TRADA
wood information

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Wood preservation - a general background

Part 2 - Chemicals and processes

A common student`s examination task is to draw up a list of the properties of an ideal preservative formulation. However, all commercial products must be compromises. They may contain a fungicide, an insecticide, a product having activity in both directions or a mixture of products conferring both forms of protection. Many hundreds of wood preservative formulations are in current use round the world and the search for cheaper, more effective, less toxic and less polluting products goes on.

WIDELY USED FUNGICIDES AND INSECTICIDES

Creosote

Bowstring bridge near Turrialba, Costa Rica erected in 1926 using pressure creosote treated Douglas fir.

The bridge is situated near a waterfall in a valley having constant high humidity and temperature

Coal tar creosote and its derivatives have a broad spectrum of fungicidal and insecticidal activity. They were widely used in the past and are still of commercial importance despite their decreasing availability and increasing cost. Creosote is available in light fraction form for *in situ* application, medium grades for steeping, hot and cold open tank, and vacuum-pressure processing and in heavier grades which require heating during vacuum-pressure processing to lower their viscosity and allow adequate penetration. Heavy tar oil type preservatives are sometimes known under the trade/generic name of Carbolineums. TC oil (a low volatility product of crude oil fractionation) and pentachlorophenol dissolved in heavy oil are more recent alternatives to creosote, with similar properties of high persistence and an oily nature which makes treated components water repellant and more resistant to weathering. Typically this tar oil family of preservatives is used for the treatment of outdoor timbers - poles, posts, sleepers, fencing and timber in dock and harbour construction.

Organic solvent preservatives

Pentachlorophenol (PCP), in addition to its use in a form of 'synthetic creosote' described above, is widely used dissolved in a light petroleum distillate (with cosolvents, resins, anti-blooming agents, etc.) to give a clean, penetrating preservative treatment for building timbers, joinery and general purpose timber used out of ground contact. This and similar preservative formulations form the group of light organic solvent preservatives, losp. Such treatments are usually formulated to be paintable. Pcp is primarily a fungicide with only limited activity against wood borers. Therefore, proprietary formulations frequently incorporate a contact insecticide such as gamma-HCH or dieldrin. When applied with appropriate co-solvents, pcp is of sufficiently low volatility when incorporated into timber to give long-term protection. However, volatile losses from the outer 1 -2 mm of timber have been shown to be both rapid and high so that the protection afforded by superficial means of application such as brushing, spraying, deluging and short-time immersion can easily be over-estimated, particularly in high temperature environments and with impermeable timbers. Pcp is currently under considerable pressure in a number of countries from health authorities, labour unions and environmentalists. Arguments continue as to whether the dangers projected for this chemical are practically significant and current attitudes in different countries vary widely.

Copper and zinc napthenates applied in organic solvent solutions are effective primarily due to their metallic content which persists even though the metal soap compounds eventually hydrolyse and the acid is lost. Their action is primarily fungicidal but inadequate levels of treatment can result in detoxification by tolerant fungi under high stress conditions. Insecticidal activity is quite high with freshly applied preservative but is lost as the acid content decreases. Combined pcp-zinc napthenate formulations have been used commercially as giving broader spectrum protection and increased persistence.

Tributyl tin oxide (tbto) is the member of the generally effective range of trialkyl tin compounds which has found commercial favour in some countries. It is usually used as an organic solvent solution, and sometimes mixed with pcp.

Gamma-Hexachlorocyclohexane (gamma-HCH, gamma-BHC, Lindane, Gammexane) is a contact insecticide widely used in the wood processing industry for both preventive and remedial treatment. Losses from treated wood surfaces are quite high due to the appreciable vapour pressure of the substance. Surface treatments are therefore unlikely to be effective for long periods unless cosolvents are used to reduce volatile losses and allow deeper penetration into the timber.

Dieldrin is an insecticide which has been extensively used in wood preservation in the past as a permanent, effective contact poison. More recently, however, formulators are coming under increasing pressure to use alternative insecticides. The extent of the pressure varies from one country to another and probably emanates from dieldrin's undesirability for agricultural use where its persistence is an environmental hazard rather than an advantage as it is in the wood preservation context.

