tested MARINE
paa
PLYWOOD

MARINE PLYWOOD AND BOATS

Marine plywood, an excellent and respected material of extensive aquatic usage, is also a most controlled timber product for boats up to 20 metres, both racing and pleasure. In addition, it has received wide acceptance in commercial and naval vessels. This leaflet is a guide to properties, applications and technical understanding of Marine plywood, particularly in reference to boat building.

points on marine plywood in boats

1. Look for the "Tested Marine P.A.A. Plywood" mark on each panel — your assurance that the panel is quality-controlled to the highest standard for Marine plywood.
2. Only one quality of Marine plywood is available, made from selected marine species of Australian timber.
3. Obtain a good boat plan and talk over your requirements with the retailer who provides your Marine Plywood.
4. Preservative treating of Marine plywood is recommended especially for all confined areas where moisture content is high and ventilation poor.
5. Glue all joints in boat assembly and use only resorcinol glues for permanent results.
6. Seal all edges, holes, openings and exposed end grain of the plywood to prevent subsequent paint problems. Use marine paint, or, preferably, boat building glue for end grain sealing.
7. Fibre-glassing of the hull to the water line is recommended. Use top quality marine paints. Varnish or clear finishes constantly exposed to direct sunshine will require constant care and maintenance and are not recommended.

1.0 properties

1.1 standard

Marine plywood made by Plywood Association of Australia members and marked "Tested Marine P.A.A. Plywood" is the only known Marine plywood manufactured in Australia which is independently checked, sampled and tested for conformance with Australian Standard A.S.086. To be so marked means that the plywood is subject to the Association's rigid quality control programme. (See Section 2).

1.2 selected species

Only veneers from selected species for marine use, as laid down in A.S.086, are used in manufacture of "Tested Marine P.A.A. Plywood". Marine plywood is manufactured with highest face quality on two sides. Veneers are selected because of freedom from defects and peeler checks, as well as high mechanical strength and suitability for permanent bonding. Other requirements for timber used in veneers include:

Density:	450-720 kg/m³
Tangential Shrinkage (green to 12%)	Maximum 8%
Izod Value	5400 Nmm
Module of Rupture	75.8 MPa
Grain Texture	Fine to Medium

1.3 phenolic glueline

Marine plywood must withstand the 72-hour boil test as laid down in A.S.086. Only permanent thermo-setting adhesives of the phenolic type are used in production.

1.4 standard sizes

Panels are obtainable in the following standard dimensions.
Lengths: 1800mm, 2100mm and 2400mm
Widths: 900mm and 1200mm
Thicknesses: 4mm, 6mm, 9mm, 12mm, 16mm, 19mm
As well as one piece panels scarf-joined panels in sizes up to 3 metres across and any transportable length (e.g. 15 metres) can be obtained.

1.5 weights

Average weights of marine plywood vary with the density which ranges from 450 to 720 kg/m³. At 560 kg/m³ density, the approximate weights are:

4mm Plywood: 2.24 kg/m²
6mm Plywood: 2.36 kg/m²
9mm Plywood: 5.04 kg/m²
12mm Plywood: 6.72 kg/m²

2.0 quality control

Quality controlled glueline is another most important aspect of plywood in a boat. The gluebond must be permanent, must maintain its strength and durability under the most exposed conditions over the full life of the boat. Phenol formaldehyde resin bonds, achieved under controlled heat and pressure in the hot press,have proved over 50 years of laboratory testing and under extreme exposed conditions to perform without deterioration.

Fully phenolic resin gluelines are specified in the Australian Standard AS.086 for Marine plywood and rigid tests are laid down. The Australian plywood industry has set up an independant quality control system to ensure that Marine plywood meets requirements of the Australian standard.

Marine plywood which passes tests involved in the quality control system is marked "Tested Marine P.A.A. Plywood". The mark is only issued to manufacturers with a system of mill process quality control involving daily glueline testing, measuring and record keeping. Plywood from current production is regularly tested at the industry's central laboratory to stringent test requirements, including 72 hours' immersion in boiling water.

Only manufacturers of Marine plywood who produce and submit test panels under the system described above are permitted to use the industry mark "Tested Marine P.A.A. Plywood". Look for it! This mark is your *only* independent assurance that the plywood has been manufactured with a permanent glueline to Australian Standard AS.086.

