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Preservation of timber for tropical building

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Double vacuum process being utilised to treat building timbers with a light organic solvent preservative

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OVERSEAS BUILDING NOTES

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SUMMARY
Timber is one of the most widely used construction materials in the world. It can be seriously damaged by certain types of fungi, insects and marine borers. Such damage can be prevented by the application of one of a number of preservative treatments selected to suit the type of timber being treated, the use to which it will be put and the environment in which it will be used.

This Note describes the various forms of treatment available, and provides information that should assist timber users and building designers in tropical countries to:

- assess the need for preservative treatment,
- select the type of treatment most appropriate to the circumstances,
- ensure that treatment is carried out satisfactorily and safely.

The first issue of *Preservation of timber for tropical building*, published as OBN 183 in 1979, has now been withdrawn.

Biographical notes
Dr Reg Orsler has worked in timber research for 36 years, initially in the United Kingdom's Forest Products Research Laboratory and later (following the merger of BRE and FPRL) in the Timber Division of BRE. He has worked in both research and advisory capacities, and has been particularly concerned with the performance of wood preservatives and the treatment of timber.

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PRESERVATION OF TIMBER FOR TROPICAL BUILDING

by R J Orsler

INTRODUCTION

This Overseas Building Note (OBN) is one of a series that addresses the use of timber in tropical countries and some of the associated problems (all available OBNs are listed on the back cover). The more general OBN 199 discusses a range of factors that must be considered to ensure the efficient use of timber in construction, including timber durability and its enhancement with wood preservatives. However, the latter topic is so important to achieving good service from building timbers that it justifies this separate Note.

WHY TIMBER NEEDS PRESERVATION

Timber is frequently the most readily available and easily acquired building material. It is natural and renewable, has a high strength to weight ratio and is easy to work. These characteristics make it especially useful where only basic building technology and procedures are available. Consequently it has become one of the most widely used construction materials and may be found in traditional buildings throughout the world. However, as a naturally occurring organic material, timber is liable to suffer attack by certain organisms, including wood-destroying fungi, insects (especially termites — see OBN 201) and marine borers, which can cause significant damage. Such attacks are often due to the prevailing service environment, for example, dampness can encourage the development of fungal growth. Fungal decay (or rot) can be prevented if the timber is kept dry (ie below about 22% mc) but that may be difficult in areas where high humidity and rainfall prevail. Even in dry climates, if timbers in a building become wet, perhaps from leaking water services, they are likely to rot.

Where no preservative treatment has been applied, the survival of a wooden component during service will depend on the natural resistance to attack of the wood species concerned. This is usually referred to as the natural durability of the timber, or more properly the natural biological durability. Most classifications (see Appendix A) are based on the resistance to wood-destroying fungi, although resistance to insects or marine borers can be similarly classified. The heartwood of some tropical hardwoods (usually those that are dense, dark coloured and physically hard) is resistant to attack by some or all of the organisms mentioned above, and is regarded as being *durable* or *very durable* in the grading system described in Appendix A. The sapwood of all timbers (ie the outer band of the wood in the round which is usually less dense and lighter in colour) is not durable and if used will almost certainly require preservative treatment.

The very durable timbers are usually too expensive to use for general building purposes. In any case, their use is to be discouraged where the production of their timber is associated with logging operations that damage indigenous forests. However, when produced from well managed, sustainable sources dedicated to timber production, such timbers are still in demand for special purposes such as floors and panelling in buildings of quality. The less durable timbers most likely to be acceptable for construction purposes are the softwoods and some of the plantation grown, less dense hardwoods. These may have sufficient natural durability for their intended end-use, but it is often necessary to increase their durability by the application of wood preservatives.

ASSESSING THE NEED FOR TREATMENT

When assessing treatment requirements for a particular service environment a number of factors should be considered.

The level of hazard

For most service environments there is a clearly identifiable hazard of biological degradation. For example, timber in contact with the ground is likely to suffer attack because it may be vulnerable to termites or have a moisture content high enough to support fungal growth. Internal joinery is generally the least likely to be attacked (except where termites are a major pest).

A structured approach to defining hazard is important for specifiers and designers. In Europe, a new standard has been issued recently in which different service environments are classified as *hazard classes* and these are used to provide a basis for specifying preservative treatment (see Table 1).

Table 1 Hazard classes related to service environment and major wood-destroying organisms.

Hazard class	Service environment	Major pests
1	Interior timbers not likely to be wetted	Wood-boring beetles Subterranean termites
2	Interior timbers subject to high humidity or occasional wetting (eg from condensation)	Fungal decay Subterranean termites
3	Structural or joinery timber not in ground contact	Fungal decay Subterranean termites
4	Timber in ground contact or partially or intermittently in contact with fresh water	Fungal decay Subterranean termites
5	In contact with the sea or estuarine (brackish) waters	Marine borers Fungal decay

Note: precautionary measures, such as soil poisoning and termite shields, included in the construction can significantly reduce the risk of attack from subterranean termites. Drywood termites may occur in coastal regions irrespective of such precautionary measures.

Table 2 Appropriate preservation treatments for various timber uses

Situation of timber use	European hazard class	Major hazards	Appropriate preservation treatments: Pressure/ vacuum	Open tank	Double vacuum*	Diffusion	Sap displacements†	Immersion
(a) In the sea including partial or intermittent wetting (marine piling, jetties)	5	Marine borers Fungal decay	✔					
(b) In fresh water including partial or intermittent wetting (jetties, piling, bridge piers)	4	Fungal decay	✔	✔			✔	
(c) In the ground (fence posts, transmission poles, verandah posts)	4	Subterranean termites‡ Fungal decay	✔	✔			✔	
(d) Not in ground contact but exposed to the weather (external joinery, cladding)	3	Fungal decay	✔	✔	✔§	✔§		✔§
(e) Interior situations of high humidity or heavy condensation (cold stores)	2	Fungal decay	✔	✔	✔	✔		✔
(f) Interior timbers remaining dry (roof timbers, interior joinery)	1	Wood-boring beetles	✔	✔	✔	✔	✔	✔

* Double vacuum treatment may be unavailable in less-developed countries. It may be referred to in relation to the supply of pre-fabricated buildings or components imported from elsewhere.

† Leaching may reduce the efficacy of preservatives applied by this method.

‡ Subterranean termites are also likely to form a major hazard in situations (d), (e) and (f) unless precautionary measures such as soil poisoning and termite shields are included in the design. In coastal regions drywood termites may occur in situations (c), (d), (e) and (f) and above water parts of (a) and (b).

§ The protection afforded by these treatments should be reinforced by a paint system.