Water borne preservatives

Waterborne wood preservatives suffer the disadvantage that the zone of wood penetrated by the preservative solution swells and usually has to be redried before the component is put into service. There are two types of waterborne preservatives. In one type the preservative chemicals remain soluble in water and can be leached from the timber if the service conditions involve prolonged exposure to water or soil. However, this type is particularly suitable for diffusion treatments where mobility inside the wood is desirable. The second type embraces mixtures of inorganic salts in solution which react within the timber over a short period (several days) to form precipitates which are virtually insoluble in water and therefore permanently incorporated in the wood.

Copper-chromium-arsenic, CCA, preservatives are available, with slightly different ratios of the three ingredient salts, worldwide under a variety of trade names and are the most common type of waterborne preservative. They come into the second category and give a highly fixed, highly effective preservative treatment suitable for even the most hazardous end use. They are not widely used for joinery or furniture-type end uses because of the difficulties of redrying without distortion. Despite their long history of satisfactory and widespread use in service, their use in some countries is restricted or banned because of their arsenic content.

Although developed some time ago, copper-chromium-boron, CCB, preservatives have come into greater prominence in part because of this disquiet over the use of arsenic. They are stated to have a slower rate of fixation than CCA preservative which allows diffusion, particularly of the boron component into impermeable timbers. However, this boron component remains essentially unfixed although potentially deep-seated within the timber. Another claimed advantage over CCA`s is that CCB preservatives are stable at above $50^{o}C$ so that treatment at elevated temperatures can be used to improve penetration. The combination of these factors supports the claim that they are more suitable than CCA preservatives for the treatment of impermeable species of hardwood.

Fluor-chrome arsenate phenol (FCAP) preservatives are available under a number of brand names. They are reported as having less effect in controlling soft-rot fungi than CCA salts but are effective against insects, particularly house longhorn beetles and termites. They do not fix as rapidly as CCA treatments and are therefore able to penetrate impermeable heartwood to a greater extent. As with the two previous types, the multi-salt formulation gives these preservatives a broad spectrum of activity against both fungi and insects.

Borates possess both fungicidal and insecticidal properties and are used alone as well as in multi-salt formulations. In practice, most boron treatment is applied to wet timber by diffusion processes which can achieve deep penetration in even impermeable timbers. The mixture usually used is of boric acid and sodium tetraborate decahydrate. The solution of the resulting disodium octaborate tetrahydrate is usually heated to achieve the concentrations necessary to get adequate loadings in the treated product but remains water soluble and thus subject to losses under leaching conditions. Borates are stated to be particularly effective against Lyctids even when applied by superficial methods. They are also useful in anti sap-stain treatments but must usually be fortified with a more efficient mouldicide such as sodium pentachlorophenate.

The list of other water-borne preservatives and their variants is extensive, particularly if an historical view is taken. Developments are also being pursued in this area. Two which deserve mention are the alkyl ammonium compounds and the use of pentachlorophenol in heavy oil applied as a dispersion in a water carrier.

AAC, alkyl ammonium compounds, have been explored particularly in New Zealand, as alternatives to established water-borne treatments. They were originally conceived as being fungicidal but then shown to be effective against two beetle borers and a species of termite. However, they have not proved very effective against Lyctids, probably because they are chemically bound to the cellulose which Lyctid larvae do not use. Other tests have also shown that selective absorption of chemicals during penetration of the preservative can result in inadequately treated heartwood which fungi from culture can reach by growing through the treated zone.

Duratreet II is a proprietary preservative, developed in the US which claims to get an equivalent level of treatment to pcp in heavy oil by using a water dispersible form, thus saving on expensive petroleum derivatives. Some 85 per cent of the treatment fluid is water but despite this, most of the drawbacks of waterborne treatments are claimed to be avoided. Similar emulsion treatments have established themselves in the remedial treatment field where added safety is another important advantage over losp systems.