3.0 plywood for boat building

3.1 general properties

Wood has been the traditional boat building material since man first began to adventure across water. Modern technology has evolved improved wood products with properties highly desirable for marine application. Marine plywood is a fully developed and controlled wood product. It is made from selected species of timber. The cross laminated veneers are bonded under controlled heat and pressure to form panels with gluelines of phenolic resin which are permanent to the extent that they will withstand complete submersion in water permanently without fear of delamination. Due to its cross laminated construction marine plywood is highly impact and puncture resistant. Available in many sizes it is extremely stable under changes in moisture content.

Wood in its natural state has the following attributes for boats: It is naturally buoyant; it is light and strong; it is easy to work — cutting and fixing is simple; it is readily repaired; it is available throughout the world. In plywood form, additional benefits accrue; Plywood is stronger per kilogram than other boat building material; its large panel sizes make the building job faster; it has multidirectional strength and is highly fatigue-resistant. Simple to preserve, finish, fit and fix, it absorbs impact and sound to give a comfortable ride.

3.2 maintenance guide

Marine plywood boats have long life, practically unlimited life, in fact, provided the boat is made from Marine plywood (to Australian Standard A.S086) fixed to recommended timbers with completely permanent adhesives and preservatively treated in high hazard areas (see Section 8 which deals with preservation). Care in construction and finishing, combined with reasonable maintenance, will ensure the life span of the boat.

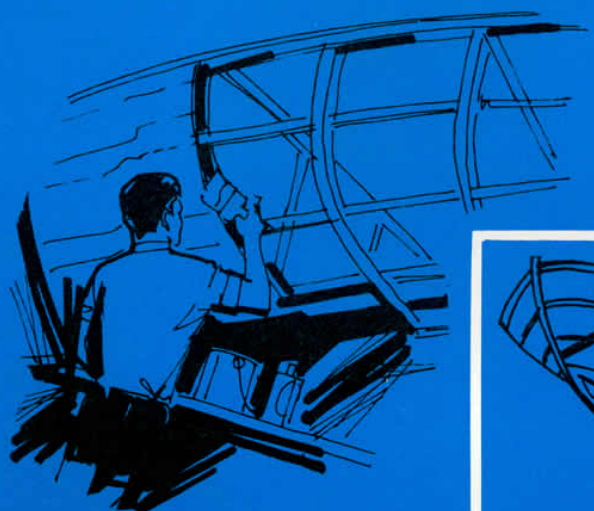
Here are some hints for care and maintenance:

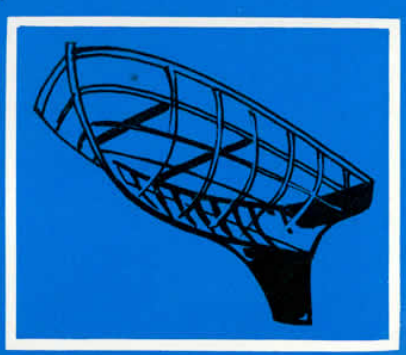
A. Make sure that all plywood edges are sealed with paint or, preferably, boat building glue. Holes cut or drilled for deck fittings, drainage, or other purposes should have the exposed end grain sealed immediately.

B. Do *not* seal the inside of the hull with fibreglass or paint unless it is necessary to do so for reasons of wear or appearance. If painting inside the hull is necessary, apply copper naphthenate, zinc naphthenate, pentachlorophenol or other brush-on, spray-on preservatives before painting. Check with the paint manufacturer to make sure that the paint selected will be compatible with the preservative.

C. It is good practice to apply water-repellant preservatives based on copper or zinc naphthenate or pentachlorophenol each season, even to unpainted sections that can dry out readily and therefore have a low rot hazard. Some preservatives which are water-repellent last longer than a season. Application of preservative is more important in sections around the stem, transom and under the deck where normal ventilation is poor and access difficult. This treatment can overcome problems of condensation in these areas.

Quality control—72 hour boil test.





D. *Don't*, as a regular practice, hose out the boat with fresh water. Fresh water laying about should be carefully sponged out and dried up. Cabin floor and housing covers should be removed and the interior left ventilated so that normal air drying can occur. Washing or hosing down with salt water is a better alternative. Undissolved salt, boric acid, or copper sulphate in bilge water provide conditions which will inhibit possible fungal attack.

E. Keep boats stored out of the rain, if possible, but *avoid* covering with a close fitting tarpaulin. If a cover sheet is used it should be raised to allow air to circulate.

