Wood Preservatives and treatment methods

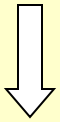
Introduction

Wood being a lignocellulosic material is liable to be destroyed by biodegrading agencies like insect, fungi etc and thus requires frequent replacements during use. Wood is used for variety of purposes and its consumption is increasing despite shortfall in production. Wood preservation is necessary to increase the service life of wood. It is now well established that the application of preservative chemicals enhances the service life of timber 5-8 times and thus reduces the demand for replacement wood. In other words one cu. m. of treated wood would save two cu. m. over a period of 15 years (at conservative estimates).

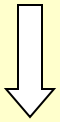
Wood Preservation helps in:

- Promotion of non- durable species for better utilization in place of durable species.
- Saving of material and labour cost occurring in replacement of decayed wood.
- Earning of foreign exchange by reducing import of timber and increasing the export of durable timber.
- Reducing the burden on Forests

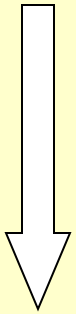
Deteriorating Agencies

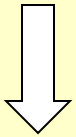


Physical	Chemical	Mechanical	Biological	Fire



Bacteria	Mould	Insects	Fungi	Marine borers





Sap stain	Decay Fungi	Soft rot

Termites	Borers	Ants

Sap stain and mould fungus

•Certain lower forms of fungi develop as molds and stains on wood. The most important stain is blue stain, although several other colours of stains may also develop in certain wood species. Such attack is confined basically to sapwood of certain wood species, rich in starch content.

•The cell wall is not attacked, although the stain fungi may penetrate deep into the wood. Such attack occurs when the wood is freshly cut and contains high moisture content. Since the fungus consumes only the stored food material, the attack does not significantly affect the strength properties of timber except toughness or the shock resistance.

Stained wood, therefore, is unsuited for certain specialized applications such as air-crafts, sports-goods, tool handles, etc. Stained wood is also not accepted in certain clear-finish articles, where such stains interfere with the aesthetic value.

Wood Rot or Decay Fungi

Wood decay can occur both during storage or use, whenever conditions for such growth are favorable.

(i) Optimum temperature, which lies in between 16 to 32^0 C,
(ii) Moisture between 35-45 per cent
(iii) Adequate supply of air and
(iv) Food.

Each fungus species has its own optimum conditions. Some fungi are active even at 45^0 C. Although high temperature for prolonged periods may kill the fungus, whereas at lower temperature, they become dormant, ready to attack whenever favorable conditions occur. However timber is regarded immune to fungal attack below 20 per cent moisture content.

Brown rots fungi

Brown rot primarily consume carbohydrates, i.e. cellulose and hemicellulose. Lignin is not much affected. Brown rotted wood changes to a brownish residue. Wood loses strength rapidly and undergoes drastic shrinkage and cracking across the grain.

White rot Fungi

White rot attacks all component of wood, i.e. cellulose, hemicellulose and lignin. The wood is reduced to a spongy or fibrous condition with white pockets or streaks. Wood loses strength gradually and retains its fibrous structure into advanced stages.

Insect degradation:

Insects, borers and termites account for major destruction of wood during storage and wood products during use. Their is considerable time gap between felling of trees and their allocation to the industry. This forced storage of freshly felled timber in forests without any protective measure and in most cases without debarking exposes the timber to degradation by insect borers. The degradation varies widely according to the climatic conditions, timber species etc.

Natural durability

Natural durability of wood is the resistance of the wood in its natural form to the combined effects of decay rots, insects, termites and borers.

