole using a piece of an old tyre tube in a ring form (see Figure 9.13).

Fill the header tanks with 5% preservative solution.

After sometime it will be seen that sap emerges out from the top end which shows that the preservative has come through.

Alternatively it is possible to treat posts without a header tank. One method is to use a polythene bag (fairly thick gauge) containing the preservative solution tied to the butt end of the pole as shown in Figure 9.14. The polythene bag should be supported using sticks driven into the ground.

The other method is to use only a tyre tube (Figure 9.15).

The procedure is:

Remove as described earlier the bark from the butt end of the freshly cut pole for about 100 mm to 150 mm leaving a smooth, clean surface so that a tight joint can be made between the wood and the rubber.

Grease the peeled surface and insert the tube (see Figure 9.15). The diameter of the tube should be much smaller than the diameter of the post.

Place the post on a stand with the butt end elevated.

Tie the loose end of the tube.

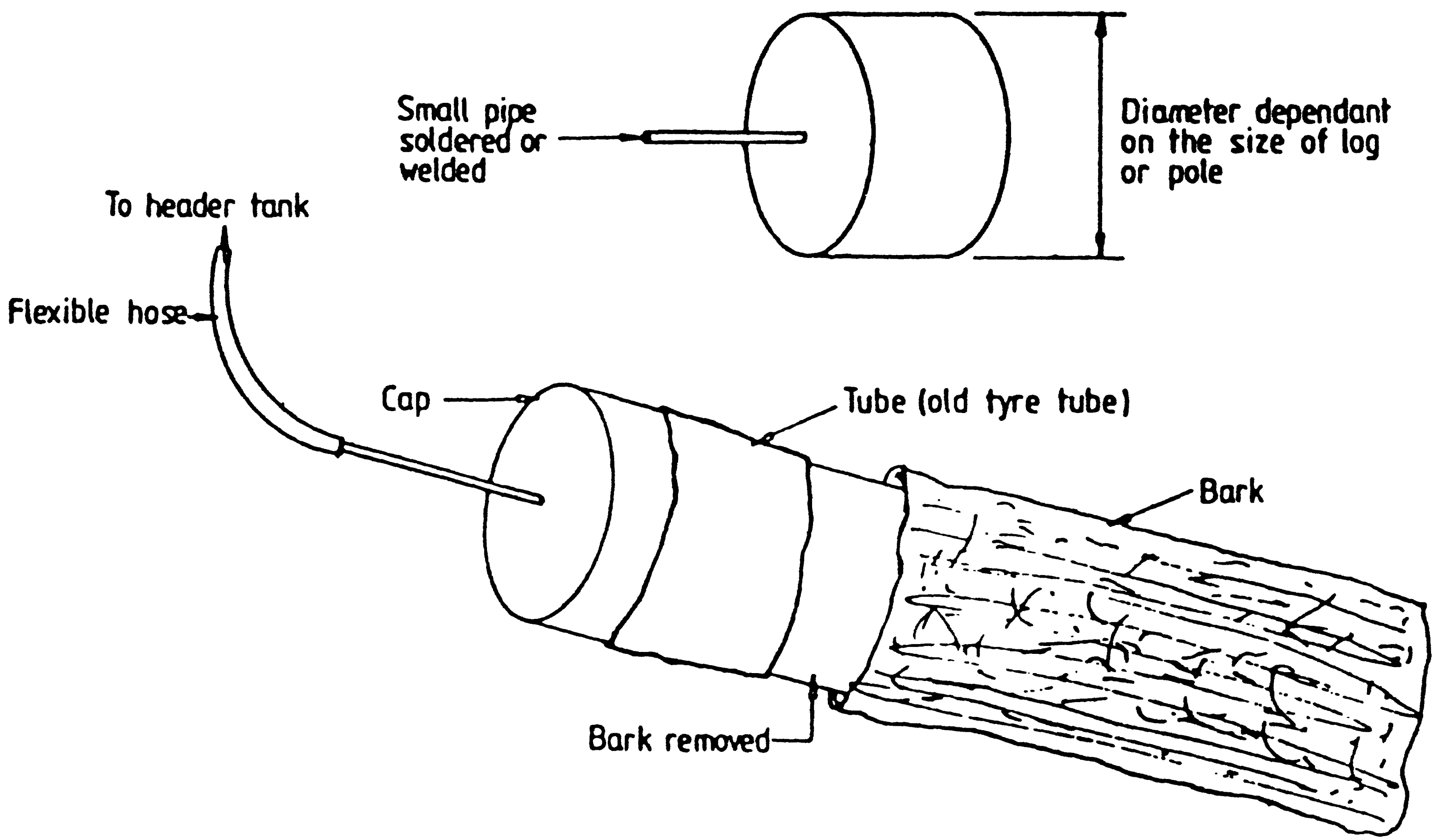
Pour the preservative solution into the tube.

As in the earlier case the preservative mill will push out the sap through the top end.

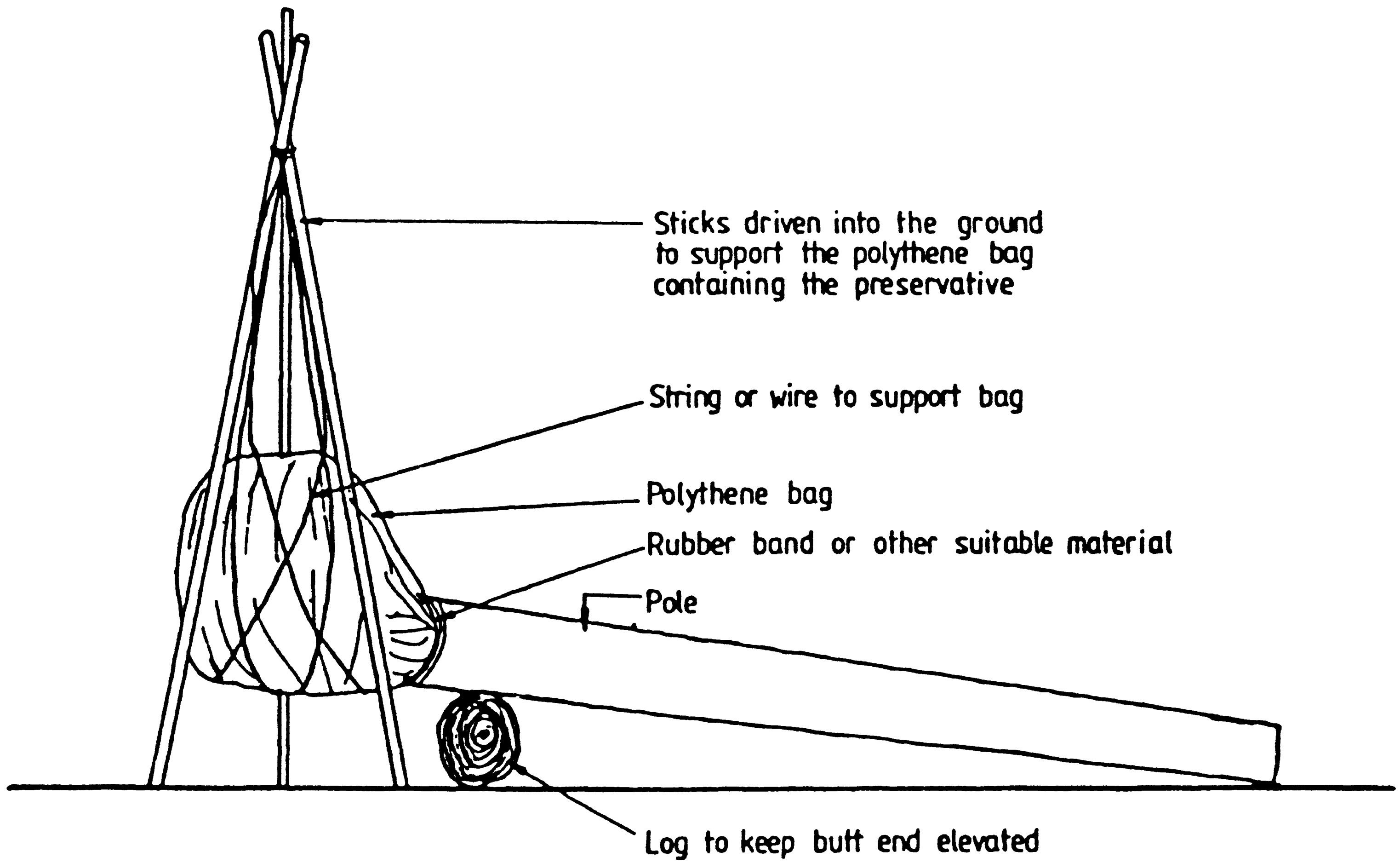
After the preservative has flowed into the wood, remove the posts and stack for seasoning.

Pressure cap

Figure 9.16 shows the details of a pressure cap which has been developed in Australia by CSIRO. If the seal is made properly, the preservative can be forced into the butt end using an external pressure system. The accompanying Table 9.4 gives the details of fittings for different diameters of logs.