F. Stripping down and repainting according to paint manufacturers' instructions is recommended. Time for refinishing varies up to five years, depending on conditions of use. Painted hull bottoms require more constant care and maintenance. The boat should be slipped regularly.

G. Despite puncture resistance higher than in most other boat materials, any craft can become accidentally holed. Because of the cross laminated construction of plywood any such hole is confined to a limited area. Here is how easy repairs can be made. First remove all damaged wood by cutting an exact square (with a key hole saw) slightly larger than the hole. Then cut from plywood of the same thickness as the hull planking a square patch the same size as the hole in the hull. Then cut another plywood square 75 mm larger all round. Fix the small square patch to the centre of the larger piece with resorcinol glue (see Section 5) and clench nail for pressure. Now fit the patch exactly into the hole with liberal resorcinol glue on all edges on the inside surfaces of the 75 mm wide surround. Clench nail all sides of the surround to the hull with nails in two rows approximately 40 mm apart. When glue has set, sand and fibreglass the outside if desired.

4.0 frame members

Timber for use in boat building is covered by Australian Standard A.S.096 — 1964 "Timber for Marine Craft". Care should be taken in the selection of timbers because there is no "marine" grade timber as such, but most good boat plans give advice on timber framing.

4.1 selection

Timber for planking, stringers, chines and ribs should be selected for straightness of grain, low shrinkage and freedom from defects. Tight gum veins, surface checks and borer holes which can be satisfactorily caulked will cause trouble only if concentrated in a small area.

4.2 moisture content

For upper boat parts and interior framing all boards are best quarter sawn and kiln dried to minimise shrinkage. Laminated masts and spars should be in the range of 10-15 percent moisture content.

4.3 species

Almost 100 timber species are suitable for marine use and your timber merchant will be equipped to choose the right ones for your purpose, or consult timber organizations in the telephone directory.

5.0 fixing

The golden rule for boat construction is: "Glue all joints well with resorcinol glue". No nailed or screwed joint is as sound as a glued joint for a good bond. Clamps should also be used where possible. In theory, nails and screws could be removed when the glue is set as they serve no further purpose, but this would be impractical and unnecessary. For the private boat builder, nails and screws are the most economical and the easiest way of providing pressure for setting the glue.

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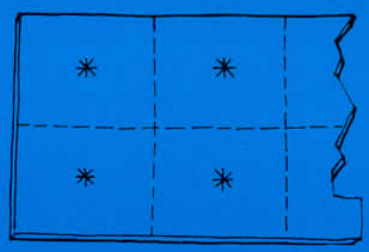
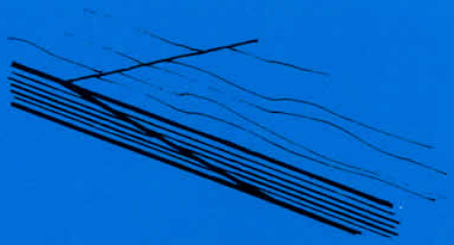


1. Each nail may supply glueing pressure for an area of nine square inches.



2. Scarf jointing — recommended 1 in 8 scarf joint. Strength loss is negligible.

3. Less than 1 in 8 scarfs not recommended.

4. Battened joint could fail at 40lbs. point loading.

5. Stitched joint withstands 75lbs. point loading.

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assembly glues for boat building

The life of a boat depends on its ability to withstand the most rigorous conditions. The adhesive used in its construction should have maximum durability. Also the boat owner has the right to expect a great length of satisfactory service from a properly constructed boat. Knowledge of assembly glue is, therefore, most important.

Marine Plywood marked "Tested Marine P.A.A. Plywood" manufactured to Australian Standard AS.086 is quality controlled to meet phenolic "A Bond" tests of 72 hours in boiling water. Process quality control in the mill and independent N.A.T.A.-approved laboratory quality control, ensures that "Tested Marine P.A.A. Plywood" meets the highest standard. Look for the quality control mark!

The boat owner or builder should not be satisfied with less than the best when he comes to use this material. A boat is only as strong as its weakest part. P.A.A. Marine Plywood and quality timber for boat building involves a considerable investment, and boats built from them should have length of service ensured by the use of glues in construction which are equal in quality to that used in the manufacture of plywood. Present research has established that so far only two types of adhesive will meet structural requirements for a marine bond. The least costly of these, but by no means inferior, is resorcinol formaldehyde or resorcinol phenol-formaldehyde, and the second recommended type is formulated from epoxy resins.

pressure application

In boats and other engineering type structures, glue bonds are usually subjected to high stresses and therefore must develop a full and calculable bond strength. Irrespective of the application, it is most essential that the instructions provided by the manufacturer of the adhesive be followed at all times.