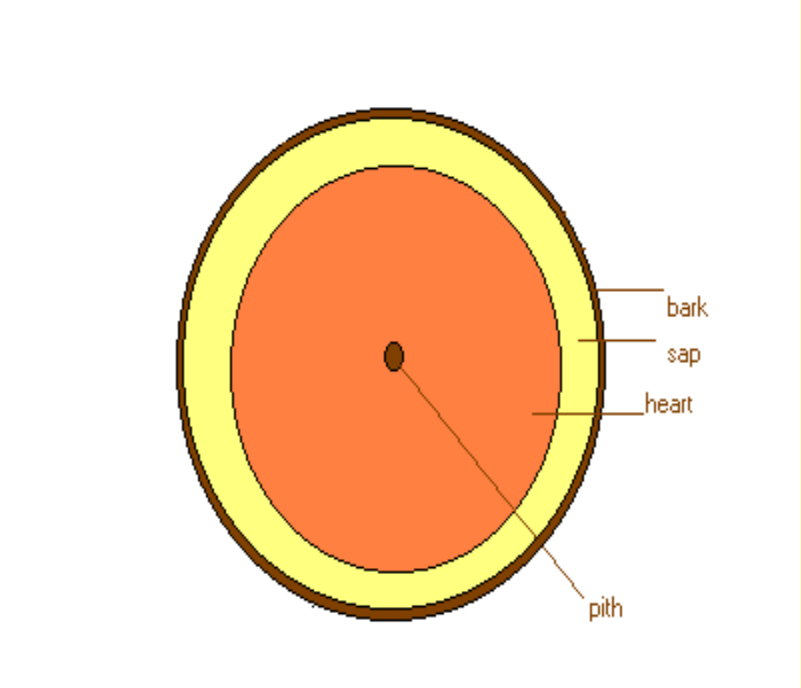
In the absence of natural resistance to biodeterioration the wood needs to be treated with preservatives.

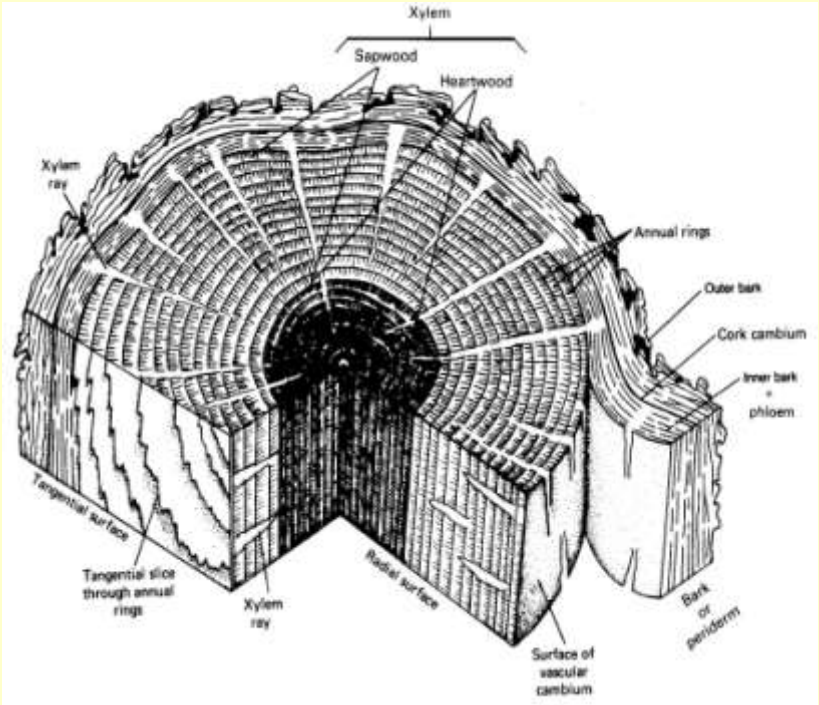
Class I	Durable	Life more than 120 months
Class II	Moderately durable	Life between 60 to 120 months
Class III	Non durable	Life less than 60 months

Sapwood of all the species even those in which heartwood is highly durable is susceptible to deterioration

Heartwood is more durable than sapwood due to the presence of extractive contents

Sapwood is easily treatable, whereas heartwood of many species are refractory to treatment





Wood Preservatives

- High toxicity
- High permanency
- High penetrability
- High stability

Types of wood preservatives

Oil type

Coal tar creosote is an oil type preservative.
It is used for the treatment of timber, products etc for exterior use.
It may be used with or with out admixture with fuel oil.