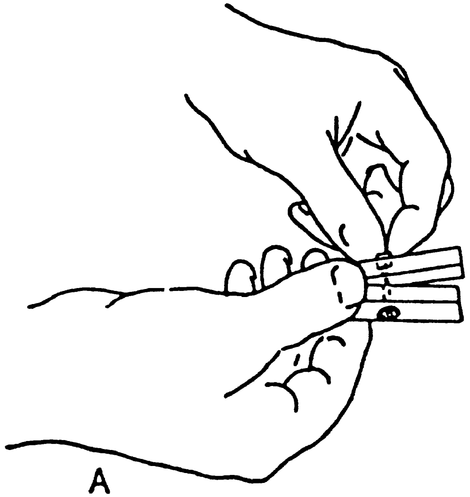


Cap for log end
Figure 9.13

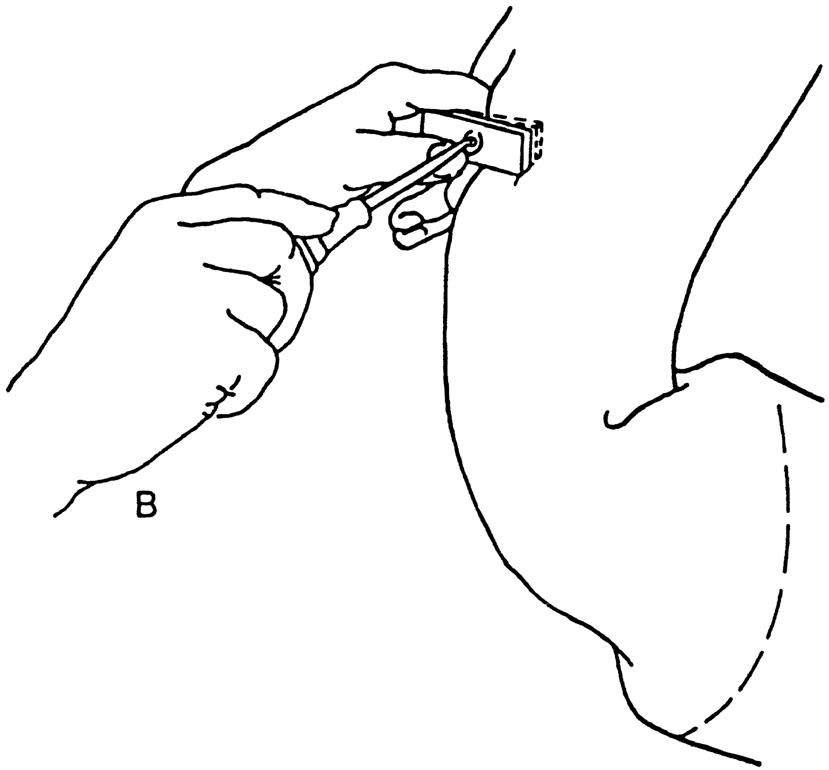


Sap displacement method

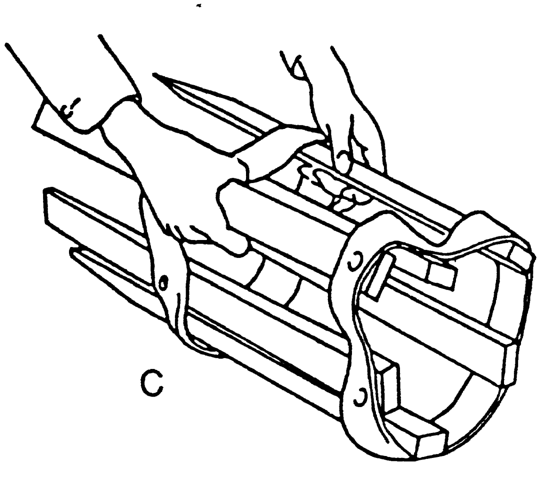
Figure 9.14



A



B



C

A, A simple clamp made with two small pieces of wood and a stove bolt, which can be used for stopping small leaks in tyre tubes; B, Attaching the clamp to a tube to stop a small leak; C, A tube stretcher made with six hardwood sticks and two rubber bands cut from an inner tube. One end of each stick is tapered. The bands and sticks are fastened together with large-headed roofing nails

Figure 9.15

Reproduced from FPL. Report No. 1158 – Forest Products Laboratory, USA

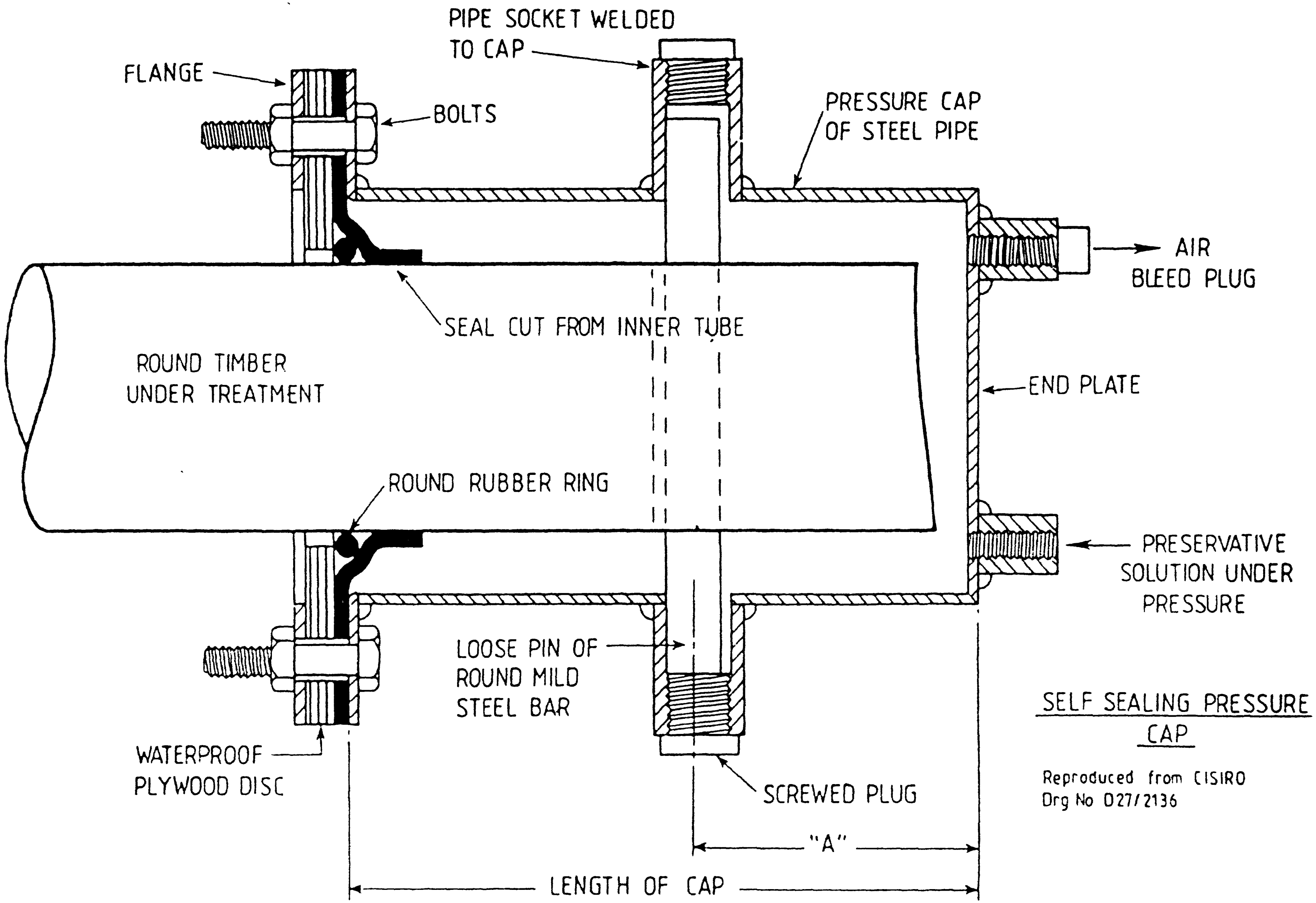


Figure 9.16

To be read in conjunction with Table 9.4.

TABLE 9.4

Table of Suggested Sizes					
	Pipe Size				
	6in	9in	12in	18in	24in
Number of Bolts	6	8	12	12	16
Size of bolts	3/8"	1/2"	1/2"	5/8"	3/4"
End Plate Thickness	3/16"	1/4"	1/4"	3/8"	1/2"
Flange Thickness	1/4"	3/8"	3/8"	1/2"	5/8"
Loose Pin Size	3/4"	1"	1 1/2"	2"	2 1/2"
Pipe Socket Size	3/4"	1"	1 1/2"	2"	2 1/2"
Ply Disc Thickness	3/8"	1/2"	3/4"	3/4"	3/4"
Bolt Pitch Circle Diameter	9"	12"	16"	22"	30"
Minimum Bolt Length	2"	2 1/2"	3"	3 1/2"	4"
Length of Cap	10"	12"	15"	18"	24"
Flange Diameter	12"	15"	20"	26"	36"
Distance "A"	4"	6"	8"	10"	14"

Notes: Bolt heads may be welded to flange to simplify loosening and tightening. Solid timber of the same thickness as the plywood disc or steel bars of half the thickness may be clamped between the flanges to prevent extrusion of the seal.

A thinner dished end may be used instead of flat plate to reduce weight.

This design has not been tested except in the 6" pipe size and some modifications may be desirable in the light of this experience.

To be read in conjunction with Figure 9.16.

Diffusion Treatment

Diffusion treatment can be done in three different ways:

(a) Treating piece by piece by dip diffusion.
(b) Treating parcels of timber by dip diffusion.
(c) Treating by spray tunnel application.

(a) Treating piece by piece by dip diffusion

Main equipment required: dip tank large enough to hold the largest timber to be treated, cover for dip tank, heating facilities, polythene or tarpaulin for covering the close piled timber, thermometer, hydrometer and jar.

Dip Tank

A trough, 6 m long, 0.5 m wide and 0.5 m deep could be constructed out of 4 mm thick steel. Two hundred litre drums cut in half longitudinally and welded to make a water tight tank of sufficient length can form a suitable vessel for a dip tank. The dip tank or the trough should be firmly supported on legs at a convenient height usually about 0.5 m above the ground.

Heating the dip tank can be done by using either a direct open fire under the tank or by fitting a coil, through which steam or hot air could be passed. If cheap electrical power is available, an immersion heater could be employed satisfactorily.

A tank cover is required to prevent rain water or dirt getting into the tank when it is not in use. The cover can be constructed out of timber or a suitable sheet material and should be placed over the tank whenever it is not being used. It will be convenient if the cover can be secured at an angle to the edge of the tank so that the boards after removal from the dip solution can be rested on the cover for draining. Thus the solution can flow back over the cover into the tank.

Chemicals recommended:

Mixture of 1.54 parts - Borax and 1.00 part - Boric acid or mixture of 1.18 parts - Neobor and 1.00 part - Boric acid or proprietary mixtures such as "TIMBOR" ("TIMBOR" is a registered trademark of Borax Consolidated Limited).

Borax is sodium borate with 10 molecules of water of hydration; Neobor is the same salt with 5 molecules of water of hydration. Solution strengths are expressed as Boric Acid Equivalent which is commonly referred to as B.A.E.. The amount of chemicals required for each of the mixture is given in Table 9.5.

Stain and Mould Control

Sodium pentachlorophenate (NaPCP) should be added to the solution to prevent mould and stain developing on the timber during the diffusion period. The quantity varies from 1% to 2%.

Procedure

Make up the required solution using Table 9.5. If adjustments of solution concentrations are needed, these can be done according to Tables 9.5A, B and C. Figure 9.17 shows how to determine the solution concentration by using the hydrometer reading.

Heat the solution to the temperature indicated in Table 9.6, which also shows the recommended solution strength for various thicknesses of timber.

Prepare the timber for treatment (Figure 9.18).

Timber for treatment should be cut from logs which have been felled not more than seven days earlier.

If the timber cannot be treated just after sawing, it should be block stacked and treated within 48 hours after being cut.

Sawn timber should be free of saw dust, mud or any other dirt.

Timber which is surface wet with rain water must not be treated as the uptake of solution can be considerably reduce. Timber for treatment should be stacked as near as possible to the tank.

Loops or coir rope or hooks or loops of 8 mm reinforcing steel bars have been found satisfactory for handling the boards.

Two men, one at each end, can immerse boards completely in the solution, board by board.