Pressure may be applied by weights (over small areas) clamps, and by nails and/or screws. Nails and/or screws, because of their ease of application are most commonly used in boatbuilding, often in conjunction with clamps (which are capable of exerting higher pressures). Fastenings, if the sole means of applying pressure, should be spaced at 40mm along the edges of a 6mm thick sheet and 75mm elsewhere. No fastening should apply pressure over an area greater than 75mm square. For thinner plywood the spacing should be reduced. It may be extended for thicker sheets.

nails or screws

Screws are useful for positioning a sheet, but clenched nails have demonstrated their greater holding power and ability to apply greater pressures. Annular ringed nails are better than the smooth type. Vibration can cause screws to work loose, and this, as well as their higher price, often makes them less desirable.

points to watch

(a) The moisture content of the timber used should not be greater than 15% when gluing. Plywood when purchased will be at equilibrium moisture content (usually 8-15% range). It should be stored flat in a dry, protected area.

(b) Surfaces should be smooth and free from dirt and grease before gluing. Light sanding just prior to gluing is a good practice. Glues with good gap filling properties are more tolerant to comparatively rough surfaces than others, but filling gaps with glues is not good practice. Epoxy resins have better gap-filling properties than resorcinol.

(c) Both contact surfaces to be bonded should be thoroughly covered and wet with glue.

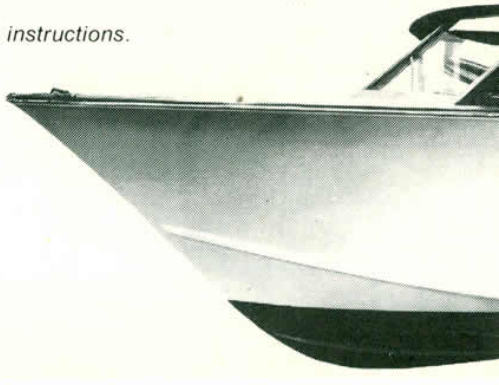
(d) Surfaces must be pressed firmly together while the glue is fluid — Check the recommended pot life and open assembly time of the glue.

(e) The glueline should be both continuous and very thin when set. This will depend on proper surface preparation, close fit, correct spread, and suitable clamping pressure.

(f) If the glue to be used has been stored for a prolonged period, check before using to ensure that it has not deteriorated.

(g) Surrounding temperature should also be taken into consideration. Use of resorcinol phenol glues at a temperature below 20 C is not recommended. Epoxy glues will set below this temperature but time required for setting is considerably increased.

(h) Closely follow glue manufacturer's instructions.



recommended assembly glues

	RESORCINOL FORMALDEHYDE AND RESORCINOL PHENOL–FORMALDEHYDE	EPOXY RESIN
1. USES	Laminating marine work wood-plywood structural components.	Gluing of non-cellulosic materials to plywood or wood or where extreme chemical resistance is required.
2. ADVANTAGES	Complete water resistant bond. Used for all joints subjected to extreme exposure. Not subject to bacterial attack.	Excellent gap filling, wetting and flow properties. Water-resistance good, but inferior to resorcinol glues.
3. DISADVANTAGES	Relatively expensive, dark colour. Poor gap filling properties.	Relatively expensive. Mixed resins not water soluble and therefore more difficult to use than other glues. Resins are toxic and may cause dermatitis or internal poisoning.
4. PREPARATION	Mix resin and hardener	Mix resin and hardener carefully.
5. WORKING REQUIREMENTS	Dry wood (8 to 15% moisture content). Wet glue spread 20 to 35kg per 100 sq. metres of glue line *Assembly time to 60 minutes. Pressure from 500KPa to 1400KPa. Clamping time 24 hours at not less than 20 C. Clamping time 10 mins. at 90 C.	Dry wood (8 to 15% moisture content). Wet glue spread 20 to 35kg per 100 sq. metres of glue line. Pressure can vary from 350KPa to 900KPa. Clamping time up to 48 hours at 20 F and approx. 1 hour at 90 C.
6. COMPOSITION	Combination of resorcinol and formaldehyde or phenol–formaldehyde. Extra formaldehyde sets glue by polymerization.	Combination of resins, one of which serves as catalyst. Glue sets by polymerization.
7. TYPES	Cold or medium temperature formulations. Formulations also available for high-frequency heating.	Cold and medium temperature formulations available. Also available in wide viscosity range.
8. COMMERCIAL	Viscous reddish brown liquid with liquid or powder hardener.	Honey like liquid or coloured paste, with liquid hardener.

