ODC 629.125

ODC 838.6

TECHNICAL PUBLICATION NUMBER 5

Published 1965
Revised 1977

timber in boat building

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FORESTRY COMMISSION OF NEW SOUTH WALES

TIMBER IN BOATBUILDING

WOOD has always been a favourite building material for small craft, and despite the advent of new materials and the increasing difficulty of obtaining suitable timber, it is maintaining its popularity. The advent of new timber products, new adhesives, and new techniques has made boatbuilding by the amateur much more popular. In order to provide guidelines for timber selection the Standards Association of Australia prepared a Standard, AS1738–1975: *Timber for Marine Craft*. Copies are available from that Association.

Timber for planking, stringers, chines, and ribs should be selected for straightness of grain, low shrinkage, and freedom from defects. If the boat is to be seaworthy very few defects can be tolerated in these particular parts, so knots, shakes, sapwood, incipient decay, compression failures, and brittle heart must be rigorously excluded. Tight gum veins, borer holes, and surface checks will not cause trouble unless they are concentrated in a relatively small area. They can usually be satisfactorily caulked.

Unless the boat is to be of glued construction, or will be out of the water for considerable periods, there is no necessity to use timber dried to 12 per cent moisture content, except for interior fittings. Because it shrinks while drying, however, timber for the upper parts and interior framing should have a moisture content of less than 20 per cent, while for those parts which are customarily submerged the moisture content should not be less than 20 per cent. Of course such requirements are much easier to specify than to observe because of the time usually required to build the boat. To minimize shrinkage during construction or when the boat is out of the water, all boards should be quarter sawn.

It is not always possible to build small craft entirely of durable timbers, and since the decay hazard in a boat kept at moorings is high, it is wise to take precautions. Some preservative-treated plywood and timber is available. Where such material is not obtainable either from stock or on order, non-durable timber should be liberally treated with a recognized preservative. Australian Standard 1604–1974: *Preservative Treated Sawn Timber, Veneers and Plywood*, should be consulted for types of preservative and appropriate loadings.

The chief advantages of timber and plywood are:

- positive buoyancy.
- high strength in relation to weight.
- resilience and thus ability to withstand suddenly applied shock loads.
- ease of shaping, bending and finishing without the need for special equipment.
- good appearance.
- high durability when properly selected, installed and ventilated.
- ability, in many cases, to accept treatment with preservatives to give long-term durability under severe conditions and where ventilation is inadequate.
- ease of working without requiring closely controlled factory conditions in respect of temperature and humidity.
- resistance to abrasion.
- ability to be altered at relatively low cost.

Improvements in plywood and adhesives have opened up a new field for constructing craft. The main advantage of plywood is that it is flexible and is obtainable in large sheets. Providing a marine grade plywood is used and correct methods of application are adopted, the plywood chine system is very successful. New methods, new materials and new forms of construction have been tried and adopted and there is still scope for progress in these fields of construction.

Seasoning of Timber

Generally the timber used in boatbuilding should not exceed 20 per cent moisture content, except when the craft is usually moored: then the planking below water line should be above 20 per cent. Laminated masts and spars, as well as joinery, should be in the range of 10 per cent to 15 per cent moisture content.

The most accurate method of checking the moisture content of timber is by determining the loss of moisture when a weighed sample is completely dried in an oven using the technique described in Australian Standard 1080–1972: *Methods of Test for Moisture Content of Timber* and Forestry Commission of N.S.W. Technical Paper No. 13: *Methods of Determining the Moisture Content of Wood*. A faster, non-destructive but less accurate method is to use a battery operated moisture meter which in the range below about 30 per cent is sufficiently accurate for boatbuilding purposes. This meter measures the resistance of the wood to an electric current and indicates the moisture content of the piece on a dial. The relationship between electrical resistance and moisture content is not the same for all timbers so it is necessary to apply species correction figures; they are given in Forestry Commission Technical Publication 13 mentioned above. The electrodes fitted to the meter are intended for the testing of nominal 25 mm thick stock, but thicker material can be tested by first driving nails to the centre of the piece, at the same distance apart as the electrodes, and resting the electrodes on the nails to make the reading.