TABLE 9.5

CALCULATION CHART FOR PREPARATION OF BORON SOLUTIONS PER 1000 LITRES

Desired Solution Concentration	Required Quantities of Borates for Concentration	
Percentage (Boric Acid Equivalent)	Neobor kg.	Boric Acid kg.
20	118	100
21	124	105
22	130	110
23	136	115
24	141	120
25	147	125
26	153	130
27	159	135
28	165	140
29	171	145
30	177	150
31	183	155
32	189	160
33	195	165
34	200	170
35	206	175
36	212	180
37	218	185
38	224	190
39	230	195
40	236	200

Note: Borax may be substituted for Neobor by using one-third more borax than Neobor.

TABLE 9.5A

CALCULATION CHART FOR ADJUSTMENT
OF BORON SOLUTIONS PER 1000 LITRES

Indicated Solution Concentration	To adjust to 25 percent Boric equivalent		
Percentage (Boric Acid Equivalent)	Neobor kg.	Boric Acid kg.	Water litres
20	30	25	
21	24	20	
22	18	15	
23	12	10	
24	6	5	
25	--	--	---
26			33
27			67
28			100
29			133
30			167
31			200
32			233
33			267
34			300
35			333

Note: Borax may be substituted for Neobor by using one-third more Borax than Neobor.

TABLE 9.5B

CALCULATION CHART FOR ADJUSTMENT OF BORON SOLUTIONS PER 1000 LITRES

Indicated Solution Concentration	To adjust to 30 percent boric equivalent		
Percentage (Boric Acid equivalent)	Neobor kg.	Boric Acid kg.	Water litres
20	59	50	---
21	53	45	---
22	47	40	---
23	41	35	---
24	36	30	---
25	30	25	---
26	24	20	---
27	18	15	---
28	12	10	---
29	6	5	---
30	--	--	---
31	--	--	33
32	--	--	67
33	--	--	100
34	--	--	133
35	--	--	167
36	--	--	200
37	--	--	233
38	--	--	267
39	--	--	300
40	--	--	333

Note: Borax may be substituted for Neobor by using one-third more Borax than Neobor.

TABLE 9.5C

CALCULATION CHART FOR ADJUSTMENT OF BORON SOLUTIONS PER 1000 LITRES

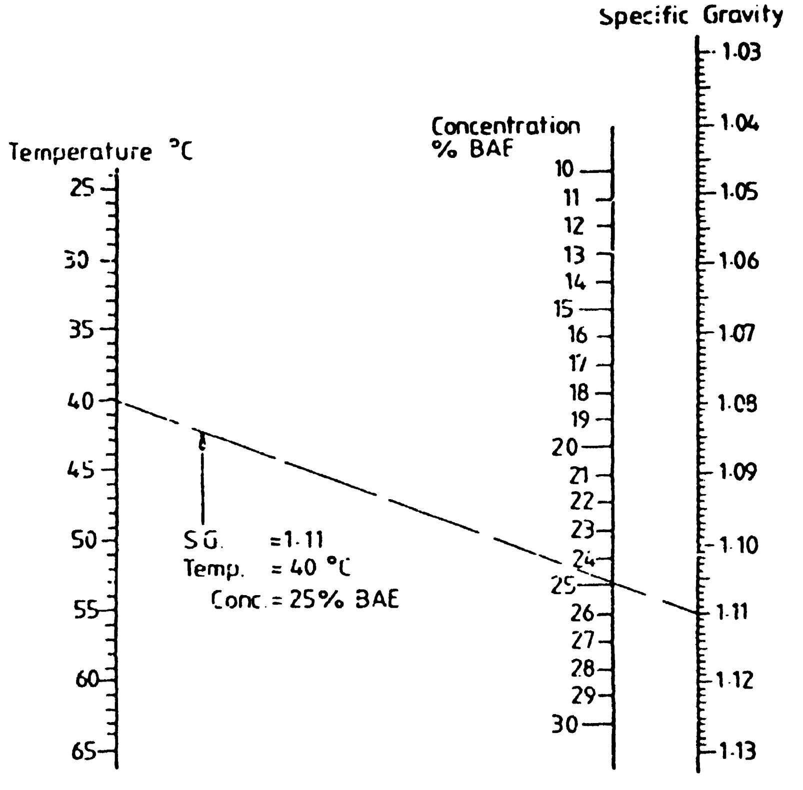
Indicated solution Concentration	To adjust to 35 percent Boric equivalent		
Percentage (Boric Acid Equivalent)	Neobor kg.	Boric Acid kg.	Water litres
25	59	--	---
26	53	--	---
27	47	--	---
28	41	--	---
29	36	--	---
30	30	--	---
31	24	--	---
32	18	--	---
33	12	--	---
34	6	--	---
35	--	--	---
36	--	--	33
37	--	--	67
38	--	--	100
39	--	--	133
40	--	--	167

Note: Borax may be substituted for Neobor by using one-third more Borax than Neobor.

Figure 9.17

SOLUTION CHART

(Specific gravity - Temperature - Concentration)



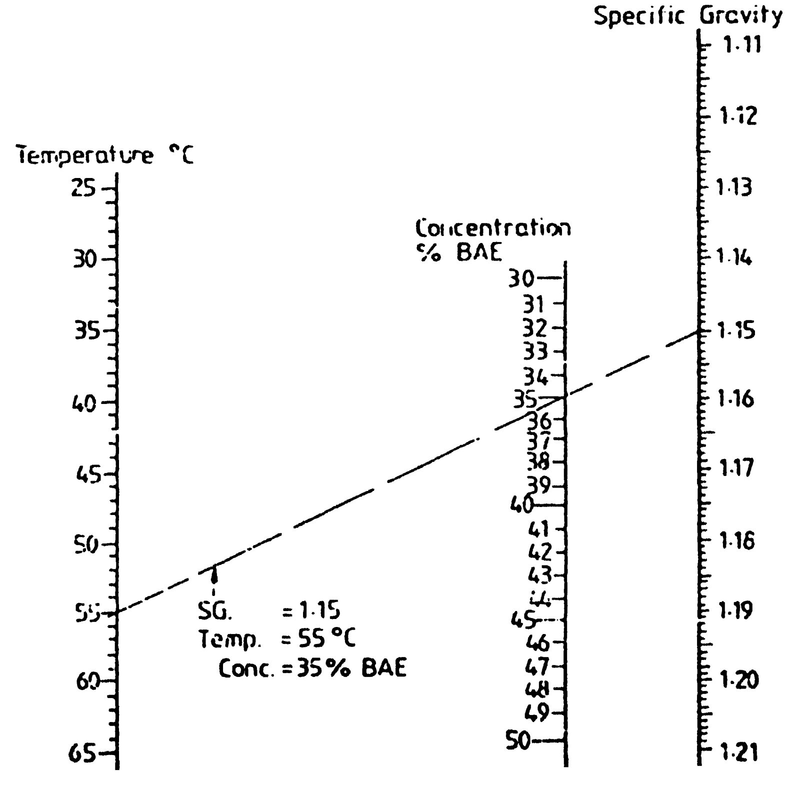


TABLE 9.6

WORKING SOLUTION STRENGTHS AND OPERATING TEMPERATURES

Thickness of Timber (mm)	Solution Concentration Weight/volume BAE %	Minimum Operating Temperature deg.C
25	25	46
38	30	52
50	35	55
75	45	58

TABLE 9.7

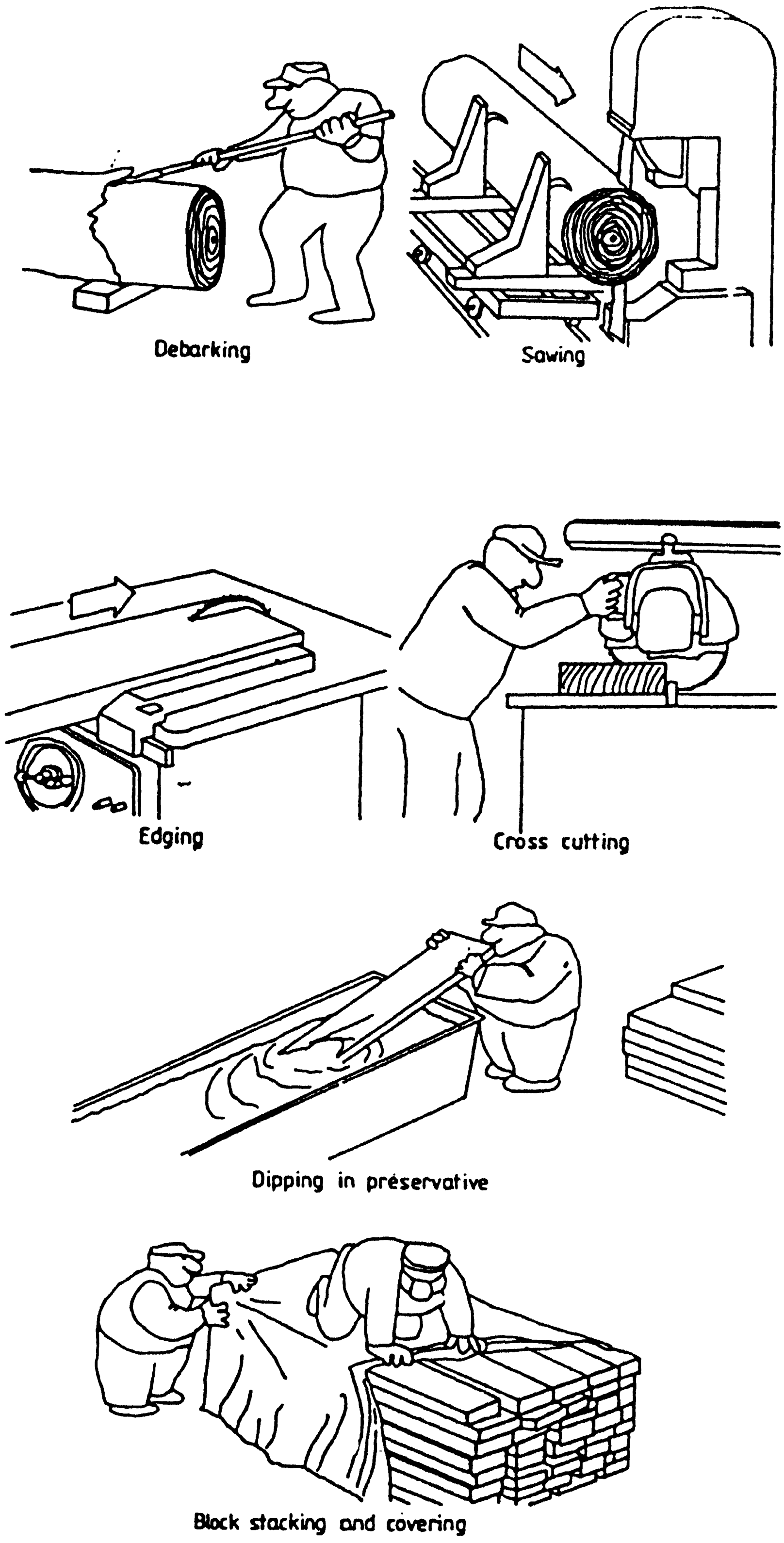
MINIMUM DIFFUSION PERIODS

Actual Timber Thickness (mm)	Minimum Diffusion Period (weeks)
25	4
38	6
50	8
75	14 - 16

TABLE 9.8

APPROXIMATE RETENTION

Colour	Bright Red	Red Brown to Brown Yellow	Yellow
Retention kg/m^3 (BAE)	1.28 or more	0.96	0.32



Diffusion Treatment
Figure 9.18

The time for immersion is the minimum time necessary to completely immerse each piece.