Table 3 Summary of types of preservative and application methods

Type	Example	Treatment methods	Characteristics
Tar oils	Creosote to BS 144:1990	Pressure Hot and cold open tank Immersion Brushing	Does not swell wood Persistent odour — cannot be used indoors. Non-corrosive to metals. Cannot be painted. Can stain adjacent materials. Resists leaching.
Water-borne salts	Copper/chromium arsenic (CCA) to BS 4072:1989	Pressure Oscillating pressure	Treatment swells wood. Painting optional. CCA in wood becomes insoluble. Corrodes some metals.
	Boron compounds	Diffusion	Painting of exposed wood essential as the compounds remain soluble.
Preservatives in organic solvents to BS 5707:1979	Fungicides* Insecticides* Water repellents	Double vacuum Immersion Brushing Spraying	Does not swell wood. Most are resistant to leaching, but some are subject to loss by evaporation. Painting of exposed wood recommended. Gluing usually satisfactory. No fire hazard when solvent has evaporated.

* There is a large number of active ingredients which can be fórmulated into organic solvent wood preservatives. Current ingredients include organometallics (usually containing copper, zinc or tin), chlorinated phenols and other halogenated organic compounds, pyrethroids.

In addition to identifying the hazard class, the risk (or chance) of the hazard actually causing biological degradation in a particular service environment should be assessed, and other, particularly economic, conditions should also be considered. The following factors will be relevant.

Building design

Attack by wood-rotting fungi, beetles or termites can sometimes be avoided by incorporating appropriate design features — eg canopies to prevent wetting by rain and termite shields to reduce the risk of attack. However, complete protection is not normally achievable at reasonable cost and a naturally durable timber or a preservative treatment will often be necessary. In addition, it is sometimes prudent to provide treatment where normal circumstances would not be associated with biological attack, but where bad workmanship or accidents may lead to such an attack — inaccurate completion of design requirements or damage to the structure, for example, may provide conditions that allow rapid degradation by fungi or colonisation by termites.

Service life

Those timbers which form part or all of the structural components of the building are normally expected to last the full life of the building, while it may be acceptable (through economic considerations or convenience) to replace various non-structural members as part of the maintenance programme.

Timber durability

The required service life may be obtained through the natural durability of the selected timber, in which case preservative treatment will be unnecessary and therefore not a cost-effective use of resources. Where timber is insufficiently durable, treatment will be necessary and will save money in the longer term.

Practical considerations

When considering the use of treated timber, it will be necessary to take account of factors such as whether the preserved timber will have to be brought in from outside or whether an appropriate preservative treatment can be carried out locally.

THE CHOICE OF PRESERVATIVE TREATMENT

The end-use of the timber must be taken into account when selecting the type of treatment to be used. Table 2 lists typical end-use situations for timber (including their classification according to the European hazard system) together with the types of treatment that are regarded as acceptable for that end-use. Where several methods are indicated, some will provide more effective long-term protection than others — they are presented in a generally decreasing order of effectiveness from left to right.

Claims made for the durability of a timber, whether through its natural resistance to biological attack or its enhanced resistance following preservative treatment, should be examined carefully with respect to its likely performance in the service environment. The natural durability of a timber is usually expressed in terms of its performance (sometimes relative to a reference timber) in a ground-contact field trial. Clearly the time to failure will depend upon the geographical location of the 'field' — a timber that survives for twenty years in a temperate climate may fail after ten years or less in a tropical climate. Similarly there can be differences in the performance of particular preservative treatments. Thus it is preferable to select timbers, treated or untreated, on the basis of local service or field trial experience.

Generally, the service life conferred by a particular wood preservative treatment will depend on:

- the type of preservative used,
- the depth of penetration, and
- the retention of preservative within the penetrated zone.

The depth of penetration and the retention achieved will, in turn, depend on:

- the treatability of the timber concerned (compare Figures 1 and 2), and
- the method of introducing the preservative into the timber.

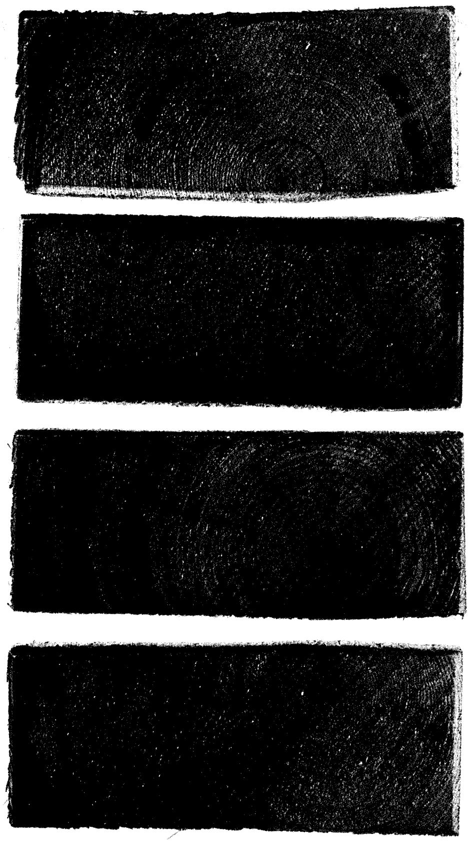

Figure 1 Penetration patterns of light organic solvent preservative into spruce (*Picea* sp), treated by double vacuum, showing variability due to spruce's natural resistance to treatment

Types of preservative
Selection of the correct type of wood preservative is very important because preservative formulations have been developed to be used for particular service environments and against specific wood-destroying organisms. This type of approach is described in more detail in the European Standard EN 599-1 (listed in Appendix B) which specifies bioassay tests and pre-test conditioning procedures to determine the effectiveness of candidate preservatives for use in the various hazard classes in Europe.

The principle types of wood preservative are:

- tar oils
- water-borne formulations
- light organic solvent formulations

Table 3 summarises the properties of these types and the methods of application associated with them.

Each preservative type has a preferred field of use. The tar oils are used for outdoor applications and for major civil-engineering construction, such as harbour works and sleepers for railway tracks. The fixed water-borne types (eg copper/chromium/arsenic — CCA — formulations) may be used similarly and also for many other building applications, particularly where exposure to the weather and to biological attack is severe. The unfixed water-borne types and the light organic solvent formulations are used for out-of-ground situations and mainly where the timber is further protected by the application of a paint or other surface coating.