Organic Solvent Type:

These are very active chemicals having high fungicidal/insecticidal properties and are applied by dissolving in suitable organic solvents.

These preservatives are permanent and the treated material is clean to handle.

They have a high degree of penetrability and can be applied by pressure treatment or even mere dipping.

These preservatives are:

Trichlorophenol
Chlorpyrifos
Synthetic pyrethroids: Cypermethrin, deltamethrin
Copper naphthenate
Zinc napthenates

Water Soluble Type Preservatives

Leaching Type:

These preservatives are inorganic or organic salts soluble in water and are recommended for use under cover as they provide limited protection in exposed conditions.

Copper sulphate
Zinc chloride
Boric acid
Borax
Sodium pentachlorophenate (NaPCP)

Fixed Type Wood Preservatives:

These preservative are mixtures of various salts which react and form insoluble complex salts and thus get permanently fixed.

Timber treated with these compositions can be used in outside locations also. Treated timber should, however, be allowed to dry for 1 to 2 weeks to complete the fixation process.

These preservatives are applied at ambient room temperatures as the chemicals are precipitated at elevated temperature.

Copper-Chrome-Arsenic composition (CCA)
Acid-Cupric-Chrome-composition (ACC)
Chromated Zinc Chloride (CZC)
Copper-Chrome-Boric compositions (CCB)

Copper-Chrome-Arsenic composition (CCA)

Copper sulphate ($CuSO_4$ 5H2O)	3
Sodium dichromate ($Na_2Cr_2O_7$ $2H_2O$) or Potassium dichromate ($K_2Cr_2O_7$)	4
Arsenic pentoxide (As_2O_5 $2H_2O$)	1

Copper-Chrome-Boric compositions (CCB)

Copper sulphate ($CuSO_4$ 5H2O**)**	3
Boric acid (H_3BO_3)	1.5
Sodium dichromate ($Na_2Cr_2O_7$ $2H_2O$)	
or	4.0
Potassium dichromate ($K_2Cr_2O_7$)	

Acid-Cupric-Chrome-composition (ACC)

Copper sulphate ($CuSO_4$ 5H2O)	50 %
Sodium dichromate ($Na_2Cr_2O_7$ $2H_2O$)	45 %
or	
Potassium dichromate ($K_2Cr_2O_7$)	
Chromic acetate ($Cr_2H_3O_3$)H_2O	5 %

Chromated Zinc Chloride (CZC)

Zinc chloride ($ZnCl_2$)	81.5%
Sodium dichromate ($Na_2Cr_2O_7$ $2H_2O$)	
or	18.5%
Potassium dichromate ($K_2Cr_2O_7$)	

Choice of treatment

The choice of treatment is governed by the timber to be treated, its sapwood content and the use to which it is put to. Treatment is necessary in the case of:

- Sapwood of all species of timber including durable species, when it is used indoors, outdoors or in wet condition

- Heartwood of non-durable species

- Heartwood of durable and moderately durable species, if timber members are required to give long life under severe conditions of service.

- **Protection methods**

  Avoid contact of water

  Poison the food material with toxic chemicals

  Modify the wood constituents so that it becomes un recognizable as a food material.

PREPARATION OF MATERIAL

For satisfactory treatment and good performance the timber must be sound and suitably prepared.

Debarking

The removal of bark is essential because

a) It harbors wood boring insects and encourages decay.

b) It resists the penetration of preservative in the treatment of poles or round timbers and increases costs of preservative treatment as it absorbs too much preservative.

c) It retards seasoning

d) Patches of bark left during treatment usually falls off in time and expose untreated wood.

Drying

The presence of of any free water in the timber retards the penetration of preservative liquid; it is therefore necessary to remove it prior to treatment.

Machining All machining operations, plaining, shaping, boring etc. should preferably be done prior to treatment other wise untreated portions will be exposed to the decay agencies and in addition the chemical will go waste during the machining operation.