After immersion, the pieces of timber should be removed from the solution and held over the solution or on the draining board (as mentioned earlier) until excess run off of solution has stopped.

After dipping, all parts of the surface of each board must retain sufficient solution, and hence chemical, to ensure the correct preservative loading. This can be done either by chemical analysis of at least two cross sections of boards after dipping and draining or by the following method.

Weigh to at least 10 g accuracy, four full length pieces of timber before and immediately after dipping and draining. Calculate from the weight increase and solution strength the total Boric Acid Equivalent (BAE) uptake. Determine by measurement the volume of each test piece in cubic metres. Calculate the Boric Acid Equivalent per cubic metres. The BAE uptake should not be less than 5 kg/m^3.

Note that checking for correct solution uptake is particularly important when starting treatment of a new species of timber which has been cut on a new or different saw than usual.

If the calculation of solution uptake is confirmed by further samples as less than 5 kg/m^3, take necessary action to:

(a) Increase dip solution strength;
(b) Experiment to see if dipping times can be adjusted to give required results;
(c) Inspect to see if surface texture of timber is abnormal or can be altered by saw change to improve solution pick up;
(d) Test to see if redipping of timber after a period of diffusion gives the required solution uptake.

After dipping, store the timber close piled (block stacked) as near as possible to the dip tank. The bottom stack should be 50 mm off the ground and all boards stacked uniformly so that the portion of the surface of any piece of timber not covered by other boards is as small as possible.

Immediately after stacking is completed, cover the timber with polythene, tarpaulin or any impervious material preventing any air circulation with the stack. This is to avoid any drying of the treated timber during the diffusion period.

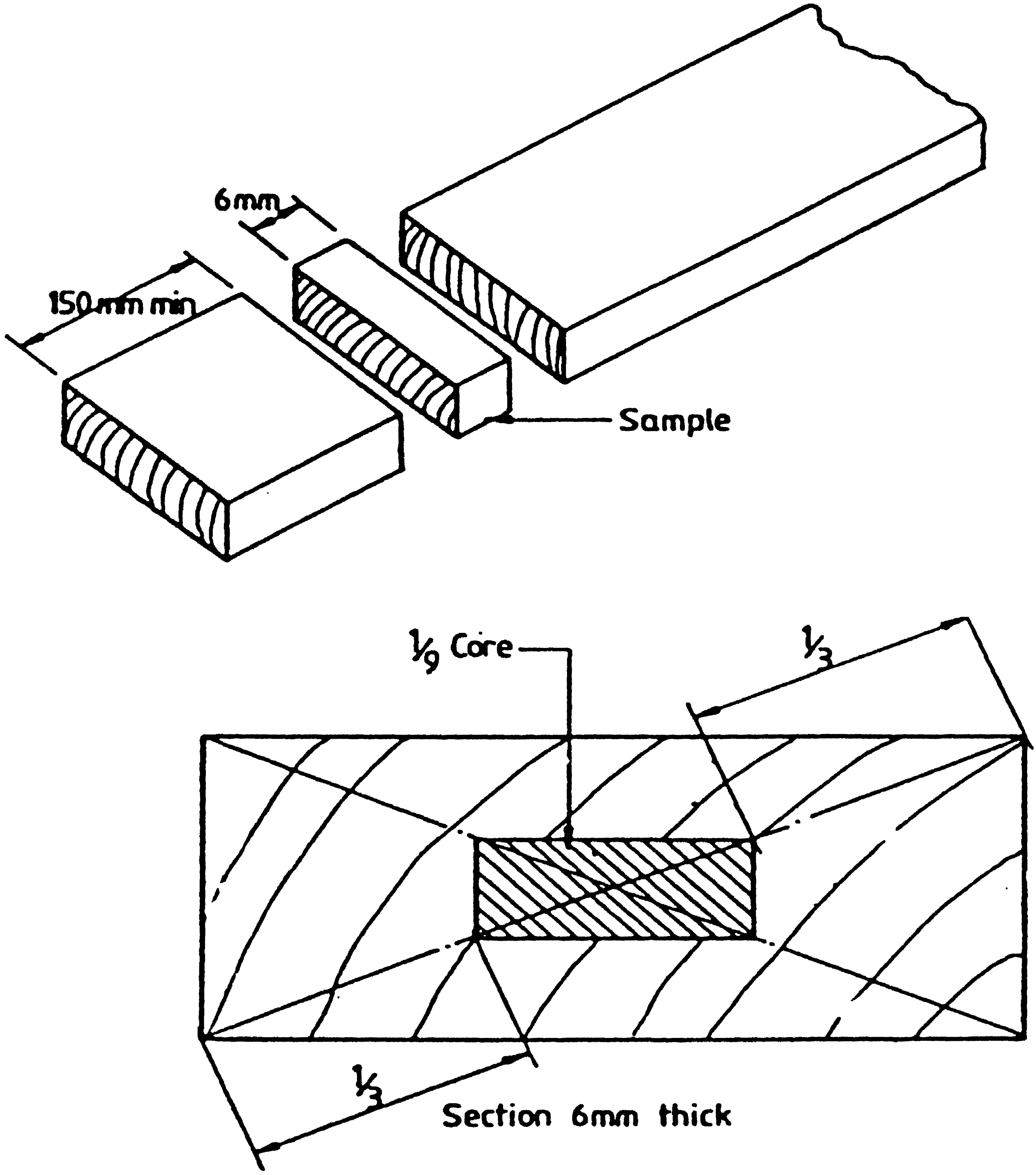
Keep the stacks covered until full penetration is obtained. The minimum diffusion periods are given in the Table 9.7.

Timber samples should be spot tested at the end of these diffusion periods and if 10% of the samples or more show defective penetration, extend the diffusion period and carry out further spot tests. Test procedure to determine the depth of penetration is as follows:

The testing reagents consist of two solutions:

(a) Solution 1 containing 10% alcoholic extract of tumeric.
(b) Solution 2 containing 6 g of salicylic acid in 20 ml of concentrated hydrochloric acid diluted to 100 ml of ethanol.

Cut a thin cross section about 6 mm thick at least 150 mm from the end of the timber to be tested (see Figure 9.19). The cutting should be done with a fine saw to get best results. Carefully dry the timber before the test is carried out. This drying can be done in a small oven similar to the type used by kiln operators employing a temperature of around 60°C. Air drying can be done if time permits. Apply Solution 1 (see above) as a fine spray to all surfaces of the timber cross section and allow to dry for a few minutes. Then apply Solution 2 (see above) in the same manner and allow to dry for a further few minutes. The approximate quantity of boron present in the wood can be judged by the colour change. Table 9.8 gives the range of colours and the approximate quantity of boron present, expressed as a percentage of boric acid on the oven dry weight of the wood. The timber must be retained under diffusion storage conditions until retention at the "core" attains a minimum 0.20% to 0.25% Boric Acid Equivalent to the oven dry weight of the timber, i.e. the "core" must show a colour change of red brown or brown yellow. The "core" is defined as 1/9th of the cross section taken at the geometrical centre (see Figure 9.19). It is imperative that all the charges of timber are properly tested at least by spot test.



Sampling and definition of core

Figure 9.19

(a) Treatment of Timbers Thicker than 50 mm

Immerse the timber in a solution of 30% concentration at a temperature of 50^{o}C.

Give a second immersion between two and four days after the initial immersion.

During the intervening period, cover the timber with polythene or other means to prevent loss of moisture.

Following the second immersion block stack the timber and cover for a period of at least 12 to 16 weeks.

Table 9.9 shows a method of keeping records of the treatments.

(b) Treating parcels of timber by dip diffusion

Treatment is carried out in the same way except the timber is close piled in parcels of suitable size for the immersion tank.

Place the timber parcel in a cradle of sufficient weight to immerse completely the packet in the treating solution (see Figure 9.20).

Raise and lower the parcel in the tank four or five times to ensure all the surfaces of the timber within the parcel are completely wetted by preservative solution. This could be achieved by having the timber loosely packed so that during the above movement, the timber will tend to float and the solution will come into contact with all surfaces of the timber.

Keep only one thickness of timber in any one parcel.

Insert fillets about 13 mm thick in every six to ten boards. These fillets will facilitate the opening up of the packet during the immersion process.

As earlier, close pile the timber and cover with polythene or tarpaulin.

(c) Treating by spray tunnel application

Spray tunnel application is one of the best methods of treating timber by diffusion on a large scale. A spray tunnel should be constructed as shown in Figure 9.21. In this process the individual boards are