More generally, the physical properties of a preservative can influence the effectiveness of a treatment process. For example, a preservative of low viscosity will penetrate deeper into the wood than one of high viscosity used under similar conditions. Light organic solvent preservatives are less viscous than tar oil creosotes even though creosotes can be heated to reduce their viscosity. Light organic solvent preservatives (which need special care in use and storage because of their volatility) should never be heated and some water-borne preservatives will decompose in solution if heated. Water-borne preservatives have the disadvantage that they swell the wood as they are absorbed, the wood later shrinking as the water dries out. These changes in dimension may cause distortion and present problems when components are machined to their final size before treatment.

Preparation before treatment
Unless the method of treatment is specifically designed to treat *green* timber (ie undried timber freshly felled or fresh from the saw), all timber must be sufficiently dry before treatment. This is essential because the objective of a preservative treatment is to introduce the preservative solution into the wood via the spaces within the cell structure of the wood. At high moisture contents these will be filled with water. The moisture content of the wood must be reduced to 28% or less (when only the wood substance will contain water) to make the spaces free of water and available to the incoming preservative solution. The importance of adequate drying before treatment cannot be over stressed. If the wood is too wet, it will be impossible to introduce the appropriate amount of preservative, leading to inadequate penetration and retention, and premature failure in service.

Inner and outer bark should be removed from the wood (this is unnecessary for the sap displacement method described later) as they are both impervious to preservatives. The timber should be free from dirt and surface water, and whenever possible, all machining, cutting, boring, etc should be completed before preservative treatment.

The moisture content of the wood should always be checked before commencing treatment.

Methods of treatment
The principle methods of applying wood preservatives to building timbers are briefly described in the following sections. Most of these are available world wide, but in some developing countries the choice of commercial processes using industrial plant may be restricted or non-existent, which limits the available methods, often to those that are less effective. However, it may be possible to arrange for the industrial treatment of construction timber by negotiation with public utilities, such as railway or post office departments, which usually have pressure treatment plant for the large number of sleepers or poles they use. If the simpler but less effective methods have to be used, it is essential that the timber is in a proper condition for treatment and that the most appropriate preservative formulation is employed.

High pressure/vacuum
The main advantage of a high pressure/vacuum process is that it provides a relatively deep, uniform penetration and a high absorption of preservative, thus ensuring the best chance of effective long-term protection. The process is normally used for the water-borne preservatives, such as CCA formulations, and creosote. But in most developing countries creosote is expensive to import encouraging preference for the CCA formulations. This type of treatment is particularly suited to the protection of timber exposed to a high risk of biological attack. It is recommended for timber that will become and remain wet during its service life, for example where it is in contact with the ground or in water.

The timber is placed in a closed cylinder and immersed in the preservative fluid. A relatively high pressure is then applied (usually 10 to 14 bar) for between one and six hours, forcing the preservative into the wood. This results in the sapwood of many timbers being completely penetrated, but penetration into the heartwood is not normally as deep and may vary considerably between different timber species. CCA preservatives are applied at ambient temperatures and never above 40°C; creosote is used at temperatures between 65 and 100°C.

There are two main types of process in this category, *full cell* and *empty cell.* The full cell (or *Bethell)* process aims to produce the maximum possible retention and depth of penetration and results in the available spaces in the wood being filled with preservative. This is achieved by first applying a vacuum to the closed cylinder after the timber has been placed in it. While maintaining the vacuum, the cylinder is filled with preservative fluid and the vacuum is then released. As the pressure inside the timber is still below atmospheric pressure, the preservative moves into the timber. The ingress of preservative is further enhanced by the application of the high over-pressure previously mentioned. On completion of the pressure period, the cylinder is drained of preservative and a final vacuum applied which withdraws a small amount of preservative (generally referred to as the *kickback*) and leaves the surface of the treated timber dry and in a reasonable state for handling.

The empty cell treatment aims to recover more of the preservative in the kickback stage, thus reducing the retention while achieving penetration generally similar to that obtained with the full cell process. This results in the internal walls of the wood cells being coated with the preservative but the spaces being only partially filled. This is achieved either by applying a pressure to the loaded cylinder before it is filled with the preservative (the *Rueping* process) or by filling the cylinder at atmospheric pressure (the *Lowry* process). In all other details the treatment is the same as for the full cell process.

High pressure/vacuum processes all require the same basic plant and equipment. This includes:

- a treating cylinder capable of withstanding vacuum and high pressure,
- storage, measuring and mixing tanks for the preservative,
- vacuum, circulating and filling pumps,
- an air compressor or pressure pump,
- tramways and bogies for carrying the timber into and out of the treating cylinder,
- heating equipment in certain cases, and
- associated pipework, valves and instruments.

Cylinder size varies. They are commonly about 1.5 m in diameter and 12 m in length but can be larger, perhaps 2 m by 36 m. Normally the cylinder has a door at one end, although having a door at each end allows treated stock to be removed at one end while fresh material is introduced at the other, giving quicker throughput.

Recent environmental legislation around the world has required a greater degree of containment of the plant and the treated timber. Bunding and concreted storage areas have been introduced to prevent loss of the preservative to the surrounding environment, especially when a major accident results in the release of a large quantity of preservative fluid. Much of the operation is now carried out under cover so that rain does not wash preservative from freshly treated timber or the immediate environs of the plant.

Double vacuum process

This method introduces light organic solvent based products into timber (see Figure 2). It is particularly useful for the treatment of made-up components (eg windows) and other exterior joinery because it does not cause any distortion or change of dimensions. It may also be used to treat roofing timbers and studding against insect (including termite) attack. For permeable timbers, the process allows control over the quantity of preservative introduced into the timber and the depth to which it penetrates.

The timber is placed in a treating cylinder and a partial vacuum created and held for several minutes before the cylinder is filled with preservative while still under vacuum. The vacuum is released and the timber allowed to remain in the preservative for up to an hour either under atmospheric pressure or under an applied pressure of up to 2 bar. After the pressure is released and the cylinder drained, a second vacuum is created to recover a proportion of the preservative from the wood and to provide a dry surface.

The plant associated with this process is similar to that required for the high pressure/vacuum process but the pressures involved are much less.