*Assembly Time — maximum time allowable before pressure is applied. Pressure must be applied while glue is still wet.

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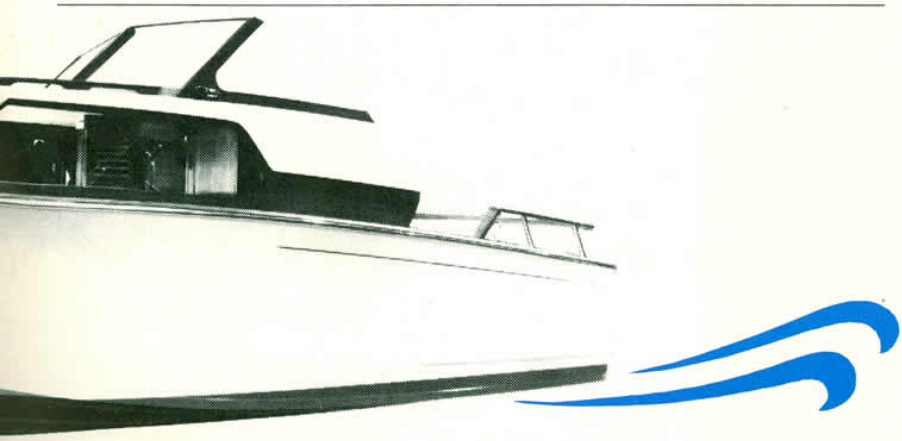


5.1 adhesives

Phenolic glues are used in the manufacture of Marine plywood and resorcinol cold setting assembly glues are recommended to the boat builder. They can be purchased practically anywhere in Australia in a two pack preparation containing a liquid resin and a liquid or powder hardener. The components should be mixed in clean containers. The bonded materials usually must be kept under pressure for 24 hours at temperature above 20 C and the bond will develop its ultimate strength in about one week. A reasonable number of fasteners are required to maintain intimate contact while the glue cures. Too many fastenings are a waste of money as they do not add strength to the joint. No fastening should apply gluing pressure to an area greater than 75 mm square but this spacing can be extended for thick panels.

Butt strapped joints if well made are stronger than scarf joints, except when the scarf joint is made in a factory under controlled conditions. When scarf jointing (or having scarfs done in a factory) specify that resorcinol or phenolic glue be used and obtain 8 to 1 scarfs or greater.

All joints to be glued should be smooth and clean before applying glue, and particular care should be taken if the plywood or timber has been preservative treated. Glue manufacturers recommendations should be closely followed.

5.2 fastenings

Metal fastenings in boats should be as immune to electrochemical corrosion as possible. To avoid possibility of this type of corrosion, use fastenings and nails of the same metal where practical. Monel or silicon bronze nails are highly recommended. Unfortunately, they are a little more expensive but well worth it in the long run.

Clenched nails are superior to screws in holding power. Annular-ringed nails are better than the smooth type. Vibration can cause screws to work loose, and screws cost more than nails. Copper nails or screws may also be used. Aluminium alloys should never be used near copper because of the corrosion explained above. Bituminous coatings can protect fastenings effectively if there is a doubt as to the likelihood of corrosion and if appearance is not impaired.

5.3 stitching

A fastening system introduced for small plywood dinghies has proved extremely efficient. It is the "stitched joint". Briefly, the process is as follows: Two plywood panels are butted together and joined by copper wires through adjacent holes drilled at regular intervals in the panels. The inside of the joint is covered with resin and, before the resin dries, fibreglass tape is laid in it and over the joint. This is then covered with another layer of resin.

6.0 bending

Compound curves are virtually unobtainable with plywood panels because they are extremely difficult to achieve without actually moulding the plywood.

Some boat plans call for flared bows with compound curves. Flared bows are simply achieved by building up the required shape with narrow strips of plywood.