Incising

Wood that is resistant to penetration by preservatives may be incised before treatment to permit deeper and more uniform penetration.

In incising, shallow slit like holes are made on the surface along the grain direction.

Incising Gives uniform penetration up to the depth of the hole.

Treatment Methods

Non Pressure

- **Prophylactic treatment**
- **Surface application**
- **Diffusion process**
- **Hot and Cold process**

Pressure

- **Full Cell Process**
- **Empty Cell Process**
- **(Lowry and Rueping)**

Prophylactic treatment

This treatment is given either by Brushing or Spraying of preservative solution on the wood surface including ends. Care should be taken to cover the entire surface completely by the preservative

The Prophylactic treatments should be given immediately after felling and the bark should be removed before treatment. The treatment may be repeated after the material arrives at mill site, if the material is to be stored as such without any further conversion.

If the material is stored after conversion, the treatment will have to be repeated as fresh surfaces will be exposed which are liable to be attacked.

The treatment may have to be repeated every three months or earlier depending upon the conditions of storage or if any attack by fungus or insects is noticed in the stacks.

Surface application

- This treatment has limited scope and is used mostly for treating the material at site or for retreatment of cut surfaces.
- This is done by either brushing, spraying or dipping the wood in a preservative solution for a short period.
- This treatment with water-soluble type salts does not afford a longer protection
- For oil type preservative, the moisture content in the timber should not be more than 20 percent whereas with water-soluble type salts moisture content of 20 to 30 percent is permissible.
- At least two coats should be applied, second and subsequent coats are applied after the first has dried or soaked in the wood.

Preservative application through spraying/brushing

Preservative application through dipping/soaking

Diffusion Processes

- Applicable for the treatment of green timber
- Treatment through water soluble type of preservatives
- Penetration of preservatives due to concentration gradient

In this process green wood is soaked in preservative solutions of 4-10 percent concentration for sufficiently long periods to get the desired absorption of the preservatives. The absorptions depend upon the type of wood, its moisture content, thickness and nature of the penetrating chemicals.

Hot and cold process:

The process is suitable for easy-to-treat species in which required absorptions can be easily obtained. The timber to be treated is heated in preservative solution to about 90^{o}C for 2 to 3 hours.

This heats the air inside wood, which escapes partially due to expansion. The preservative and timber is allowed to cool by itself. On cooling, the preservative flows into wood as a result of partial vacuum created by the contraction of air

The cooling can be curtailed when suitable absorptions are obtained and can thus be used to control absorption of the preservatives.

This process is recommended for material containing sapwood, easily treatable heartwood with water soluble fixed type preservatives.

Pressure Treatment Process

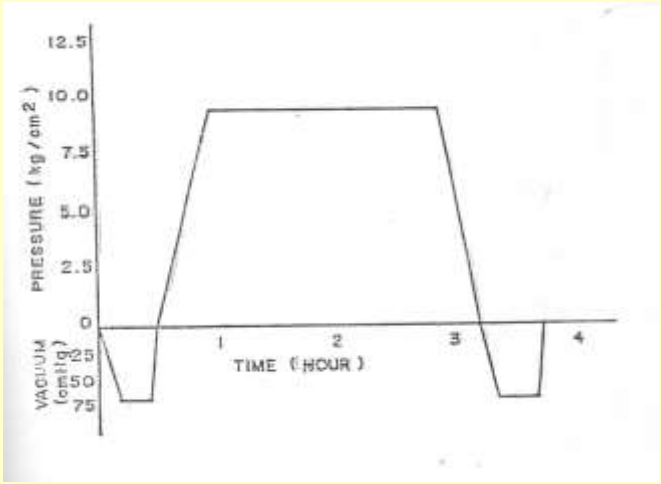
Impregnation of wood under pressure is the best method to get uniform and proper treatment under controlled conditions. This is usually done in a pressure cylinder equipped with vacuum-pressure system, storage tanks and mixing tanks for preservative solutions.