TABLE 9.9

TREATMENT RECORDS

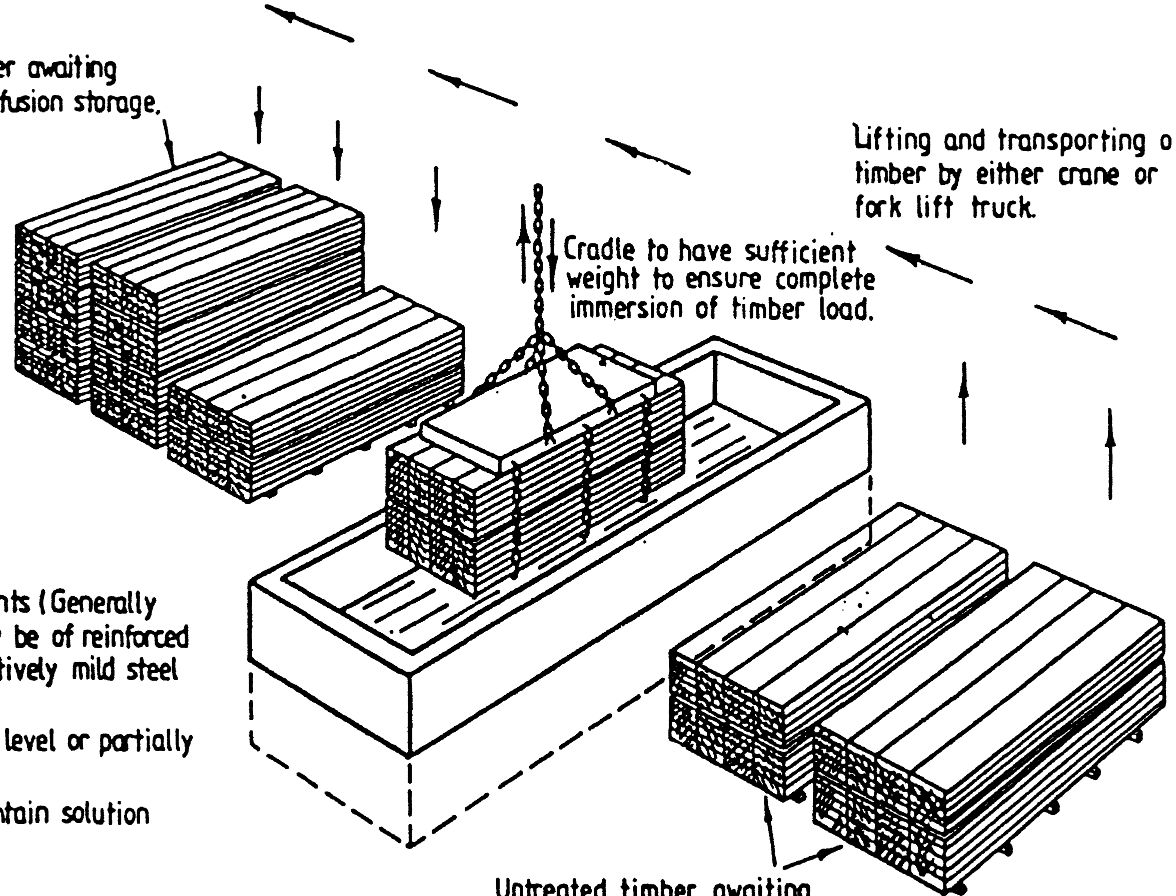
Boron Preservation Treatment

Location of Plant

Week Commencing:

DAY	SPECIES	SIZE	SOLUTION STRENGTH %	SOLUTION USED	SALT USED kg.	TIMBER TREATED m^3	AVERAGE SALT RETENTION kg./m^3

WEEKLY TOTAL ____________________



Perspective drawing illust ing 'momentary immersion' type of diffusion impregnation plan

Figure 9.20

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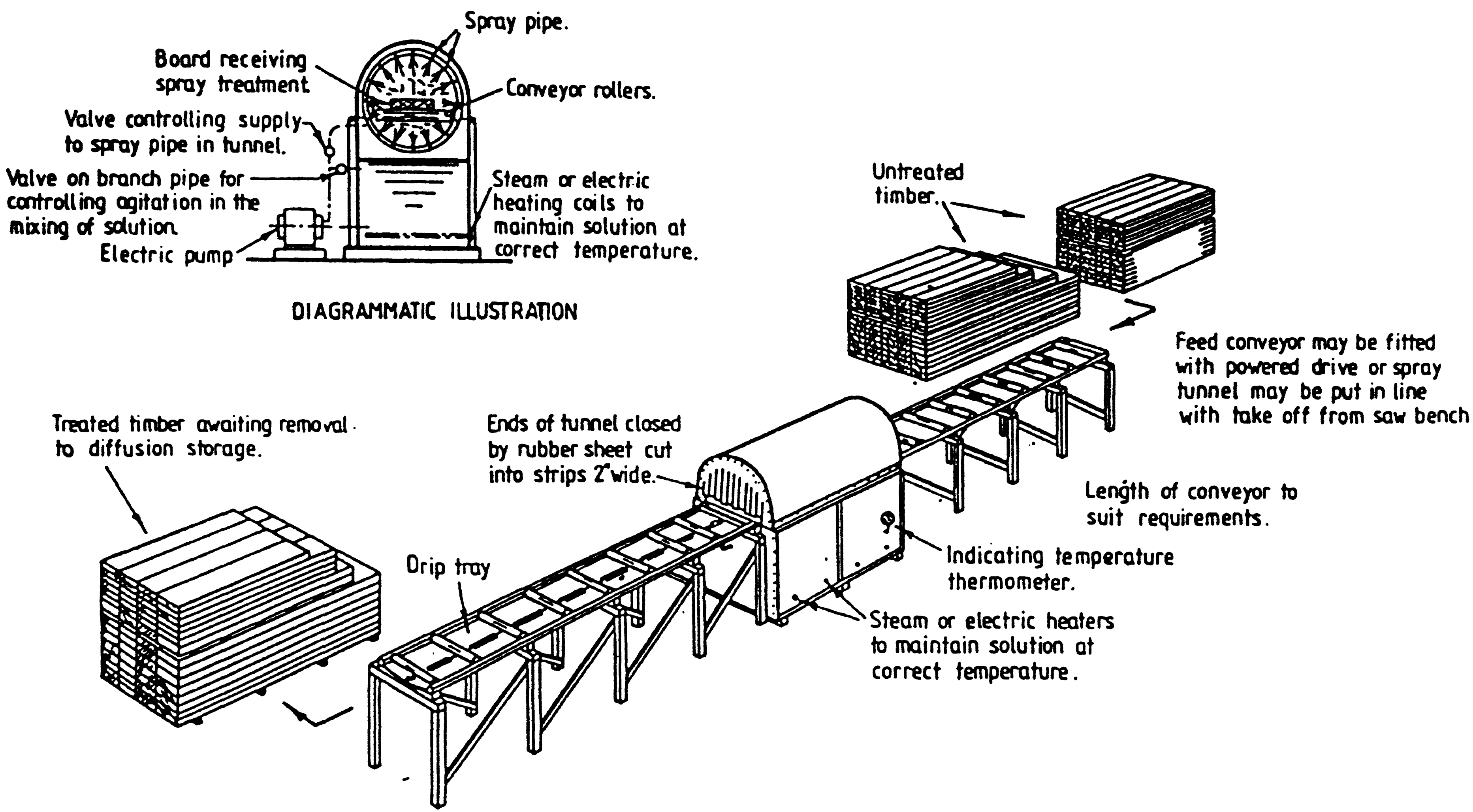


Perspective drawing illustrating 'spray tunnel' type of diffusion impregnation plant

Figure 9.21

Reproduced by permission from the 'TIMBOR Preservative Plant Operators Manual of recommended practice, Borax Holdings Limited 1984 passed through a spray of hot preservative solution inside a tunnel. The block stacking, covering and diffusion period are the same as before.

Treatment of Poles

Poles treated by the following method can only be used in a dry condition and not in situations where the timber is going to be wet or in ground contact.

Freshly felled timber poles can be treated using the osmose process where the preservative chemical is applied in a paste form onto the surface of the green, peeled timber and then covered as earlier to prevent moisture loss.

Preservative used: a mixture of Borax and Boric acid as for diffusion treatment.

Procedure:

Prepare a solution of 20% concentration using hot water.

Debark the freshly cut poles (preferably felled on the same day).

Place them in a stack on bearers.

Ensure the debarked poles do not contain any dirt on their surface.

Spread a plastic or polythene sheet on the ground near the debarked poles. The polythene sheet should be able to cover all the poles after applying the preservative.

Paint them with the preservative using a brush.

Place the painted poles on the polythene sheet. Paint again the poles which are already on the polythene sheet.

Ensure that all the surfaces of the poles are properly painted.

Cover the bundle of poles fully so that no air can get in.

Keep them covered for a few weeks. If the poles are 150 mm or less in diameter, leave them for at least two weeks.

Poles of diameters between 150 mm and 200 mm should be painted twice, once at the start and again after one week.

Poles of diameter more than 200 mm should be painted three times, once at the start, again after one week and then after two weeks.

Treated poles should not be allowed to get wet.

Double Diffusion

This process consists of soaking green timber first in one chemical solution and then in a second solution. The two chemicals diffuse into the wet timber and react together to form a compound which is practically non-leachable.

Chemical used: Copper sulphate and Sodium fluoride.

These preservative solutions are harmful and care should be taken when handling them. Wear rubber gloves when working and wash off any solution or dry chemical that gets on to the hands. Goggles, respirators, boots and aprons should be worn to protect from the dust arising from the dry chemicals.

Procedure

Two containers are required to hold the separate solutions. A wood barrel is preferred for the copper sulphate solution since it is corrosive to steel. If a steel drum is used, coat the inside of the drum with roofing pitch. Care must be taken to avoid damaging the coating when the posts are placed in or taken out of the drum.

Make a 4% solution of sodium fluoride.

Stand the peeled freshly cut timber with butt end down in the sodium fluoride solution. Keep the posts submerged for three days.

Remove posts from the above solution and keep then submerged in the copper sulphate solution.

Remove after three days and rinse with water.

Stack the treated timber for drying.

Dispose of the left over solutions by dumping them into a hole some distance from wells, rivers, canals or livestock ponds. After they have seeped away, fill the hole with soil.

Chapter 10

POST TREATMENT HANDLING

Drying

Freshly treated timber should be left in the draining area until dripping has completely stopped. Care should be taken that timbers treated with CCA preservatives remain for at least a few days. These timbers have to be redried before use except when they are destined for use in marine conditions. The moisture content to which treated timber should be dried depends on its end use, however, in all cases, it should be below the fibre saturation point, i.e. below 25% moisture content. When drying treated timber, the same careful attention should be given to stacking, use of stickers, protection from direct sun and rain, etc.

Quality Control

Quality control in timber preservation ideally should differ with the type of treatment, the end uses and the product itself. Transmission poles treated with creosote in a pressure cylinder in which the treatment is dependant to a large extent on the condition of the timber substrate, will require a different quality control procedure to green veneers immunised by dip diffusion with a water soluble preservative. In addition a fence post is more expendable than a load bearing pile. These extremes may need to be taken into account when developing a quality control procedure. A basic requirement for a suitable quality control procedure is to present a system whereby the treated product can considerably exist in a given situation for a longer time than it would be expected to without such a treatment. The extension of life is related to the preservative itself, its toxicity, permanence, the amount and its location in the wood.

It is essential that the quality control system should protect the buyer of the treated timber from an inferior product or a product that will not comply with a prescribed preservation specification. Generally in developing countries, method of quality control is prescribed by the government or an independent body affiliated with the government. Mandatory requirements for various processes include moisture contents prior to treatment, schedules, pressures, solution concentrations, treatment times, rates of flow, operating temperatures and so on. For some processes, the requirements are detailed and must be followed precisely, while for others there is a considerable latitude permitted, provided that adequate control of the standard treatment achieved can be exercised.

Standards and Specifications

In many countries standards and specifications have been prepared to ensure a certain level of quality in a product for meeting specific service requirements. These also act as a guide to the consumer to define and specify his material requirements and help the producers to ensure conformance to those requirements through suitable tests conducted at different stages of manufacture.

In the preparation of standards, due weight has to be given to the views of the manufacturers of the preservatives and treatment plants, wood technologists, forestry officers, environmentalists, consumers, etc. and also to the trade practices followed in the field of wood preservation in the country. While preparing local standards in a country, it is worthwhile consulting standards and specifications employed in other countries as well as the international standards.