6.1 timber bending

Timber to be bent should be of a species known to have good bending properties and be straight-grained and as free as possible from defects. The timber should be reduced to the smallest possible size before bending and should be dressed all round. Moisture content of 15 to 20 percent is required. Sharp bends for a thick member may require laminated timber.

6.2 plywood bending

Wetting, or more preferably steaming, will measurably increase marine plywood bending properties, but the plywood must be subsequently dried before it can be glued. As an alternative to bending thick panels, the same result can sometimes be obtained by individually bending two thinner panels with the second panel then glued to the first.

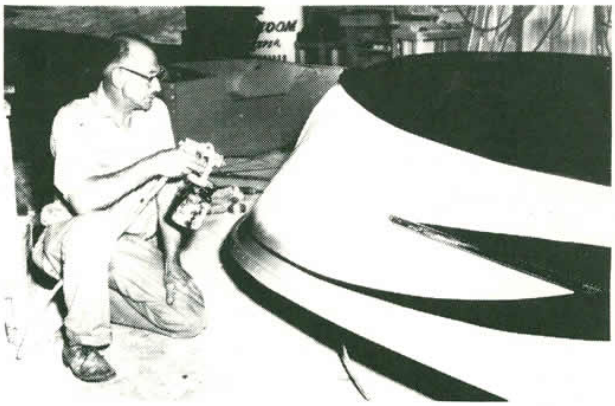
7.0 finishing

More argument is raised over maintenance of plywood boats than any other aspect. High maintenance is *not* a built-in disadvantage with plywood boats. Using good building practice and thoroughly applied preservative, a plywood boat will give long service life with minimum attention. Finishes if well chosen and applied will not cause a maintenance problem, but will enhance the pride of ownership. Clear finishes exposed to direct sunlight are not recommended.

7.1 medium density overlays

Marine plywood may be obtained with a medium density phenolic resin and cellulose fibre overlay (e.g. crezon and micatan) which has been bonded to the panels by the same hot press process used to produce the plywood. A bond is formed with the molecules of the wood and the overlay is permanently fused to the plywood.

Advantages of the medium density overlays are: Smooth surface — no prime coat required; provides ideal key for paint; does not need sanding; resists abrasion; eliminates checking; requires no special maintenance; will not separate from the plywood.



7.2 above waterline

Epoxy polymer plastic finishes are popular with modern boat builders for use above the water line. They are tough and long lasting. Their glass finish, ease of application and colour retention are good. Spar varnishes and other clear finishes have poor resistance to strong sunlight and are not recommended. Alkyd enamels are widely used for above waterline applications and have good weather resistance. They have a high gloss and good adhesion.

7.3 below waterline

Polyurethane paints are available in a wide colour range for finishing hulls. They are supplied as a two-pot system and are considered durable. The best finish is obtained with the wet-on-wet techniques, if possible by spraying. Other marine paints are also available.

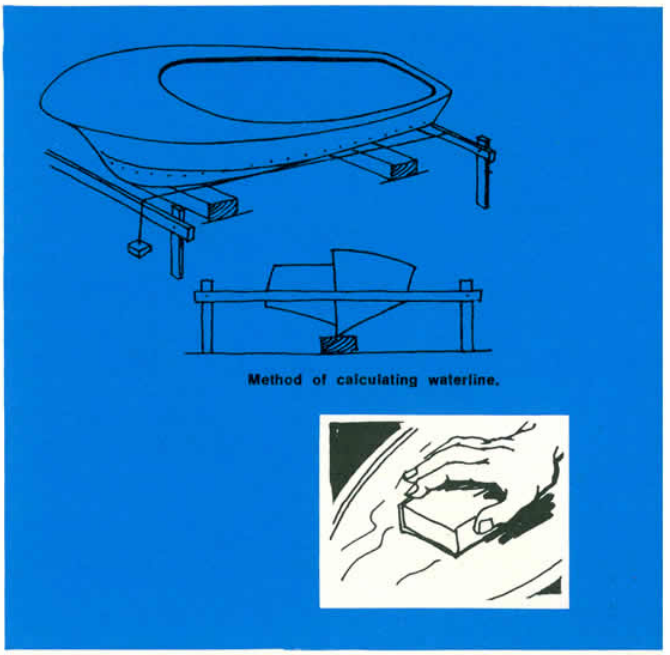
Anti-fouling paints fall into two categories. One, the contact leaching types contain a high concentration of copper in a hard insoluble vinyl binder. Two, the scrubbing matrix types, less costly, contain less copper and work by washing away at the surface at a controlled rate.