The details for the pressure treatment plants and guidelines to install are given IS: 2683

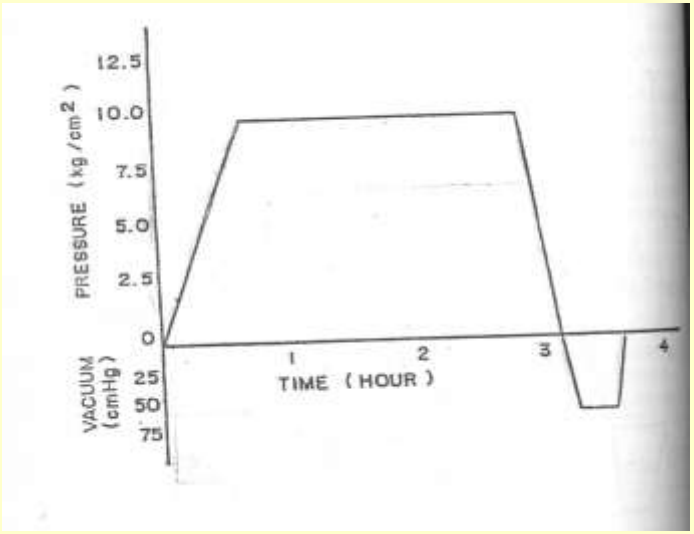
The basic principle for all pressure impregnation processes for treatment of wood is to inject preservative solution either hot (as in case of creosote) or at ambient temperature (as in case of CCA type) into the wood structure under pressure with or without the use of initial vacuum.

The pressure duration and magnitude vary with treatability class of timber. The advantage of the process is to have quick and continuous flow of treated material

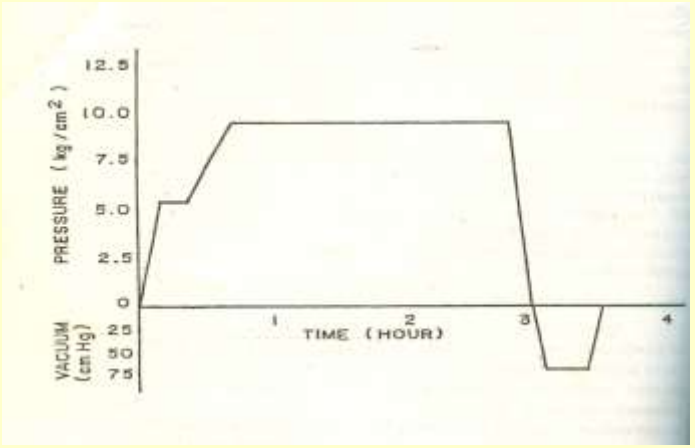
Full Cell Process
Empty Cell Process (Lowry and Rueping)



Full cell Process



Empty cell Process (Lowry Process)



Empty cell Process (Rueping Process)

Short term protection

Brush , spray or dip treatment with insecticide plus anti sap stain chemical to protect against initial attack of insects and sap staining fungi and then should be stored under shade on a clean place on the piles of treated wood or cement concrete / bricks.

Various agricultural insecticides/pesticides have been tested and following chemicals have shown their versatility against sap stain and termites.

i) Borax:boric acid: Sod. pentachlorophenate (1:1:0.5)
ii) Borax: Sod. pentachlorophenate (1.5:0.5)

Long term protection

For long term protection of wood and wood products, require treatment as per IS: 401: 2000

Conventional wood preservatives copper-chrome-arsenic (CCA), copper-chrome-boric (CCB),acid cupric chromate (ACC) etc are very effective but stain the wood with light green color on the sap wood portion.

Boric acid : borax (1:1) solution has been found suitable for treatment of timber for use under shade.