Timber may be seasoned by air-drying or kiln drying, or by a combined process of air and kiln drying. For the drying process the timber must be stacked so that there is good air circulation around each piece in the stack. To obtain this circulation the timber must be spaced by placing 20–25 mm thick strips between each layer of boards in the stack, the strips being placed in vertical lines so that the boards will not become distorted. It is very desirable that drying stacks should be covered to prevent the entry of rain and the excessive splitting of the top layers of boards. Further information on drying procedures is given in Forestry Commission Technical Publication 9: *Seasoning of Timber*.

Timber contains free water (that inside the cells) and "hygroscopic" or "combined" water (that held in the cell walls). The free water will evaporate first at quite a rapid rate but the combined water will leave the wood much more slowly. When the combined water begins to leave the cell walls, the cells begin to change shape and shrinkage takes place. As the outer part of the wood can dry more quickly than the centre, shrinkage is not uniform and surface checking may occur because of the resulting development of stresses.

Moisture can escape more readily through the end grain and may cause considerable end splitting. This can be reduced by the use of a heavy bodied paint, bituminous paint or a wax preparation brushed onto the end of each board to slow down the rate of escape of moisture.

Method of Ordering Timber

The order should be placed in writing and a copy should be retained by the purchaser. It should state the seasoned condition required, e.g., 10 to 15 per cent or 15 to 20 per cent, etc., and refer to the relevant quality description clause in Australian Standard 1738–1975: *Timber for Marine Craft.*

The order should also state the timber species required, the time and place of delivery and the purpose for which the timber is required so that the merchant can supply accordingly.

The Forestry Commission has a timber inspection service† available at a small fee for checking timber for compliance with specifications. The inspector will grade the timber according to standards as laid down by the Standards Association of Australia or to such other grading rules as are acceptable to both buyer and seller.

Timber Species

Because of the wide variety of marine craft it is not possible to list individual species in order of preference as design considerations must be taken into account when selection is being made. It is presumed that the designer will relate the known characteristics, strength, density, bending properties, permeability to preservative treatment and ability to take an adhesive bond when making a selection for a particular purpose.

Some of the more common species listed in Australian Standard 1738–1975 for the various boat parts are given below:

Part	Timber	Strength group (see note *a* below)	Seasoned weight (kg/m^3)	Durability in marine craft (see note *b* below)
Planking and bulkhead sheathing	Beech, white	D	510	High
	Blackbutt	B	900	High
	Cedar, red	D	420	High
	Fir, Douglas	D	540	Medium
	Gum, spotted	A	930	High
	Gum, Sydney blue	B	910	Medium
	Kauri species	D	460–540	Low to medium
	Maple, Queensland	D	540	Medium
	Meranti, red	C-D	Must exceed 540	Medium
	Messmate	C	830	Medium
	Pine, celery top	D	640	High
	Pine, hoop	D	540	Low
	Pine, Huon	D	540	High
	Pine, King William	D	420	High
	Pine, klinki	D	450	Low
	Stringybark, yellow	B	860	High
	Tallowwood	A	990	High
Decking	Beech, white	D	510	High
	Bollywood	D	500	Medium
	Gum, rose	C	700	Medium
	Gum, spotted	A	930	High
	Gum, Sydney blue	B	910	Medium
	Kauri species	D	460–540	Low to medium
	Pine, celery top	D	640	High
	Pine, hoop	D	540	Low
	Pine, Huon	D	540	High
	Pine, klinki	D	450	Low
	Pine, white cypress	D	690	High
	Stringybark, yellow	B	860	High
	Tallowwood	A	990	High
Steam bent timbers	Ash, silver	C	690	Medium
	Beech, myrtle	C	700	Low
	Brigalow	C	990	High
	Gum, spotted	A	930	High
	Oak, tulip	C	840	Medium
	Pine, celery top	D	640	High
	Pine, Huon	D	540	High
	Quandong, silver	D	540	Low
	Yellowwood	C	700	Medium

† *See* note at end of publication.