Sodium pentachlorophenate (Na pcp) is the sodium salt of pcp. It is water soluble and was extensively used worldwide as the standard chemical for the prevention of sap-stain, often in conjunction with borates. It continues to be used in this way but is under increasing pressure due to its supposed health hazard.

New insecticides

The research literature contains numerous references to the search for `new' insecticides to act as replacements for those in current use which are increasingly being frowned upon on health and safety, and environmental pollution grounds. Much of this research must be covered by commercial secrecy but considerable work is being done by various government research establishments to screen chemicals for their effectiveness and other attributes. The various members of the organophosphorus family have received much attention but most hope seems to be being pinned on the synthetic pyrethroid (SP) compounds and Permethrin in particular.

METHODS OF PRESERVATIVE TREATMENT

In spite of general views to the contrary, timber and its derivative board materials are not porous materials which soak up liquids like a sponge. Most preservative treatments result in penetration of only the surface layers of the timber to a depth of two to several millimetres, providing a protective 'envelope' around a still susceptible core. The thickness of the envelope should be related to the type of protection, and the type of exposure anticipated in service. To be effective, the envelope of adequately treated timber must be and must remain intact. Timber (or plywood) in service conditions which may result in splitting must be treated to a depth greater than the depth of the splits; all the vulnerable sapwood of, for example, a pole or post of a naturally durable species must be impregnated. It also follows that all cross-cutting, shaping, boring, etc. must be done before preservative treatment or at the very least, the protective shell must be reinstated by local application of appropriate preservative. These considerations are no less important for insecticide treatment than for fungicidal preservatives. In both cases, a breach in the protective envelope can result in destruction of the centre of the piece leaving an outer shell of preserved timber.

For deep penetration (and to reduce the extent of subsequent splitting), it is necessary for timber to be dried to levels approaching its service moisture content before being treated. Attention to this factor of material preparation is vital for satisfactory performance of wood preservative treatment.

Exceptions to this 'envelope protection' are diffusion treatments carried out on small dimension (up to 50 mm thick) and the incorporation of wood preservative into boards during manufacture in such a way that uniform distribution of a sufficient amount of chemical is achieved.

METHODS OF PRESERVATIVE APPLICATION

Brushing and spraying

Brushing and spraying are the least effective methods of applying wood preservatives. The amount of preservative chemical loaded into the timber is generally small - but much greater for rough-sawn surfaces than for planed ones. For in situ remedial treatment, they are usually the only processes available and their effectiveness must be maximised by formulation, use of penetrating solvents, and liberal and possibly repeated application. Spraying is also appropriate for the short term protection of logs in the forest or at storage sites. Here again, accessibility dictates the process but only a superficial protection layer is required for effective protection and volatilisation losses of the preservative, which are most severe from the first 1 - 2 mm of treated timber, are not too significant. The main difficulty with this form of treatment is control of the process and ensuring total coverage.

The only case where such superficial methods can be considered to give a useful degree of long term protection is when they are periodically renewed as a maintenance procedure. This limits them to accessible timbers out of ground contact. Even in these cases, a more effective initial treatment is a more satisfactory solution.

Deluging

Deluging, where the components to be treated are put through a spray or flood-curtain tunnel, is an alternative to brushing or spraying for superficial application for short-term protection. The equipment is relatively simple and is capable of being operated with greater safety than is simple dipping. The resulting treatment levels are comparable with brushing or spraying.

Immersion treatments

This category is often arbitrarily divided into 'dipping' and 'steeping' with a dividing duration of about ten minutes. Higher loadings of preservative chemical and deeper penetration result from longer immersion but the benefits do not increase in direct proportion to time. Most of the absorption occurs in the first few minutes, but deep penetration, particularly into end grain, requires up to one or several hours depending on the size and species of timber. The method has the merit of being simple and requiring a minimum of equipment but its very simplicity makes it a difficult process to control where more than a quick `in and out' treatment is called for, eg sap stain control. Automatic immersion systems which ensure that the whole load is submerged and with tamper-proof duration control are available.