Retention Requirements for Different End Uses

The retention of preservative chemicals in timber member depends upon the condition of its use as it is subjected to different hazards of deterioration. If the member is used in hazardous conditions, higher retentions are required. For mild conditions, where there is no fear of leaching, lower retentions can be used effectively. On this basis the recommended practice with regard to choice of preservative, treatment process, retention and penetration to be adopted is given in IS 401: 2001

Service Condition of Treated Timber	**Commodity**	**Process of Treatment**	**Preservative**	**Recommended Absorption kg/m^3**
Timber for packing cases to be stored outside and exposed	Packing cases, pallets, ammunition boxes, cable drums, etc.	Hot and cold/pressure processes	a) CCA	3.2
			b) ACC	4
			c) CCB	4
			d) ACA	3.2
			e) Copper naphthenate/abietate	0.5
			f) Zinc naphthenate/abietate	0.8
			g) TCP	4

Service Condition of Treated Timber	**Commodity**	**Process of Treatment**	**Preservative**	**Recommended Absorption kg/m^3**
Timber for packing cases to be stored inside or under cover	Packing cases, pallets, ammunition boxes, cable drums, etc.	Brushing/Spraying/Dipping	a) CCA	3.2
			b) ACC	4
			c) CCB	3.2
			d) TCP	4
			e) ACA	3.2
			f) Boric acid:borax	3
			g) Copper naphthenate/abietate	0.4
			h) Zinc naphthenate/abietate	0.6

Service Condition of Treated Timber	**Commodity**	**Process of Treatment**	**Preservative**
Prophylactic treatment for storage of timber etc.	Timber logs and converted timber	Brushing/Spraying /Dipping	a) Sodium pentachlorophenate: borax (0.5:1.5)
			a)Gamma BHC:NaPCP (1:1) 2 percent emulsion solution in water b)Gamma-BHC (Lindane) 1 percent in petroleum oils
			d) TCP: gamma lindane (2:0.5)
			e) Chlorpyrifos/synthetic pyrethroids 1 percent emulsion

Retention of Preservatives

Retention is the amount of preservative retained in a unit volume of wood.

Retention is calculated by formula

$$\text{Retention } (kg/m^3) = \frac{GC \times 10}{V}$$

G = weight of the treating solution absorbed by wood $(W_2 - W_1)$ in grams

C = Concentration (%)

V = Volume in cm^3.

Permissible Moisture Content at the Time of Treatment of Timber (IS 401:2001)

Sl. No.	Timber	Process	Approx Moisture Content, Percent
i)	Poles, fence posts and timber belonging to treatability grades (a) and (b)	Open tank hot and cold process	15-20
ii)	All other classes of timber whether included in (i) above or otherwise.	Pressure treatment	Less than 25
iii)	Poles, fence posts (with branch/bark intact)	Boucherie treatment	Green, freshly felled
iv)	Round of sawn	APM	Green, freshly felled, more than 60

NOTE: The moisture content specified shall be that of the outer layer of the sleepers/poles to a depth of about 20 mm and may be estimated by a suitable moisture meter or by means of conventional oven drying method. In the case of sawn timber of lower dimensions, the moisture content shall be an average of the entire cross-section.

Storage of wood

The following precautions should be observed while making stacks:

1. The site for storage should be clean and hygienic. There should be no weeds, debris and dung or decomposed organic materials which becomes source of infection. If the place has been used for storing material earlier, it should be thoroughly sterilized. All debris of infested material and wood dust etc. must be burnt and the ground sprayed with 5% emulsion of chloropyrifos.

2. The chemically treated ground should perfectly be plastered with lime and coal ash. This will form a hard mass and protect against dampness and termite attack from underneath.

3. Pucca platforms above the ground be raised so that the material does not come in contact with ground and free passage of air and rain water is provided below the stacks.

4. Prophylactic treatment should be given before stacking. Stacking should be done under shade. If the timber is stored in open, it should be covered with tarpaulin after treatment.

5. Fresh coming material should be stacked at some distance from old stacks and the latter should be consumed first.

6. Stacks should be made under cover as it will protect the material from severe drying under sun and thus prevent checking and also protect the treatments during rains if water soluble chemicals have been used. Sawn material should always be stored under cover.

Penetration Tests (Spot Test)

The penetrability of the preservative is very important property. If the preservative is not deeply penetrated it will not protect the timber for long time as cracks and checks developed make entrance routes for insects and fungi spores and start decay of untreated portions. The penetrability is determined by the colour change or by spot test on cross section of the wood sample by cutting the sample in the middle.