7.4 fibreglass

Fibreglassing of hulls (particularly the underwater section) and phenolic-impregnated overlays are extremely popular. These provide excellent protection and give additional abrasion resistance. It is not advisable to overlay both sides of the plywood on a hull as this does not allow the wood to "breathe". In fact the hull interior should never be sealed with any product, but stains and preservatives may be used if desired. Either glass cloth or acrylic fibre can be used, and what is known as scrim weave is usually employed. Glass cloth is rather cheaper than acrylic fibre and gives excellent results, but the latter is less springy and hence drapes better when wet. One other advantage of the acrylic is that it has greater intrinsic strength than does glass.

For fibreglassing, a priming coat of resin and hardener is applied to the clean, dry, previously stopped and sanded plywood surface. Thinners may be used to thin this priming coat up to 20 percent. Certain applied preservatives can substitute for the priming coat (8.2).

The second resin coat should be applied in warm weather when the first is touch-dry. Application of the glass cloth can proceed as soon as the second primer coat is touch-dry. When the cloth has been laid on the hull it should be saturated with a resin and hardener mixture, applied with a paint roller. After curing (about four days at 20°C) the entire job should be sanded and cleaned. It can then be undercoated and finished.

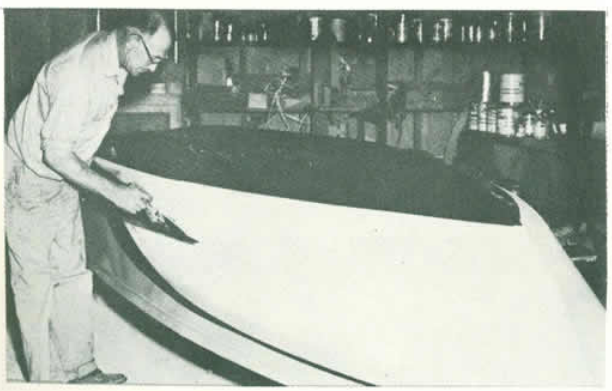


Method of calculating waterline.

7.5 clear finishes

As previously mentioned no known clear finish can be recommended to stand up in constant direct sunshine and marine conditions. However, the following techniques are suitable to give a high gloss finish to craft that spend a minimal amount of time exposed to sunlight such as racing dinghies. It will be necessary to spend considerable time each season to maintain this finish.

A. Stop nail holes and cracks with the appropriate colour timber putty, repair bruises and sandpaper surface smooth.
B. Stain if desired with wood stain. Allow to dry a minimum of four hours.
C. Apply, at intervals of not less than six hours and no more than 24 hours, sufficient coats of liquid plastic to fill the grain. Allow to dry for 24 hours after the final coat.
D. Wet the surface with mineral turpentine and sand flat along the grain with No. 320 "wet or dry" abrasive paper, using a cork or a rubber sanding block. Wipe clean with a soft cloth.
E. Apply two coats of liquid plastic at intervals of not less than six hours and no more than 24 hours, and allow to dry for 24 hours after the final coat.
F. Sand the surface flat as directed in paragraph D but using No. 600 abrasive (wet or dry) paper. Wipe clean with soft cloth.
G. Remove all paper scratches with water-rubbing compound. Wipe clean with soft cloth.
H. Remove fine scratches with finishing spirit.