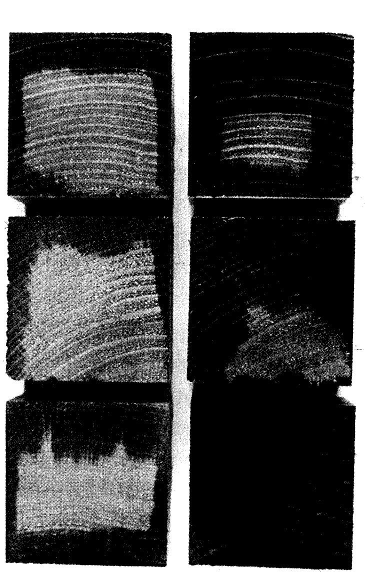

Figure 2 Comparison of penetration of light organic solvent preservative into permeable sapwood treated by a 3-minute immersion (left) and double vacuum (right)

Diffusion with aqueous solutions
The diffusion process can result in complete penetration of the wood, even in timbers resistant to penetration by pressure methods. The preservative usually introduced in this way is a highly soluble boron compound which acts as both a fungicide and an insecticide/termiticide. Since the preservative remains water-soluble even after drying, timber treated in this way cannot be used where significant leaching is likely to occur, eg where timber is in contact with the ground or directly exposed to the weather. However, it may be used when protected by paint or design, and since the boron compounds concerned are relatively harmless to man and other mammals, the treatment is especially suitable for internal woodwork where protection against insects (including termites) is paramount.

The diffusion method is unusual in that it is applied to green timber. In fact, the higher the moisture content of the timber, the better the treatment. The timber is immersed for a short period in a concentrated (sometimes hot) solution of a water-soluble wood preservative and then close-stacked under cover to prevent drying. Over a period of several weeks the preservative diffuses into the wood to give complete penetration. The timber is then dried to the required moisture content. Because the treatment must be completed before any drying has taken place, the diffusion process is carried out close to the sawing operation, usually at the saw-mill itself.

The *double diffusion* process provides the opportunity to incorporate a non-leachable preservative system in timber using simple diffusion techniques. This is achieved (using the method described above) by introducing a water-soluble chemical into the wood and then similarly introducing a second chemical that reacts with the first as it diffuses through the wood to produce a water-insoluble preservative. For example, the first solution might contain copper sulphate and the second a mixture of sodium dichromate and sodium arsenate, which together form an insoluble preservative similar to that ultimately obtained by treating with a CCA formulation. Although simple to carry out, the process is time consuming and there is little control over the depth of penetration and the retention achieved.

Immersion treatment
This type of treatment method is suitable only for the more permeable timbers (see Figure 2) where the risk of biological degrade is relatively low, such as in internal joinery. Immersion treatment includes *dipping*, *soaking* and *steeping*. Dipping usually refers to short immersion periods (up to 10 minutes) while soaking and steeping are associated with longer periods (hours or days). Only light organic solvent preservatives and certain grades of creosote are suitable for immersion treatments; water-borne preservatives achieve relatively little penetration even after prolonged steeping. The process involves merely submerging the timber below the surface of the preservative fluid for the required period. The equipment is simple and any tank capable of supporting the weight of the timber and preservative can be used (see Figure 3). Some arrangement is needed to keep the timber submerged, for example holding-down bars or a weighted cradle or cage.

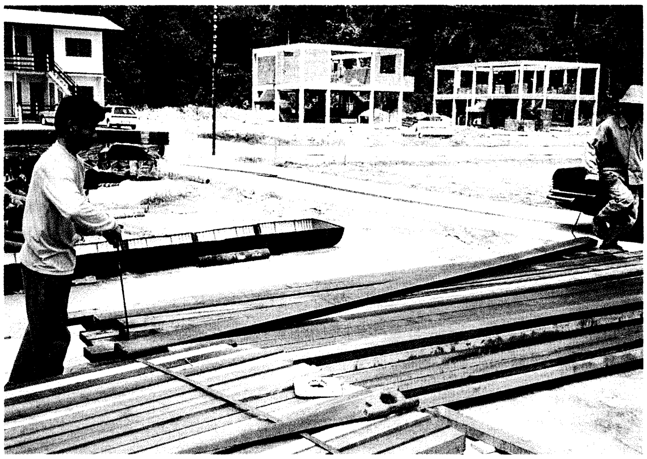

Figure 3 Timber preservation using an immersion tank made by welding oil drums together

In addition, on-site immersion can be useful for treating small pieces of timber used in repair work, and for the treatment of cut ends if the component can be stood upright in a container of preservative for as long as convenient (minimum 15 minutes).

Care should be taken in processing timber in this way because the open tanks of preservative and the handling of treated timber can represent a significant health risk to operatives.

Brushing, spraying and deluging
Although brushing and spraying are probably the easiest and most widely used methods of applying wood preservatives, their effectiveness is slight compared with other methods, particularly for protection in the tropics. If such methods have to be used, the woodwork should be flooded with as much preservative as possible, particularly at the end-grain and where joints and cracks appear. If brushing, the application should be liberal and not brushed out as with painting. A second treatment after a few days and regular retreatment every few years is recommended, always when the timber is very dry.

Deluging is essentially a sophisticated form of spraying. The timber is passed through a tunnel on a conveyor system during which preservative is sprayed or flooded over all surfaces of the timber. The process is generally regarded as equivalent to a ten second immersion.

As with immersion, all of these treatments are only useful with light organic solvents and certain grades of creosote.

Hot and cold open tank process
This simple process is probably the most effective method of introducing preservatives into timber without the use of expensive equipment and is therefore especially attractive to the less developed countries. The penetration and retention of preservative achieved with this process results in treated timber that can be used in most situations where the risk of biological degrade is high. However, the use of open tanks of preservative fluid and the application of heat are potentially hazardous operations requiring all possible safety precautions.

The process relies on the changes in volume that occur when a fixed quantity of air is heated or cooled. Seasoned wood is immersed in a tank of cold preservative which is then heated to 85 °C to 95 °C for up to three hours. During this period the air within the spaces in the wood expands causing much of it to be expelled. The heat source is removed and the tank contents are allowed to cool, during which time the residual air within the wood contracts and draws preservative into the vacated spaces. The treatment times and temperatures are varied to suit the treatability and the size of the timber. If a relatively large retention is required the process can be terminated at this step. However, similar penetration but less retention can be achieved by reheating the preservative for one to three hours (thus inducing a kickback) and removing the wood while the preservative is still hot. The hot timber is then allowed to cool in the air.

The hot and cold open tank process can be used with any preservative that does not decompose with heating, although it is not recommended for light organic solvent formulations and similar volatile preparations because of the fire risk. Creosote or creosote type preservatives are probably the most commonly used. Where the preservative is liable to heat degradation, the timber can be heated in hot water, hot air or steam and then quickly transferred to a tank of the cold preservative where it is left to cool.