The minimum aspects the standards should cover are:

- methods of applying wood preservatives;
- technical requirements of wood preservation plants;
- health and safety requirements of manufacturing, transporting, storing and application of different wood preservatives;
- methods for estimation of the amount of preservative chemical in the treating solution and treated timber;
- methods for estimation of the distribution of the preservative chemical in the treated wood;
- methods of testing natural durability of timber and efficacy of wood preservatives against different decaying organisms;

In developing countries, it is suggested that initially a basic code of practice is implemented which can be refined slowly as the industry develops and eventually standards can be established.

Handling and Storing Treated Material

Removal of timber from the treatment plant does not necessarily complete the treatment process. Appropriate clothing given in Chapter 12 should be worn when handling the timber just after treatment. This is very important with timber impregnated with water borne preservatives. Treated timber can be redried by either air seasoning or kiln seasoning. This is done in the same way as for green timber. Treated timber should be stored under cover to eliminate exposure to direct sun and rain. Heavy petroleum oil treatments may require a period of air drying to make the timber clean to handle. They rarely dry out completely and are therefore reserved for purposes where resistance to weathering or leaching is more important than a clean surface, such as railway sleepers and marine piling. Most preservative oils have irritant properties with distinctive odours which combine to ensure that they are handled carefully.

Chapter 11

PROPERTIES AND USES OF TREATED WOOD

Strength

Preservative treatment does not appreciably reduce the strength of wood. Strength may sometimes be affected while timber is being prepared for treatment such as in the case of incising and steaming.

Incising

A slight reduction in strength is caused by the small slits made during the incising process. However, this effect is more than offset by the increased durability of the material.

Steaming

Unless the steaming temperatures are suitable for the species involved and the duration of steaming is not too long, the timber can be seriously affected. There are standards and specifications available in many developed countries giving detailed information on the limits for steaming temperatures and periods for various timber species.

Preservative Treatment

The major factor which may affect the strength of timbers during a treatment is the high pressures that can cause the wood cells to collapse especially in low density timbers. For this reason, in the case of creosote treatment, the temperature of the preservative is kept high and the pressure is kept low for a longer period.

Type of Preservative or Flame Retardant

Some flame retardant treatments can affect several properties, including strength. This is mainly due to the hygroscopic nature of the inorganic salts used. Furthermore, the amount of flame retardant which is required for a unit volume of timber is about four to five times the amount required in preservative treatment.

Flammability

The possibility of catching fire in freshly treated timber with creosote or oil and PCP solutions is much greater than that of wood treated with water borne salts. However, there is a tendency for the latter to glow for sometime after flaming has ceased.

Electrical Conductivity

Electrical conductivity increases in wood with the presence of moisture and is almost negligible in the case of dry wood. The effect of creosote and organic preservatives has no effect on the treated wood. However water borne preservatives do increase the conductivity slightly.

Safety

Safety of treated timber has to be carefully considered especially if it is used for items such as food containers, childrens' toys and playpens. Although wood treated with water borne salts can be used safely due to the preservatives becoming fixed in the wood after treatment, it is recommended that any surface deposits should be removed before use. This is normally done by drying, washing it down and allowing it to redry. Then it should be finished with two coats of clear water repellant varnish or paint. Creosoted wood cannot be used inside buildings due to the unpleasant odour which is given off for a long time after treatment.

Paintability

Most of the treated timber used in domestic dwellings has to be painted. Timber treated with organic solvents can be painted easily, but timber treated with water borne salts should be dried before applying paints or varnishes. Creosoted timber cannot be applied with paints or varnishes and in any case it is normally used where painting is hardly required.

Metal Fittings

Normally fittings and fixtures are attached to the timber after preservative treatment. However, if timber is treated with metal fittings attached, there may be a possibility of damage with some preservatives such as CCA.

When fittings are attached to the treated timber after drying, they are not likely to be affected since they do not come into contact with the preservative solution. Corrosion is hardly possible in dry conditions such as in heated buildings. However, if damp conditions arise, corrosion can occur, the wetter the situation, the more severe the attack. This is mostly due to electrochemical action, the electrolyte being the moisture and the salt in the treated wood. This means the permeability of the timber influences corrosion in wood treated with most water borne salts. Therefore CCA treated timber should be dried below 25% moisture content before any metal fittings are attached.

Corrosion of metal fittings in creosoted timber is less likely than in untreated timber, because the creosote restricts the penetration of moisture.

Timber treated with organic solvents has not been found to have any effect on metal fittings although it may affect plastic fittings.

Metal fittings can be attached to boron treated timber without any problems of corrosion.

Gluability

Timber treated with CCA or Boron salts can be glued with almost all types of glue provided that the timber is dried to a moisture content below 22% and lightly sanded before glueing.

Creosoted timber may not be suitable for any type of glueing due to the oily surface on the treated timber.

Timber treated with organic solvents can be glued satisfactorily as long as excess solvent has evaporated.

USES

The advantages of using treated timber was discussed earlier. Timber is particularly suitable for marine structures, bridges, railway sleepers, transmission poles, buildings and for many other purposes.

Marine Structures

Treated timber offers considerable advantages for wharves, jetties, groynes, retaining walls and piles. However, it should be noted that unless the timber is of a very durable species it should be adequately treated with preservative to withstand the decaying organisms present in marine conditions. There are two separate hazardous environments present in these conditions. Firstly, the timber above the waterline is exposed to fungal attack and secondly the timber under water may be attacked by marine borers. However, properly treated timber can withstand a marine environment for decades.

Bridges

Both solid and laminated timber can be used in bridge construction. It is particularly suitable for piles, abutments and decking. If the timber is not of a naturally durable species, it should be properly treated. Treated round timber can be used as stringers or suitably treated sawn timber can be fabricated into laminated beams and then used for bridge members. Alternately these can be treated after lamination is carried out.

Use of timber piles in bridges or any other construction gives the advantages of low cost, high strength and ease of handling and driving.

Railway Sleepers

Timber railway sleepers or cross ties have been preferred because of their ease of handling and replacement. Properly treated timber sleepers have been used for decades in many parts of the world.

Pole Construction

Treated timber poles have been successfully used in electricity and telecommunication lines for many years. In addition, timber poles can be efficiently used in building construction. Poles can be erected very easily and they produce a rigid framework to support the walls and roof and if necessary part of the floor as well (see Figure 11.1). Generally poles have a fairly thick outer sapwood layer which could be easily treated by preservatives. Therefore, the durability of treated poles depends upon the preservative retention of the anulus of the treated wood. Hence care should be taken not to cut through, machine, drill or otherwise remove the treated wood exposing the interior untreated wood.

Farm Buildings

Treated timber is used in the construction of farm buildings, fencing, greenhouses, seed boxes, etc.. In places where there is a risk for the plants or the farm animals from the preservative, creosoted timber and that treated with organic solvent preservatives containing pentachlorophenol are not recommended.

Board Materials

Treated board material is being used in all types of buildings. Sometimes the extra cost of treated plywood compared to the equivalent solid timber may often be offset by its convenience, light weight and speed of erection. The simplest way to preserve plywood is by pretreatment of veneers. This can be done by dip diffusion of green veneers or pressure treatment of dry veneers. Also it is convenient to add insecticide to the glue line during the production of plywood. Unless plywood is specifically made wholly of sapwood or permeable heartwood veneers, it cannot be effectively pressure treated in made up form if complete penetration is required.

In the case of other board materials such as particle board and waferboard, they can be treated with preservatives easily during or after manufacture. These boards are used for partitioning, ceiling and thicker boards for flooring.

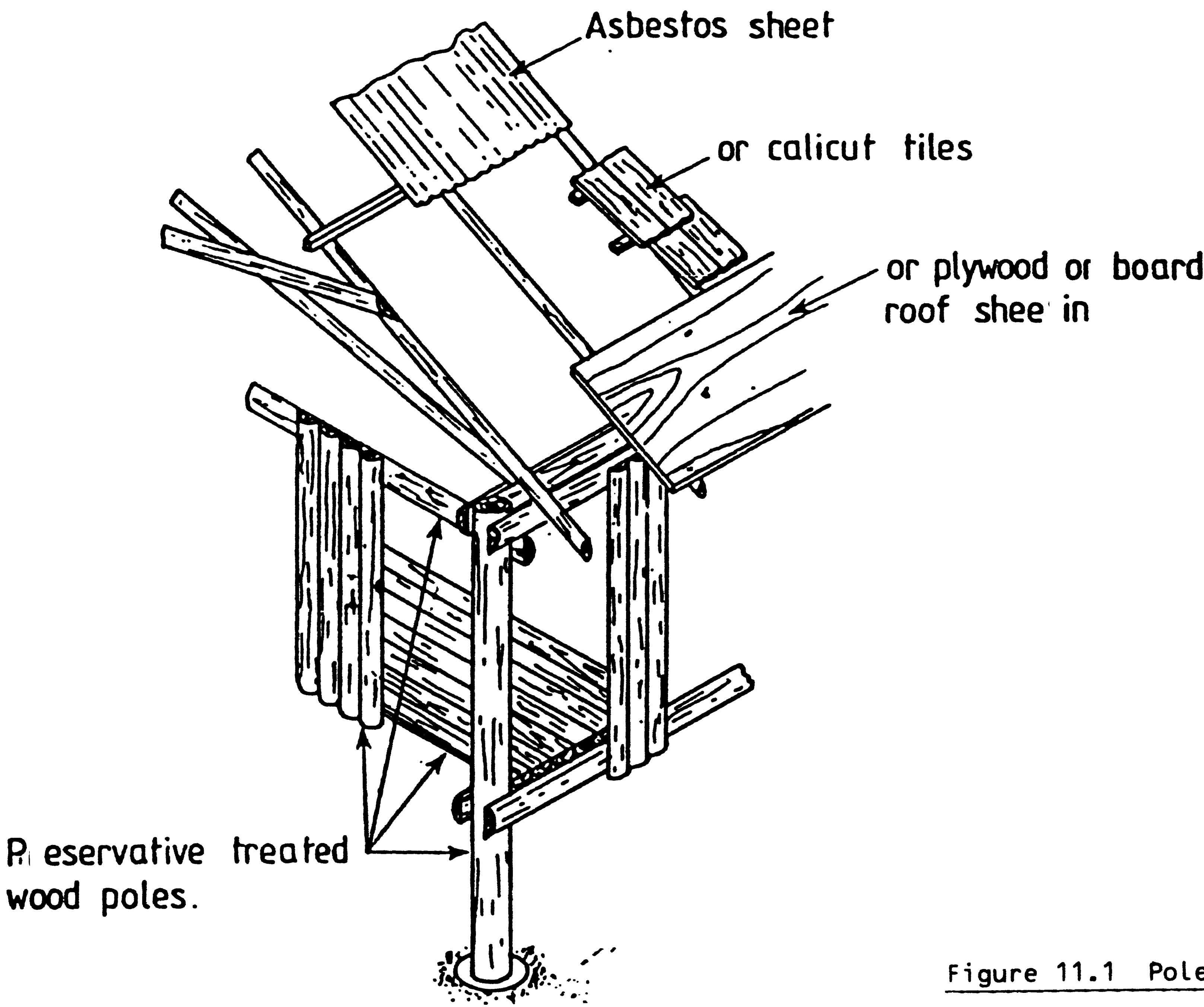


Figure 11.1 Pole Building

Chapter 12

ENVIRONMENTAL HEALTH AND SAFETY ASPECTS

Hazards from Preservatives

Hazards from preservative chemicals depend mainly on their toxicity to human beings. In addition it depends on their form (solid or liquid), method of packing and storing and the way they are diluted and applied to wood. There are three ways these chemicals can enter the body, these are inhaling, swallowing or from contact with the skin.