8.0 preservation

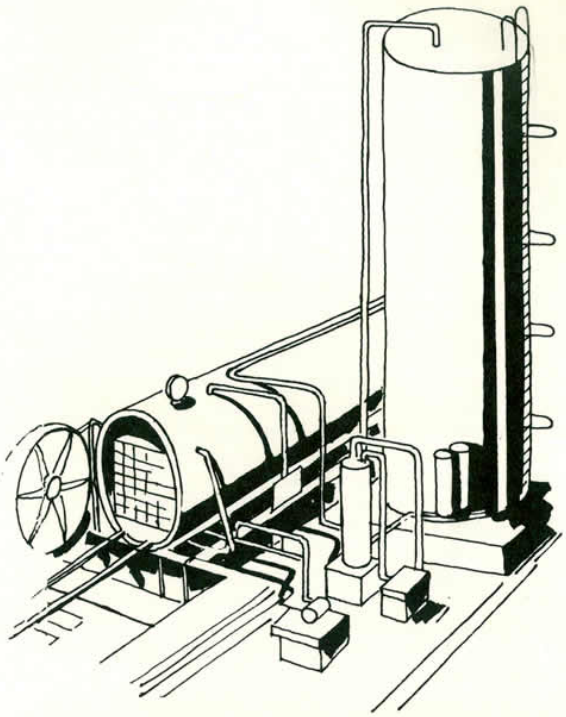
All wood products in boats are subject to fungal attack in those areas which are poorly ventilated and therefore remain damp for much of the time. A satisfactory service life, however, can be achieved by making sure the boat is of sound construction, undergoes regular maintenance and uses preservative treated marine plywood in poorly ventilated areas such as bilges, bulkhead to hull connections gunwales etc. It is strongly recommended that the plywood is sealed on one side only to allow it to dry out and thereby minimise the rot hazard.

Preservation of the high rot hazard areas of the boat is relatively cheap insurance to ensure a satisfactory service life. This is particularly significant as the conditions under which the boat will operate are not forseeable.

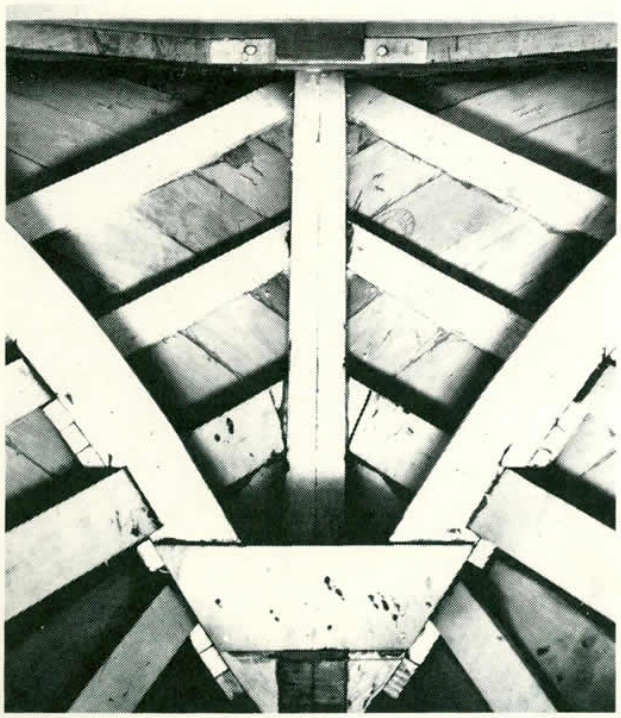
There are two ways of preservatively treating marine plywood — in the factory or at the boat building site.

8.1 factory applied preservative treatments

The two most common types of factory applied preservative treatments are pressure treatment with waterborne preservatives of the copper chrome arsenic (CCA) type and light oil solvent preservatives of the copper naphthenate, zinc naphthenate, tributyl tin oxide and pentachlorophenol types. All these treatments are effective against fungal attack provided the correct preservative retention and penetration is obtained. Full details on preservation are given in Australian Standard A.S.1604 Preservative Treated Sawn Timber, Veneer and Plywood.



Industrial pressure preservation plant.



8.2 on site preservative treatments

On site preservative treatments are usually carried out by brushing, spraying or immersing of the plywood in a solvent based preservative such as copper naphthenate, zinc naphthenate, pentachlorophenol or tributyl tin oxide. It is important that the chemical manufacturers instructions are followed in detail to get maximum preservative benefits and minimise the health hazard. All cutting and boring should be carried out prior to the application of the preservative.

Generally the factory applied preservative treatments are more effective as they are carried out under controlled conditions and therefore give better preservative retention and penetration than those carried out at the building site. The on-site treatments are ideal for low hazard areas of the boat or for applying extra protection for plywood which has been cut or bored in the fabrication process. Brush-on preservatives also should be applied as part of the regular maintenance of the boat.

With either treatment method it is a good policy to lightly sand the surface prior to gluing or finishing to remove surface salt. However, in the case of brush-on preservatives it is preferable to carry out all gluing prior to the application of the preservative.

The Plywood Association will be glad to assist you in providing additional information on preservation. Alternatively assistance also may be obtained from State Forestry Departments, Division of Building Research C.S.I.R.O. or the Timber Preservers Association.

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For further details

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