The plant required for this process can be simple and inexpensive (see Figure 4 overleaf). As with the immersion process, all that is required is a tank capable of supporting the weight of the timber and preservative together, with a system to keep the timber submerged. The heat source can be an open fire built beneath the tank. An example of the simplicity of the system is the treatment of fence posts using an old oil drum. The posts are placed upright in the drum with their butts immersed in the preservative (creosote) to a depth that exceeds slightly the depth to which they will be inserted in the ground. The drum is then heated and cooled as described above. During the heating period the exposed parts of the posts are brushed liberally with the preservative from the drum, paying special attention to the exposed end-grain at the top of the post. Particular care should be taken to minimise the risk of fire and spillage.

Sap displacement method
This method is used mainly to treat unseasoned green poles, essentially expelling the sap by forcing a preservative solution in to replace it. The level of treatment achieved is good because the whole of the sapwood band is saturated with the preservative. There are several variants to the process, although all involve water-tight caps being attached to the ends of the poles. Tubes from the caps either allow entry of the preservative or removal of the sap. In the *Boucherie* process the poles are laid on the ground and the preservative led into the pole through the cap from an elevated tank. The hydrostatic pressure of the solution forces the preservative through the pole, pushing the sap out of the other end. The process takes several days to penetrate a pole completely. The *Gewecke* process uses caps to remove the sap while the poles are in a cylinder filled with preservative solution. Tubes from the caps carry the sap to the outside of the cylinder while an over-pressure inside the cylinder forces the preservative to replace the sap in the poles.

TREATMENT WITH LIMITED RESOURCES

For long-lasting protection with limited resources, the most effective methods are:

- those based on the principles underlying the diffusion process,
- the hot and cold open tank process, and
- prolonged steeping.

Where local timber is felled for use in building, the diffusion process offers advantages of cost and convenience, as well as the ability to treat timber normally regarded as difficult to treat. The undried sawn timber can be treated and close stacked during the diffusion period and then transferred to open stacked storage to allow drying to take place. While such timber cannot be used in situations where rain or other water sources would leach out the soluble preservative, the double diffusion process can provide treated timber containing a fixed preservative.

The hot and cold open tank process also requires a minimum of equipment yet provides a very effective treatment for relatively permeable timbers. With the available variations to the basic method, a range of treatment levels can be achieved to suit the service requirements of the particular timber components.

Prolonged steeping is the least complicated way of achieving relatively deep penetration but only provides an effective treatment for the more permeable timbers. Because water-borne preservatives do not penetrate well with this method and light organic solvents are costly, steeping is practical only with low viscosity creosotes.

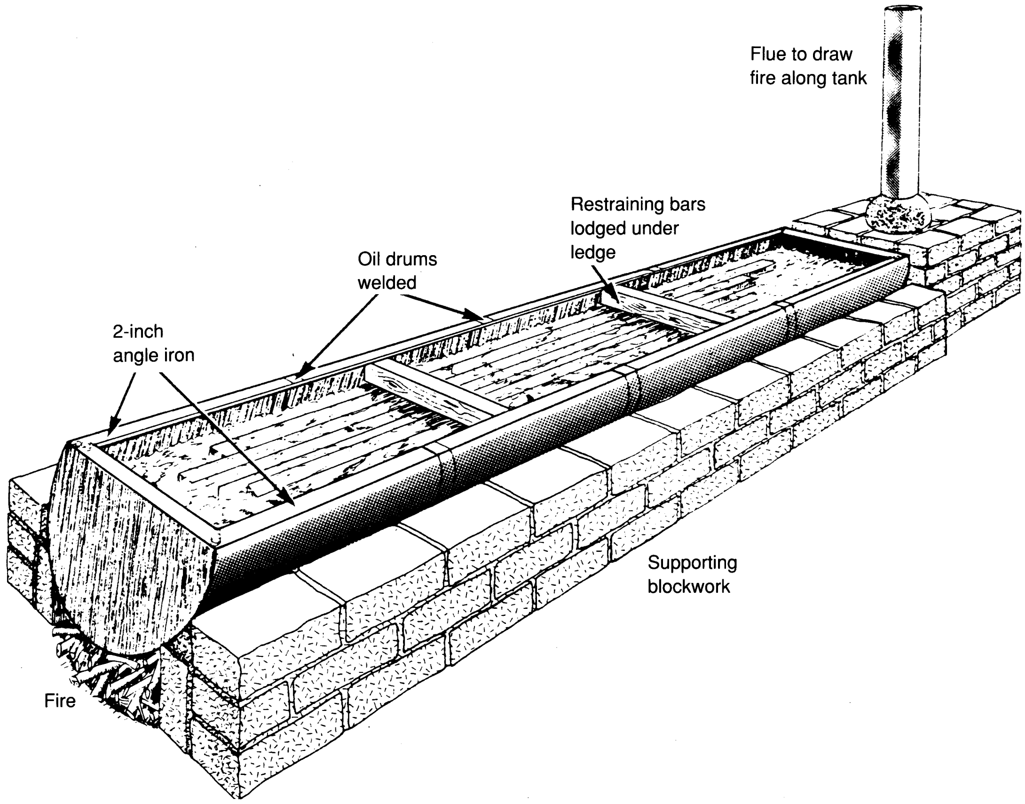

Figure 4 Construction for hot and cold open tank treatment using oil drums and other available materials

PROCESSING AND HANDLING OF TREATED TIMBER

Drying

Timber treated with CCA preservatives requires a period of storage without drying to ensure fixation of the preservative (ie its conversion to insoluble forms) within the wood. In temperate climates this will take 7 to 14 days but in the tropics a shorter fixation period can be expected. Recent developments in plant technology have led to accelerated fixation systems where the preservative is fixed in the timber before it leaves the cylinder. Following the fixation period, the treated timber may be brought to its service moisture content either by open-stacking to allow air-drying or by kiln-drying. Timber treated by water-borne diffusion systems can also be dried in this manner when the diffusion treatment is complete.

Timber treated with light organic solvent preservatives or creosote are normally open-stacked immediately after treatment to allow the solvent to evaporate. For light organic solvents this may take 2 to 7 days or longer depending on the ambient temperature. Creosote is used undiluted and does not contain a drying solvent. Nevertheless a period of storage does allow the more volatile components to evaporate and the timber to acquire a relatively dry surface.

Concern in certain countries over the uncontrolled emission of volatile organic compounds and impending legislation has increased interest in the more technical and expensive forced-drying systems which incorporate solvent recovery.

Retreatment of cut surfaces

Most preservative treatments are best done after all machining, cutting and boring operations are complete. Any of these operations carried out on treated timber may result in the exposure of untreated wood that would be vulnerable to biological attack. If cutting after treatment is unavoidable, all freshly cut surfaces should be liberally coated with the preservative fluid originally used or with a formulation especially made for this purpose. However, in general such action cannot reinstate the original quality of the treatment.