Immersion treatments are suitable for tar oil and water borne preservatives as well as for appropriately formulated losp products. They are used effectively for sap-stain control, fence post, building timbers and joinery when the appropriate preservatives and durations are used.

Hot and cold treatments, applicable to tar oil and CCB preservatives, are a development of immersion treatments which additionaly use soaking in hot solution to expel air from the timber followed by immersion in cold preservative (or cooling down) when atmospheric pressure forces liquid in deeper and at higher loadings than would be achieved by straight immersion. Fence posts and other agricultural timbers are the main commodities treated by these processes but they are more widely applicable if the penalty of a high labour requirement can be offset against the simplicity of the equipment.

Diffusion treatments

Diffusion treatments require the use of water-borne preservatives, which either do not `fix' in the wood or do so only slowly. CCA preservatives can be applied by a double diffusion process, one component following the other to react and fix within the wood. This means extra handling, storage and processing and so is not widely practiced. It is, however, a means of achieving deep penetration of an effective preservative without the need for expensive equipment. More commonly, diffusion is used for boron or similar water soluble preservatives for treating, green, ie wet, timber or veneers. A high moisture content is essential for efficient diffusion, as is a wet storage period of several weeks to months (depending on species, thickness and temperature) followed by drying to suit end-use service. Again, the equipment requirements are minimal, but effective quality control measures are necessary if the method is to be successful.

Sap displacement

Sap-displacement is the only other method which can (and needs to) be applied to green timber. It is only of use for treating poles or posts and involves replacing the sap with water-borne preservatives applied under pressure to one end of the pole.

Pressure methods

Pressure methods are the most effective for the majority of types of preventive application of wood preservatives and are more amenable to control than most of the alternatives. Nevertheless, they are by no means a universal solution to the problem of impregnating timber or wood-based board materials and the many schedules and variants of the basic procedures are testimony to the difficulty and complexity of the problem. Pressure methods, usually incorporating a vacuum phase, are suitable for most preservatives and commodities where deep penetration and high or controlled loadings are required. With the appropriate equipment, it is possible to control loading and penetration independently within the limits required by adjusting the following factors.

- the concentration of the treatment solution
- its temperature
- the level and duration of the initial vacuum stage (if present)
- the level and duration of the initial pressure stage (if present)
- the level and duration of the main pressure phase
- the level and duration of the final vacuum stage (if present)

Suitable schedules are available for the effective treatment of the sapwood of most species and the heartwood of many. There are, however, certain difficult-to-treat species which do not respond well to the conventional treatment schedules. For these, alternating or oscillating pressure processes have been developed using special plant. More extended use may need to be made of such developments as the pattern of timber species availability changes.

The conventional processes bear names such as double vacuum, empty cell, and full-cell processes depending on the process variables used. It is usually desired to obtain deep penetration without an excessive loading of preservative. An initial pressure or at least an absence of vacuum coupled with a final vacuum to withdraw most of the preservative fluid from the cell cavities is the normal way of achieving this end although double vacuum schedules perform similarly. For very high hazard situations where leaching is inevitable, full cell processes are required. In this case, some of the air in the wood cells is evacuated before the pressure phase so that it does not force out the preservative fluid on release of the main pressure application.

All pressure processes require specialised plant, skilled operation and efficient supervision of the prepararation and treatment of the timber.

FURTHER READING FROM TRADA

Prices and a full list of publications are available on request.

TIMBER PRESERVATION

Published jointly by TRADA and the British Wood Preserving Association

TBL 37 Revised 1986

Covers the priciples of preservation, hazards to timber in use, types of preservative treatment available, preparation of timber for treatment, methods of application and the properties of treated timber. Also discusses the remedial treatment of timber in situ.

WOOD INFORMATION SHEETS

2/3-16 Preservative treatment for timber - a guide to specification

2/3-21 Wood preservation - processing and site control

2/3-32 Wood preservation - a general background. Part 1 - the risks

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