Detection of Copper

Chromeazurol- S method

- Dissolve 0.5 gm chromeazurol-S and 5.0 gm of sodium acetate in 80 ml water and dilute to 100 ml.
- Spray –on cut sections. Treated portions with copper containing preservatives will turn blue while untreated portions will remain red.

Detection of chromium

Dissolve 0.5 g diphenyl carbazide in 50 ml isopropyl alcohol and 50 ml of distilled water.
Spray- on the boring or cross section. Portions containing chromium will develop a purple colour while untreated portions will remain as such.

Detection for boron

Sol.1 20 % of conc. HCl saturated with salicylic acid (about 13 g/ 100 ml).
Sol.2 Extract 2% turmeric powder in rectified sprit

Apply sol. 1 on dry surface of wood, wait for few minutes, then apply sol. 2. Areas having presence of boron turns red.

Precautions:

All insecticides and fungicides have are toxic and should be used after taking proper precautions such as: -

1. Gloves, protective garments and goggles etc. should be used while spraying or brushing the insecticides.
2. Persons with cuts and wounds should not touch these insecticides.
3. Hands or other parts of the skin, which may get in contact with these compositions, should be thoroughly washed with soap and water.
4. No food items should be exposed during spraying process.

Wood Fumigation

Wood Fumigation in India is mainly carried out with Methyl Bromide and Aluminium phosphide

Methyl Bromide is most widely used fumigant for Quarantine purposes. It is a preferred fumigant, because of its good penetrating ability, rapid action, high toxicity to a broad spectrum of insects and pests.

It is frequently used for fumigating timber, agricultural products, empty containers, food stuffs, and other agricultural produce.

It is very effective in controlling all stages of insects from egg to the adult stage. Quarantine Authorities around the world have stipulated that methyl bromide fumigation has to be carried out for all the packing materials which is made out of Wood, Straw materials.

Methyl Bromide fumigation should be carried out for packing wood crates, skids and other packing materials

Plant material such as straw, rice hulls and similar plant material used as packing material can carry exotic insect pest and diseases. The wooden crates has to be treated prior to shipment by carrying out fumigation with Methyl Bromide. The maximum thickness of the packing wood should not exceed 200 mm.

Aluminium Phosphide

Aluminium Phosphide is used worldwide for fumigation of raw and processed commodities including grains, tobacco, cocoa beans, nuts seeds, animal feeds, tea, coffee leaf, wheat flour, processed spices, dried fruits.

Fumigation Under cover

Fire retardants

Apart from deterioration from biological agencies, wood is also susceptible to serious damage from fire. Decayed wood can be ignited more easily than the sound wood.

The chemicals that are used in the protection against fire can be grouped under three categories.

Highly hygroscopic chemicals. These chemicals retards fire because they give off water vapor when exposed to fire and act as automatic fire extinguisher like Zinc chloride

Chemicals that gives off non combustible gases due to decomposition when exposed to fire like Sod. Carbonate, Ammonium chloride

Chemicals that crystallize in wood and swells wood on exposure to fire these plug in the pores in and keep out air like boric acid, borax.

The fire retardant chemicals can be added to the water soluble preservatives to offer protection against fire and and biodegrading agencies

Fire Retardant compositions

Inside use

1. **Zinc chloride**
2. **Ammonium Phosphate**
3. **Ammonium Borate**

Outside use

1. **Zinc chloride 54 parts and Ammonium phosphate 46 parts**
2. **Magnesium arsenate**
3. **Magnesium pyrophosphate**
4. **Sodium dichromate 4 part, Zinc chloride 4 part, Ammonium sulphate 1 part and Boric acid 1 part**