Timbers treated by diffusion processes that result in complete penetration can usually be machined or worked on site without the need for retreatment, although the re-sawing of treated timber over 50 mm thick is not recommended.

HEALTH AND SAFETY

All preservatives should be handled with care, paying great attention to the manufacturer's recommendations and instructions. Protective gloves should be worn at all times when handling treated timber that is wet or contains solvents (this is not normally necessary once the timber is dry). After any operation involving the handling of treated timber, hands should be washed thoroughly especially before handling food. If treated timber is machined or sanded an efficient dust extraction system should be used and wastes disposed of safely in accordance with local regulations or guidance. If dust extraction is not available, dust masks should be provided and used.

The general philosophy on containment is that the only preservative that should leave the treatment plant is that which is inside the treated wood. Bunding around plant, drainage pits to collect run-off, concrete bases and covers for storage areas are some of the ways that can prevent unused or waste preservative contaminating the environment. Such measures prevent immediate problems, eg spillage into rivers which can damage aquatic life, and future difficulties, such as those encountered should land become contaminated through prolonged use as a treatment plant site and be unable to be easily used for other purposes. Where all necessary measures cannot be put into operation, an appreciation and regard for the reasoning underlying their recommendation may assist greatly in damage limitation.

PROPERTIES OF TREATED TIMBER

Strength

In general, the treatment of timber with wood preservatives does not significantly affect its strength properties and can be ignored in design calculations. However, treatment with some fire retardants (not covered by this Note) may cause a reduction in strength. In such cases, high temperature drying of the treated timber should be avoided. Tests should be carried out to determine the effect of the particular treatment, but if this is not feasible guidance can be obtained from the product manufacturer or from BRE.

Corrosion of metal fasteners and fittings

Certain types of metal fixings (eg nail plates for trussed rafters, see Figure 5) will be liable to corrode if the wood in which they are embedded becomes wet. This effect is exacerbated if salt-type wood preservatives are present (eg CCA formulations) and if the ambient conditions are hot and humid. There are several ways of minimising this effect.

- If CCA preservatives are to be used, an oxide rather than a salt-type formulation should be selected and the fittings not attached until the chemical fixation process is complete and the moisture content of the wood is below 20% m/m.
- If the timber is likely to become wet during service and a long life is required from fittings, they should be made from austenitic stainless steel (excluding free machining grades) or copper or silicon bronze.
- If only occasional dampness is expected, coated low-carbon steel (eg sherardised, galvanised or cadmium plated) fittings may be used. Better performance will be achieved with thicker coatings.
- If the timber will remain at or below a moisture content of 20% m/m for most of its service life and be situated in indoor, well protected environments, then unprotected low-carbon steel, iron and aluminium may be used.
- For CCA treated wood, aluminium alloys containing copper should not be used. Sheet aluminium roof coverings or claddings should not be used in direct contact with CCA treated timber.

Figure 5 Use of nail plates in roof construction

Surface finishes

Conventional wood paint systems or exterior wood finishes can be applied to timber treated with water-borne and most light organic solvent wood preservatives provided the timber has been allowed to dry properly. Exceptionally porous wood may need an extended drying period.

Timber treated with creosote, or pentachlorophenol in heavy oil cannot be painted.

SPECIFYING PRESERVATIVE TREATMENTS

The most readily available approach to the specification of any commodity is to refer to a recognised standard. There are no International Standards describing wood preservative treatments, but many countries, including those in tropical regions, publish their own standards dealing with wood preservatives and preservative treatments. Reference should be made to the appropriate standards organisation for details.

Currently there is a range of British Standards available which deals with the preservation of timber (see Appendix B). This may be divided into two main categories (i) end use or commodity standards which define preservatives and treatment processes for particular end uses, and (ii) preservative and treatment standards which define the chemical composition of the main wood preservatives and give details of the treatment processes involved. Both of these categories may be applied to the specification of wood preservation in the tropics.

Many British Standards covering the production of timber commodities (eg transmission poles, fences and cooling towers) contain clauses concerning the preservation of timber. These usually refer to the standards listed in Appendix B.

Complementary to British Standards in the UK is the *BWPDA* Manual* which contains specifications

* British Wood Preserving and Damp-proofing Association, Building 6, The Office Village, 4 Romford Road, Stratford, London, E15 4EA.

developed by the UK preservation industry for wood preservative active ingredients and formulations, methods of applying wood preservatives, and the treatment of various timber commodities. In addition, the main UK wood preservative manufacturers offer their own recommendations on treatment methods for timber commodities when using their products.

At the European level, a group of standards is being developed which will eventually supersede the individual national standards — see Appendix B. These will provide a basis for specifying preservative treatment in general terms. European Standards for specific commodities, eg transmission poles, will call up these standards as a means of specifying requirements.

None of the standards listed in Appendix B deal with sap displacement or double diffusion methods. Advice on the use of these treatment methods should be obtained from the manufacturers of the preservatives to be used. General advice may be obtained from BRE.

Before a specification is written advice should be sought — from the preservative manufacturer, the local forestry service, BRE or BWPDA — on the types of wood-destroying organisms likely to occur in a specific service environment, and the risk of them attacking the timber species selected for the job in this situation. These organisations should also be able to advise on the most appropriate type of preservative treatment.

VALIDATION OF TREATMENTS

It may be possible to ascertain by general visual inspection whether a preservative has been applied to timber, but if the preservative is colourless and has no distinct odour, it will be necessary to apply chemical tests. There are methods which can be used to determine the presence (but not the quantity) of certain preservatives in wood. These include the use of spray reagents to reveal the penetration patterns of preservatives within the wood and the separation and identification of preservatives in solvent extracts obtained from treated wood. Guidance can be obtained by reference to British Standard BS 5666†:Part 2.

Wood preservative treatments can be specified or recommended by defining the process to be used (as in current British Standards). Thus for CCA and light organic solvent preservatives, the solution strength and the process details (eg duration, pressure and vacuum levels) are laid down. Treatment by creosote is specified by both process instructions and the average absorption of the preservative by the charge of timber. The boron diffusion process is the only method of treatment associated with a specified loading or retention of the preservative within the wood (see the *BWPDA Manual* for details). Treatment plant operators usually complete plant records or *charge sheets* as proof of their control over the treatment process. These can be demanded by specifiers as evidence of treatment, or if the contract is large enough to bear the cost, the treatment can be supervised by a clerk-of-works at the plant. It is useful in any case to check some feature of the treated timber to ensure adequate treatment, eg complete penetration of sapwood when expected or specified.