Inhaling

When breathing, toxic chemicals in the form of vapour or dust, can pass through the nose or mouth into the eyes. This could happen in different ways, some of which are: dusts from powdered chemicals such as CCA; vapours from organic solvents and creosote oils; mists from spraying equipment.

Swallowing

Traces of preservative chemicals can pass into the stomach through contamination of food, water or other liquids. This could happen by not washing the hands and face properly after coming into contact with chemicals or eating food on which invisible chemical dust has been deposited.

Contact with Skin

Preservative chemicals can enter the body through the skin especially if the skin is damaged, needless to mention that the eyes are the most sensitive.

This could happen from sprays, splashes of spills onto damaged skin during storage of chemicals, while matching up solutions, while handling the treated wood incorrectly after treatment, whilst handling used containers without getting rid of the chemical deposits.

Protective Measures

Ensure that the hazards from preservative chemicals are well understood.

Display precautionary notices stating the hazards and correct procedures.

Display precautionary wording on labels of containers and packages.

Wear suitable protective clothing (see Figures 12.1 and 12.2).

Follow the recommended code of hygiene; especially go through the instructions given by the manufacturers.

Store preservatives in the correct manner.

Do not allow unauthorized persons to get into the treatment area or chemical stores.

Ensure First Aid help is always available.

Train all the staff involved.

Do not remove the treated timber from the treatment area until the preservative has stopped dripping.

Do not enter the treatment area without changing into safety clothes.

Avoid building up of sludge during treatment with water borne preservatives. Sludges in storage tanks should be buried at least one metre below ground far away from wells, rivers and other bodies of water.

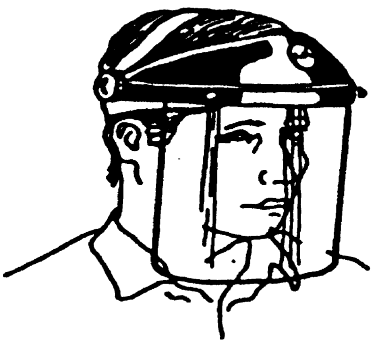
Clean thoroughly the used drums and rinse them with water before they leave the treatment site. The tops and bottoms should be cut and flattened. These drums should not be used for any other purpose. Even if it is sold for scrap metal, they should be very well cleaned before disposing.

Use impervious rubber or plastic coated gloves.

Wherever necessary use face masks, goggles, head and foot gear.

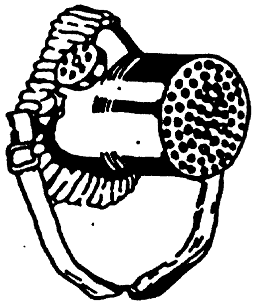
Rubber gloves. Heavy duty

Gauntlets, coated. P.V.C. heavy

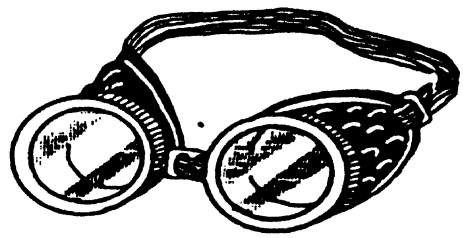


Face screen

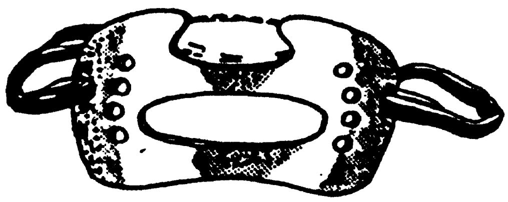
Safety helmet



Respirator



Cup goggle



Protective mask

Rubber knee boot

Protective clothing

Figure 12·1

Treatment operator
Figure 12.2

Use suitable impervious aprons or clothing. They should be made of impermeable material such as plastic. Nylon overalls are neither sufficiently impermeable nor sufficiently absorbent to offer any worthwhile protection.

Change working clothes after work and launder clothing regularly.

Supply washing facilities, hot and cold water and soap.

Frequently wash hands and face with soap and water.

Keep the work area clean.

Use wet wash down techniques during close down periods.

Do not eat or drink in the work area.

Pollution

Pollution can occur from three sources, namely wood preservatives, preservation process and the treated timber. However, pollution mainly occurs from preservative chemicals and preservation processes and rarely from the treated timber. In most cases the pollution problem originates from the preservative chemicals themselves. The extent of pollution differs widely with the type of preservative and the treatment process employed (see Table 12.1).

The disposal of waste from treatment requires much care. CCA preservative solutions are toxic and should never be released into streams or canals. CCA treated timber should not be burned and especially it should never be used for cooking or in a barbeque.

Table 12.1

POLLUTION POTENTIAL
WITH DIFFERENT TREATMENT METHODS

Treatment	Place of Pollution	Intensity of Pollution
Brushing	Place of use	High
Spraying	Place of storage Log/timber yard	High High
Spraying tunnel	Treating area	Low
Immersion	Treating area	Moderate
Dipping	Treating area	Moderate
Hot and Cold treatment	Treating area	Moderate
Diffusion	Treating area	Moderate to high
Sap displacement	Forest/close to felling area	Extremely high
Double vacuum	Treatment plant area	Low
Pressure treatment	Treatment plant area	Low

Chapter 13

DESIGN OF TREATMENT AREA

Yard layout is important in the economic, efficient and safe operation of a preservative treatment system. It should have sufficient area for seasoning, storing and for housing the machinery for timber for treatment in addition to the preservative treatment operation itself. The area should be designed to accommodate any mechanical handling equipment (if available), transport routes, buildings for changing and shower rooms.

Design of treatment area is not difficult as long as the treating is done in a permanent place. In designing a treatment area, the following should be considered:

It should be well drained and fairly level.

All surface water in the area including rain water should be made to flow into a tank and collected. The size of the tank should be designed to cater adequately for excessive rainfall. Waste water should not be allowed to go astray.

Store room for the chemicals should be sited so that accident spillages will not pollute the environment and designed in such a way that the spillages should be able to be recovered for reuse. Posters giving details of safety precautions and First Aid should be displayed. These details are normally available with the manufacturer of the preservative chemicals.

Sludges in storage tanks should be disposed of as given in Chapter 12.

Drip-off preservative solution from freshly treated timber should be made to collect safely.

Chapter 14

ECONOMIC ASPECTS OF WOOD PRESERVATION

If untreated , non-durable wood is used, the possibility of decay is inevitable calling for early replacement of material, sometimes with heavy labour changes. Failure of a piece of wood in a building through decay or insect attack may involve expenses enormously greater than the actual cost of the piece of wood itself. There are also indirect costs involved such as in the case of replacement of bridge timbers where there will be a traffic diversion and hence transportation costs, etc. Therefore the use of untreated wood gives rise to maintenance problems and high annual costs. A comparison of the annual charges presents the true cost of timber construction. This cost represents the amount necessary to provide simple interest on the investment, and an amount set aside annually at compound interest to provide for renewal. Comparing only the initial cost of treated and untreated material is misleading. It is also important to take into consideration, its useful life. It is a mistake to determine annual charge on the basis of excessive life, if relocation or revision is needed sooner, as is often the case with the temporary structures.

The annual cost of a structure is the amount of money that will have to be provided annually to replace the structure at the end of its useful life, and thus provide for perpetual service. This annual cost can be computed by the compound interest formula:

$$A = P \frac{r(1+r)^n}{(1+r)^n - 1}$$

where A = annual charge
P = total investment cost
r = rate of interest expressed in decimals (0.15 for 15%)
n = number of years service

Investment on a Preservation Industry

Before investing, a survey should be carried out in order to find out the demand for treated wood, if so the types of wood product and what type of treatment required.

The most important aspects which should be taken into account are:

- a suitable site
- amount of land and buildings required and the costs involved
- equipment required for the process
- transport requirements
- design of treatment area
- approval of local authority in the disposal of chemical waste
- safety equipment
- fuel and/or electrical costs
- cost of preservative chemicals
- cost of labour
- cost of raw material (timber)
- maintenance costs

Appendix 1

PERMEABILITY OF SOME TROPICAL BUILDING TIMBERS

If a timber offered locally for building purposes does not appear in this Appendix information as to its standard or botanical name, permeability and general suitability should be sought from the local forestry service, or from the Building Research Establishment.

This Appendix does not include timbers generally considered as being cabinet, furniture or superior joinery woods, for example the "mahoganies". Neither does it include woods which are very dense, hard and durable and which are more appropriately used for heavy duty flooring or engineering and marine works.

The timbers are listed by their standard names, followed in brackets by the botanical names. The standard name may not be that used locally.

The timbers listed are classified into four groups as follows:

Permeable (P)

These timbers can be penetrated completely under pressure without difficulty and can usually be heavily impregnated by the hot and cold open tank process.

Moderately Resistant (MR)

These timbers are fairly easy to impregnate and it should be possible to obtain a lateral penetration of 6-18 mm (softwoods) in about 2 to 3 hours under pressure, or the penetration of a large proportion of the vessels (hardwoods).

Resistant (R)

These timbers are difficult to impregnate under pressure and require a long period of treatment. It is often impracticable to penetrate them laterally more than about 3-6 mm. Incising of the surfaces is sometimes resorted to in order to improve penetration.

Extremely Resistant (ER)

These timbers absorb only a very small amount even after a long pressure treatment. Lateral penetration may be under 1/2 mm.