Fire proofing cum antiseptic compositions

a) Chromated Zinc chloride

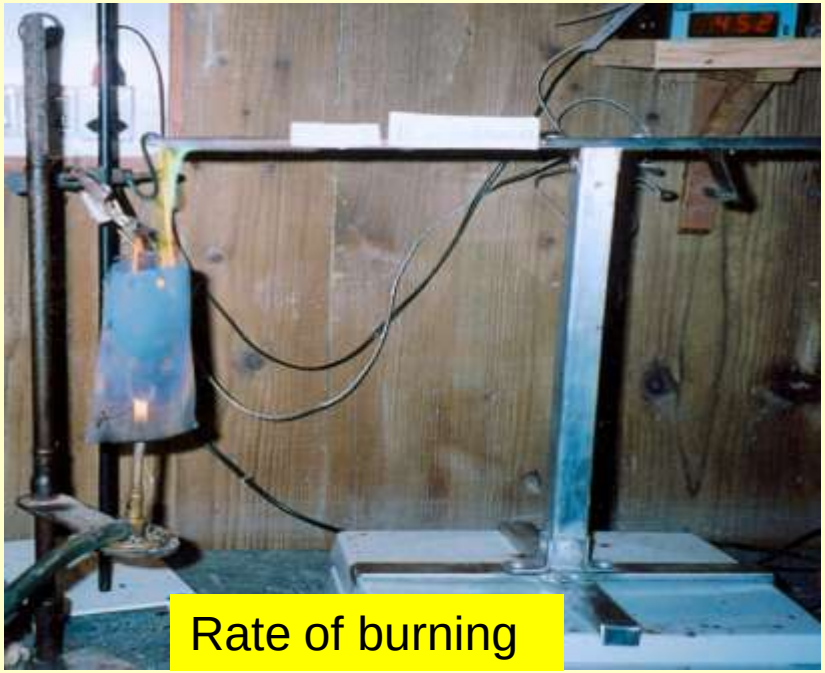
b) Boric acid 3 parts, Copper sulphate 1 part, Zinc chloride 5 parts. Sodium dichromate 6 to 7 parts

c) Ammonium phosphate 3 parts, boric acid 3 parts, Zinc chloride 5 parts, copper sulphate 1 part and Sodium dichromate 3 parts
A 15% solution is used for treatment.

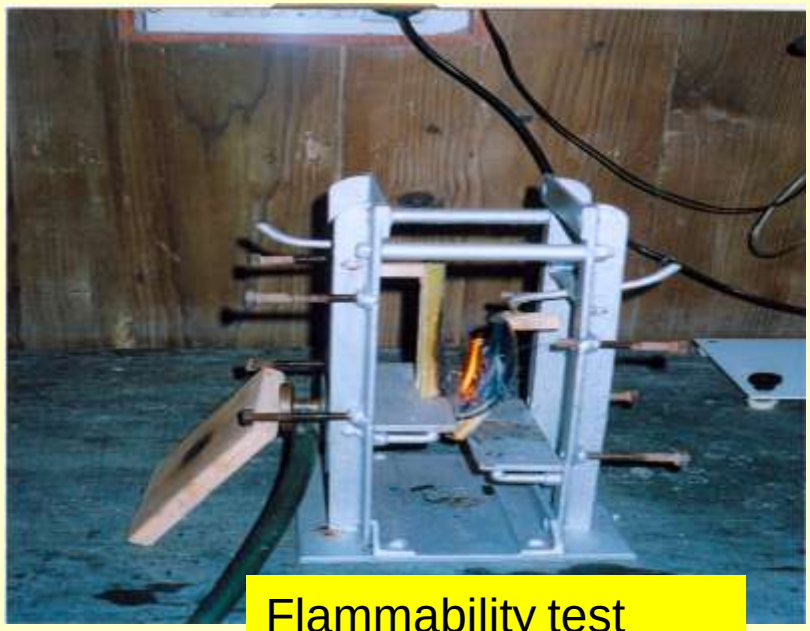
d) Copper sulphate 1 part, Sodium dichromate 3 parts and Aluminium sulphate 9 parts.

A 16 % solution is used for treatment

Flame penetration



Rate of burning



Flammability test

THANK YOU