An alternative approach, and the one adopted for the new European Standard, EN 351-1 (Appendix B), is for specifiers to describe the treatment that they require in terms of the results of the process (ie by defining the penetration and retention achieved) rather than by the process itself. This requires a greater emphasis on chemical analysis of the treated timber to determine whether the appropriate level of treatment has been achieved. Methods of analysis exist for treated wood containing certain types of wood preservative (eg BS 5666†:Parts 3 to 7), though not all formulations are included in this set of standards. Where no standard method of analysis exists the manufacturer's advice must be sought.

When taking treated timber samples for checking it is important to ensure that the sample will provide the required answer. For instance, if cross-sections or borings are being taken to determine lateral penetration and retention, they should be taken as far away from the ends of the sample as possible. Penetration from exposed end-grain in the axial direction is relatively easy and a sample taken near to this region may give a false impression of the extent of lateral penetration. The distribution of preservative will rarely be uniform throughout a given charge of timber. Even if species are not mixed there will be variations in density, moisture content and percentage of sapwood which will affect treatability and cause differences in penetration and retention between pieces.

Effective 'policing' of preservative treatment specifications is far from easy and, in developing countries, may be virtually impossible. Where sophisticated sampling procedures and analytical equipment are unavailable, reliance must usually be placed on simple physical checks, common sense and trust in the commercial integrity of those carrying out the treatment.

† **British Standards Institution.** Methods of analysis of wood preservatives and treated timber. *British Standard* BS 5666. London, BSI.

CONCLUDING REMARKS

Wood has been successfully used for building in the tropics, as elsewhere, for thousands of years. Furthermore, it is usually available locally at a reasonable price, and is readily worked with straightforward skills and simple equipment.

A proper specification of the timber to be used, and of any preservative treatment that may be needed, should ensure a good performance for the service life of the construction.

Before writing a specification it is advisable to refer to the local forestry service, BRE, BWPDA or the preservative manufacturer for guidance on the wood-destroying organisms that are likely to attack the timber, the risk of this happening in the intended service environment and the type of preservative treatment, if needed, that will be acceptable.

Architects and others concerned with specifying and procuring building timbers should make themselves aware of the timber species available locally. Usually there is a greater choice than may be at first apparent. Almost all countries, including the least developed, have published books or leaflets describing their timbers. These should be available from the local forestry service.

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APPENDIX A PROPERTIES OF RELEVANCE TO PRESERVATION OF SOME TROPICAL BUILDING TIMBERS

The timbers described here (Table A1 overleaf) do not include those generally considered for furniture or superior joinery work, such as the *mahoganies*. Neither do they include woods that are very dense, hard and durable and which are more appropriately used for heavy duty flooring or engineering or marine works.

The timbers in Table A1 are listed by their standard names, followed in brackets by the botanical names as the standard name may not be that used locally. If a timber offered locally for building purposes does not appear in Table A1, general information on its properties, including those listed, may be obtained from the local forestry service or BRE. Alternatively, reference may be made to the European Standard EN 350-2 (listed in Appendix B) which lists these characteristics for many timbers in commercial use. The treatability and durability classification schemes are those used in the European Standards EN 350-1 and EN 350-2 and are as follows.

Treatability classification

Class 1

Easy to treat. Sawn timber can be penetrated completely by pressure treatment without difficulty. (Old UK system = permeable).

Class 2

Moderately easy to treat. Complete penetration is usually not possible, but after 2 or 3 hours of pressure treatment more than 6 mm lateral penetration can be reached in softwoods, and in hardwoods a large proportion of the vessels will be penetrated. (Old UK system = moderately resistant).

Class 3

Difficult to treat. 3 to 4 hours of pressure treatment may not result in more than 3 mm to 6 mm lateral penetration. (Old UK system = resistant).

Class 4

Extremely difficult to treat and virtually impervious. Little preservative absorbed even after 3 to 4 hours of treatment; both lateral and longitudinal penetration minimal. (Old UK system = extremely resistant).

Durability classification

The durability classification for resistance to fungal attack subdivides timber species into the five groups listed overleaf. The classification refers to heartwood only: sapwood of all species should be regarded as not durable (class 5) unless other data are available. The classes indicate the expected life of the timber relative to a reference timber when half buried in the ground as a stake. The reference timbers are *Pinus sylvestris* sapwood and *Fagus sylvatica* with the one giving the more durable results used as the reference. This approach allows service life to be assessed for different climates and soil types.

Class 1
Very durable. Greater than five times the life of the reference stakes.

Class 2
Durable. Greater than three and equal or less than five times the life of the reference stakes.

Class 3
Moderately durable. Greater than two and equal or less than three times the life of the reference stakes.

Class 4
Slightly durable. Greater than 1.2 and equal or less than two times the life of the reference stakes.

Class 5
Not durable. Equal or less than 1.2 times the life of the reference stakes.

Table A1 Properties of a selection of tropical building timbers

Species	Where grown	Air dry density kg/m³	Treatability class Heartwood	Treatability class Sapwood	Durability class of heartwood
A Softwoods					
Cypress, EA *(Cupressus lusitanica)*	East Africa	450–500	3	1	2
Parana pine *(Araucaria augustifolia)*	South America	500–600	2	1	4–5
Pine, Caribbean Pitch *(Pinus caribbea)*	Western Caribbean, Central America and in plantations elsewhere	710–770	4	1	3
Pine, patula *(Pinus patula)*	Plantations in East and Southern Africa	380–420	1	1	4
Pine, Radiata *(Pinus radiata or P insignis)*	Extensively planted in tropics and sub-tropics	420–500	2–3	1	4–5
Podo *(Podocarpus spp)*	East Africa	490–530	1	1	4
Yellowwood, British Honduras *(Podocarpus guatemalensis)*	Central America	480–520	1	1	3
B Hardwoods					
Abura *(Hallea ciliata)*	West Africa	550–600	2	1	5
Afara *(Terminalia superba)*	West Africa	550–600	2	1	4
Agba *(Gossweilerodendron balsamiferum)*	West Africa	480–510	3	1	2–3
Albizia *(Albizia ferruginea)*	West and East Africa	580–820	4	1	1
Alstonia *(Alstonia congensis and A boonei)*	West, Central and East Africa	380–420	1	1	5
Antiaris *(Antiaris toxicaria subsp welwitschi)*	West and East Africa	430–460	1	1	5
Avodiré *(Turraeanthus africanus)*	West Africa	540–560	4	1	4
Ayan *(Distemonanthus benthamianus)*	West Africa	690–740	4	n/a	3
Balsa *(Ochroma lagopus)*	Tropical America	80–250	3	1	5

continued...