Species	Where grown	Average air Dry Density kg/m^3	Permeability Class: Heartwood	Permeability Class: Sapwood	Most Suitable Treatment Process
A. <u>Softwoods</u>					
Cypress, EA (Cupressus lusitanica)	East Africa	500	R	P	Pressure, may need to be lengthy
Parana pine (Araucaria angustifolia)	South America	545	MR	P	Pressure
Pine, Caribbean Pitch (Pinus caribaea)	Western Caribbean, Central America and in plantations elsewhere	700	MR	P	Pressure
Pine, patula (Pinus patula)	Plantations in East and Southern Africa	400	P	P	
Pine, Radiata (Pinus radiata or P. insignis)	Extensively planted in tropics and sub-tropics	480	P	P	
Podo (Podocarpus spp)	East Africa	510	P	P	
Yellowwood, British Honduras (Podocarpus guatemalensis)	Central America	500	P	P	

Species	Where grown	Average air Dry Density kg/m^3	Permeability Class Heartwood	Permeability Class Sapwood	Most Suitable Treatment Process
B. <u>Hardwoods</u>					
Abura (Mitragyna ciliata)	West Africa	560	MR	P	Pressure
Afara (Terminalia superba)	West Africa	550	MR	P	Pressure
Agba (Gossweilerodendron balsamiferum)	West Africa	510	R	P	Pressure
Albizia (Albizia ferruginea)	West & East Africa	700	ER	P	Extended high pressure
Alstonia (Alstonia congensis and A. boonei)	West, Central and East Africa	400	P	P	
Antiaris (Antiaris africana and A. welwitschii)	West & East Africa	430	P	P	
Avodiré (Turraeanthus africanus)	West Africa	550	ER	P	Extended pressure

Species	Where grown	Average air Dry Density kg/m^3	Permeability Class		Most Suitable Treatment Process
			Heartwood	Sapwood	
Ayan (Distemonanthus benthamianus)	West Africa	670	R	-	Pressure
Balsa (Ochroma lagopus)	Tropical America	80 to 250	R	P	Pressure
Banak (Virola koschnyi)	Central America	530	P	P	
Berlinia (Berlinia spp)	West Africa	700	R	P	Pressure
Binuang (Octomeles sumatrana)	East India and Western Pacific Islands	400	MR	P	Pressure
Bombway, white (Terminalia procera)	Andaman Islands	640	MR	-	Pressure
Canarium, African (Canarium schweinfurthii)	West & East Africa	530	ER	P	Extended high pressure
Celtis, African (Celtis spp)	Tropical Africa	780	MR	P	Pressure

Species	Where grown	Average air Dry Density kg/m^3	Permeability Class		Most Suitable Treatment Process
			Heartwood	Sapwood	
Dahoma (Piptadeniastrum africanum)	West and East Africa	690	R	MR	Pressure
Danta (Nesogordonia papaverifera)	West Africa	740	R	MR	Pressure
Ilomba (Pycnanthus angolensis)	Tropical Africa	510	P	P	
Keruing (Dipterocarpus spp)	SE Asia	720 to 800	R or MR	MR	Pressure
Mengkulang (Heritiera spp)	SE Asia	640 to 720	R	MR	Pressure
Meranti (Shorea spp)	SE Asia	510	ER	MR	Extended high pressure
Mtambara (Cephalosphaera usambarensis)	East Africa	590	MR	MR	Pressure
Musizi (Maesopsis eminii)	West and Central Africa	460	P	P	

Species	Where grown	Average air Dry Density kg/m^3	Permeability Class Heartwood	Sapwood	Most Suitable Treatment Process
Niangon (Tarrietia utilis)	West Africa	510 to 750	ER	R	Extended high pressure
Obeche (Triplochiton scleroxylon)	West Africa	380	R	P	Pressure
Odoko (Scottellia coriacea)	West Africa	620	P	P	
Ogea (Daniellia ogea and D. thurifera)	West Africa	420 to 580	MR	P	Pressure
Okwen (Brachystegia spp)	West Africa	530 to 770	ER	P	Extended high pressure
Opepe (Nauclea diderrichii)	West Africa	740	MR	P	Pressure

Species	Where grown	Average air Dry Density kg/m^3	Permeability Class		Most Suitable Treatment Process
			Heartwood	Sapwood	
Pterygota (Pterygota bequaertii and P. macrocarpa)	West Africa	530 to 750	P	P	
Ramin (Gonystylus spp)	SE Asia	660	P	P	
Waika Chewstick (Symphonia globulifera)	Tropical America and West Africa	700	ER	R	Extended high pressure

NATURAL DURABILITY OF HEARTWOOD OF SOME COMMON TIMBER SPECIES

Softwoods

Perishable	Non-durable	Moderately Durable	Durable	Very Durable
	Fir	Douglas fir	Caribbean	
	Hemlock	Larch	Pine	
	Parana pine	Maritime pine	Western red	
	Radiata pine		Cedar	
	Scots pine			
	Podo			
	Redwood			
	Spruce			
	Whitewood			

Perishable - less than five years

Non-Durable - 5 to 10 years

Moderably Durable - 10 to 15 years

Durable - 15 to 20 years

Very durable - more than 25 years

(The above classification is based on performance in ground contact).

NATURAL DURABILITY OF HEARTWOOD OF SOME COMMON TIMBER SPECIES

Hardwoods

Perishable	Non-durable	Moderately durable	Durable	Very durable
Abura	Afara	Ayan	Agba	Afrormosia
Alder	Avodire	Brush box	Dahoma	Afzelia
Antiaris	Berlinia	Crabwood	Danta	Ekki
Balsa	Elm	Keruing	Idigbo	Greenheart
Beech	Gaboon	Krabak	Karri	Guarea
Birch	Mengkulang	African mahogany	American mahogany	Iroko
African celtis	Mubura	Oak (Turkey)	Light red meranti	Ironbark
Horse chestnut	Musizi	Sapele	Mora	Jarrah
Black poplar	Obeche	Red seraya	Muhimbi	Kapur
Ramin	Grey poplar	Yellow seraya	Niangon	Makore
Sycamore	White seraya	European walnut	European oak	Muhuhu
Willows			Robinia	Muninga
			Sepetir	Okan
				Opepe
				Purpleheart
				Pyinkado
				Teak
				Wallaba

Perishable - less than five years

Non-Durable - 5 to 10 years

Moderably Durable - 10 to 15 years

Durable - 15 to 20 years

Very durable - more than 25 years

(The above classification is based on performance in ground contact).

Appendix 2

SPECIFICATIONS AND STANDARDS RELATING TO WOOD PRESERVATION

Abbreviations

AS - Australian Standard
AWPA - American Wood Preservers' Association, USA
BS - British Standard, UK
BWPA - British Wood Preserving Association, UK
DIN - West German Standard
IS - Indian Standard
NZ - New Zealand Standard

AS 1143 : 1973	High temperature creosote for the preservation of timber
AS 1144 : 1973	Arsenical creosote for the preservation of timber
AS K 55 : 1965	Creosote Oil for the preservation of timber
AS INT 91 : 1945	Preservative treatment of timber
AS INT 92 : 1945	Preservation of structural timber
AWPA M5 : 1974	Glossary of terms used in wood preservation
AWPA P1 : 1965	Creosote: Standards P2, 3, 4, 7, 11, 12 and 13 - Creosote mixtures and creosotes for high hazard applications
AWPA P8 : 1974	Oil-borne preservatives
BS 1282 : 1975	Classification of wood preservatives and their methods of application
BS 144: 1954	Coal tar creosote for the preservation of timber
BS 3051 : 1972	Coal tar types of preservative (other than creosote specified in BS 144)
BS 3452 : 1962	Copper/chrome water borne wood preservatives and their application

BS 3453 : 1974	Fluoride/arsenate/chromate/dinitrophenol water borne wood preservatives and their application
BS 4072 : 1974	Wood preservation by means of water borne copper/chrome/ arsenic compositions
BS 5268 Part 5 : 1985	Preservative treatments for constructional timber
BWPA 104 : 1975	Wood preservation by means of solutions of pentachlorophenol
BWPA 106	Copper napthenate based solutions for wood preservation and their application
BWPA 108 : 1975	Wood preservation by means of solutions of pentachlorophenol with gamma hexachlorocyclohexane
BWPA 109 : 1975	Wood preservation by means of solutions of tributyltin oxide
BWPA 110 : 1975	Wood preservation by means of solutions of tributyltin oxide with gamma hexachlorocyclohexane
BWPA 111: 1975	Wood preservation by means of solutions of zinc naphtenate with pentachlorophenol
BWPA Section 5 : 1975	Methods of applying preservatives
DIN 68800 Blatt 1: 1974	Protection of timber used in buildings: general specifications
DIN 68800 Blatt 2: 1974	Protection of timber used in buildings: preventive constructional measures
DIN 68800 Blatt 3:	Protection of timber used in buildings: preventive chemical protection of timber
DIN 68800 Blatt 4: 1974	Protection of timber used in buildings: control measures against fungal decay and insect attack

IS 218 : 1961	Creosote and anthracene oil for use as wood preservatives
IS 716 : 1955	Specification for pentachlorophenol
IS 1078 : 1957	Copper naphthenate
IS 401 : 1967	Code of practice for preservation of timber
IS 131 : 1964	Treatment of timber with copper chrome or copper chrome arsenic water borne wood preservatives
NZS CP4 : 1953	Code of practice for timber preservation
NZ TPA Spec F1 : 1969	Creosote
NZ TPA Spec F2 : 1969	Water borne preservatives
NZ TPA Spec F3 : 1969	Other water borne preservatives

Appendix 3

REFERENCES AND USEFUL ADDRESSES

References

Anon (1975) Proceedings of the Tropical Wood Preservation Seminar held in Papua New Guinea.

The following Technical Notes are from Building Research Establishment, Dept. of Environment, UK.

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No. 24	(1972)	Preservative treatment of external joinery
No. 39	(1969)	The house longhorn beetle
No. 40	(1969)	The natural durability classification of timber
No. 41	(1969)	Preservation of building timbers by diffusion treatment
No. 42	(1972)	The hot and cold open tank process of impregnating timber.
No. 43	(1969)	The kiln sterilization of Lyctus-infested timber
No. 44	(1969)	Decay in buildings. Recognition, prevention and cure.
No. 45	(1970)	The death watch beetle
No. 46	(1970)	The moisture content of timber in use
No. 47	(1970)	The common furniture beetle
No. 50	(1971)	Sap-stain in timber - Its cause, recognition and prevention
No. 53	(1971)	Timber decay and its control
No. 55	(1972)	Damage by ambrosia (pinhole borer) beetles
No. 58	(1972)	"Woodworm" control in domestic roofs by dichlorvos vapour
No. 59	(1972)	Marine borers and methods of preserving timber against their attack
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USEFUL ADDRESSES

Australia

Division of Chemical and Wood Technology
Council for Scientific and Industrial Research
Organization
(CSIRO)
P.O. Box 56
Graham Road
Highett
Victoria 3190
Telex: 33766 AA   Tel: 03 555 03 33

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Wood Technology and Forest Research Station
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Wood Chemistry and Timber Preservation Laboratory
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Telephone: 70 21

Japan

Laboratory for Wood Protection
Wood Research Institute
Kyoto University
Gokasho
Uji
Kyoto 611
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New Zealand

Forest Research Institute
New Zealand Forest Service
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Telephone: 73-47 58 99

Papua New Guinea

Forest Products Research Centre
PO Box 1358
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Telephone: Port Moresby 25 65 55

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150 Southampton Row
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