Species	Where grown	Air dry density kg/m³	Treatability class		Durability class of heartwood
			Heartwood	Sapwood	
B Hardwoods continued...					
Banak (*Virola koschnyi*)	Central America	500–560	1	1	5
Berlinia (*Berlinia spp*)	West Africa	550–820	3	1	4
Binuang (*Octomeles sumatrana*)	East India and Western Pacific Islands	270–470	2	1	5
Bombway, white (*Terminalia procera*)	Andaman Islands	620–660	2	n/a	4
Canarium, African (*Canarium schweinfurthii*)	West and East Africa	490–530	4	1	5
Celtis, African (*Celtis spp*)	Tropical Africa	760–800	2	1	5
Dahoma (*Piptadeniastrum africanum*)	West and East Africa	620–780	3	2	2
Danta (*Nesogordonia papaverifa*)	West Africa	710–760	3–4	1–2	3v
Ilomba (*Pycnanthus angolensis*)	Tropical Africa	440–510	1	1	5
Keruing (*Dipterocarpus spp*)	SE Asia	740–780	3v	2	3v
Mengkulang (*Heritiera spp*)	SE Asia	680–720	3	2	4
Meranti (*Shorea spp*)	SE Asia				
Light red meranti		490–550	4v	2	3–4
Yellow meranti		560–660	3–4	2	4
White meranti		600–670	3v	2	5
Dark red meranti		600–730	4v	2	2–4
Mtambara (*Cephalosphaera usambarensis*)	East Africa	560–620	2	2	5
Musizi (*Maesopsis eminii*)	West and Central Africa	440–480	1	1	4
Niangon (*Heritiera utilis*)	West Africa	670–710	4	3	3
Obeche (*Triplochiton scleroxylon*)	West Africa	370–400	3	1	5
Odoko (*Scottellia coriacea*)	West Africa	590–650	1	1	4
Ogea (*Daniellia agea and D thurifera*)	West Africa	480–510	2–3	1	4–5
Okwen (*Brachystegia spp*)	West Africa	530–770	4	1	3
Opepe (*Nauclea diderrichii*)	West Africa	740–780	2	1	1
Pterygota (*Pterygota bequaertii and P macrocarpa*)	West Africa	510–630	1	1	5
Ramin (*Gonystylus spp*)	SE Asia	560–670	1	1	5
Waika Chewstick (*Symphonia globulifera*)	Tropical America and West Africa	640–780	4	3	2

n/a = not available
v = variable

APPENDIX B SPECIFYING PRESERVATIVE TREATMENTS — BRITISH AND EUROPEAN STANDARDS

British Standards include:
BS 144:Part 1. Wood preservation using coal tar creosotes. Part 1. Specification for the preservative.

BS 144:Part 2. Wood preservation using coal tar creosotes. Part 2. Methods for timber treatment.

BS 1282. Guide to the choice, use and application of wood preservatives.

BS 4072:Part 1. Wood preservation by means of copper/chromium/arsenic compositions. Part 1. Specification for preservatives.

BS 4072:Part 2. Wood preservation by means of copper/chromium/arsenic compositions. Part 2. Method for timber treatment.

BS 5268:Part 5. Structural use of timber. Part 5. Code of practice for the preservative treatment of structural timber.

BS 5589. Code of practice for preservation of timber.

BS 5707:Part 1. Solutions of wood preservatives in organic solvents. Part 1. Specification for solutions for general purpose applications, including timber that is to be painted.

BS 5707:Part 2. Solutions of wood preservatives in organic solvents. Part 2. Specification for pentachlorophenol wood preservative solution for use on timber that is not required to be painted.

BS 5707:Part 3. Solutions of wood preservatives in organic solvents. Part 3. Methods of treatment.

European Standards include:
EN 335-1. Hazard classes of wood and wood-based products against biological attack. Part 1. Classification of hazard classes.

EN 335-2. Hazard classes of wood and wood-based products against biological attack. Part 2. Guide to the application of hazard classes to solid wood.

EN 335-3. Durability of wood and wood-based products. Definition of hazard classes of biological attack. Part 3. Application to wood-based panels.

EN 350-1. Durability of wood and wood-based products. Natural durability of solid wood. Part 1. Principles of testing and classification of the natural durability of wood.

EN 350-2. Durability of wood and wood-based products. Natural durability of solid wood. Part 2. Guide to natural durability and treatability of selected wood species of importance in Europe.

EN 351-1. Durability of wood and wood-based products. Preservative-treated solid wood. Part 1. Classification of preservative penetration and retention.

EN 351-2. Durability of wood and wood-based products. Preservative-treated solid wood. Part 2. Guidance on sampling for the analysis of preservative-treated wood.

EN 460. Durability of wood and wood-based products. Natural durability of solid wood. Part 3. Guide to the durability requirements for wood to be used in hazard classes.

EN 599-1. Durability of wood and wood-based products. Performance of wood preservatives as determined by biological tests. Part 1. Specification according to hazard class.

EN 599-2. Durability of wood and wood-based products. Performance of wood preservatives as determined by biological tests. Part 2. Classification and labelling.

APPENDIX C RECOMMENDED FURTHER READING

Books and leaflets describing local timbers and their properties will usually be available from the forestry service of the country.

In addition to the references given in the text and in Appendix B, more information regarding the protection of the wood used in building can be found in the following publications.

Farmer R H. *Handbook of hardwoods.* Building Research Establishment Report. Garston, BRE, 1972.

Building Research Establishment. *Handbook of softwoods.* BRE Report. Garston, BRE, 1977.

Findlay W P K. *Preservation of timbers in the tropics.* 1985, ISBN 90-247-3112-7.

Building Research Establishment Digests:
296 Timbers: their natural durability and resistance to preservative treatment. 1985.

299 Dry rot: its recognition and control. 1985.

304 Preventing decay in external joinery. 1985.

327 Insecticidal treatments against wood-boring insects. 1987.

345 Wet rots: recognition and control. 1989.

354 Painting exterior wood. 1990.

364 Design of timber floors to prevent decay. 1991.

371 Remedial wood preservatives: use them safely. 1992.

378 Wood preservatives: application methods. 1993.

387 Natural finishes for exterior wood. 1993.

393 Specifying preservative treatments. The new European approach. 1994.

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200	December 1993	Maintenance of low-cost buildings (R G Smith)
201	March 1994	Termites and tropical building (R W Berry)
202	August 1994	Preservation of timber for tropical building (R J Orsler)

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