Part	Timber	Strength group (see note *a* below)	Seasoned weight (kg/m³)	Durability in marine craft (see note *b* below)
Sawn worked frames	Blackbutt	B	900	High
Floor frames	Box, grey	A	1 110	High
Bulkhead frames	Fir, Douglas	D	540	Medium
Engine beds	Gum, grey	A	1 080	High
	Gum, mountain grey	B	960	High
	Gum, rose	C	700	Low to medium
	Gum, spotted	A	930	High
	Gum, Sydney blue	B	910	Medium
	Ironbark species	A	1 120	High
	Messmate	C	830	Medium
	Stringybark, brown	B	900	Medium
	Stringybark, white	B	900	High
	Tallowwood	A	900	High
	Tea-tree, broad-leaved	C	740	High
Straight stems	Blackbutt	B	900	High
Deadwoods	Box, grey	A	1 110	High
Keels	Gum, grey	A	1 080	High
Keelsons	Gum, river red	B	850	High
Stern Posts		D in bending		
Horn Timbers	Gum, spotted	A	930	High
	Ironbark species	A	1 120	High
	Mahogany, red	B	960	High
	Mahogany, white	B	990	High
	Stringybark, white	B	900	High
Stringers	Ash, silver	C	690	Medium
Chines	Blackbutt	B	900	High
Gunwales	Fir, Douglas	D	540	Medium
Deck framing	Gum, spotted	A	930	High
	Gum, Sydney blue	B	900	Medium
	Mahogany, red	B	960	High
	Mahogany, white	B	990	High
	Spruce, Sitka	D	430	Low
	Stringybark, yellow	B	860	High
	Tallowwood	A	990	High
Mooring and Towing Bitts	Box, grey	A	1 110	High
	Gum, grey	A	1 080	High
	Gum, spotted	A	930	High
	Ironbark species	A	1 120	High
	Mahogany, white	B	990	High
	Tallowwood	A	990	High
Masts	Ash, alpine	C	610	Low
Spars	Ash, silver	C	690	Medium
Derricks	Fir, Douglas	D	540	Medium
	Gum, spotted	A	930	High
	Maple, Queensland	D	540	Medium
	Pine, klinki	D	450	Low
	Quandong, silver	D	540	Low
	Spruce, Sitka	D	430	Low
	Stringybark, yellow	B	860	High

NOTE (a)

Strength Groups

Average Properties of Clear Material

Group	Modulus of rupture MPa		Modulus of elasticity MPa		Crushing strength parallel to the grain MPa		Shear strength MPa	
	Green	12% moisture content	Green	12% moisture content	Green	12% moisture content	Green	12% moisture content
A	105	168	16 800	21 000	52.5	84	14	17.5
B	84	140	14 700	18 200	42	70	10.5	13.3
C	70	112	11 900	15 400	35	56	8.4	11.2
D	49	84	10 500	13 300	24.5	42	5.6	7.7

NOTE (b)

Durability

The term "durability" as used in Australian Standard 1738–1975: *Timber for Marine Craft*, refers to the natural resistance of unpreservatized heartwood used in the most extreme conditions and in the most vulnerable applications existing in a craft kept continuously at mooring.

Rating	Description
High	Indicates that the heartwood should be satisfactory under the above conditions.
Medium and low	Species with such ratings should be treated with more caution and preservative treated, if amenable, for rigorous conditions. Timbers of these ratings may be suitable without preservation when used in applications where durability is not particularly called for, as in craft which are usually stored on shore under cover.

All sapwood is non-durable but can be effectively treated against both fungal and insect attack if proper treatment is carried out before its incorporation into the boat.

Plans and Specifications

Plans: The design drawings of the vessel, usually to scale, showing layout, shapes, sizes and dimensions.

Specifications: Written matter setting out further information and requirements to be read in conjunction with the plans. Specifications usually cover such items as types of material, fittings, standards of finish and workmanship required, amounts of material, any special methods involved, and types of adhesives, caulking materials, paints and other finishes necessary for the job.

Some designers provide full size drawings or templates of parts for the smaller craft being made by the amateur boat-builder. These templates shall be glued to plywood or hardboard if they are to be retained. Otherwise they may be glued to one of the member pieces and then all the other similar members can be shaped to the original member.

Where scale drawings or plans are provided, the plans must be "lofted." That is, set out on the floor, full size. **The markings must be heavy enough to last until the job is completed.**

All templates should be checked and double checked for size, shape, and for being either left or right-hand set-out. It is cheaper to check than to waste a piece of select timber.

When marking out, the template should be tacked in position with two or more panel pins or nails, as necessary.

It is desirable that templates, plans and specifications should be carefully stored away so that future repairs may be more readily made.

There is a general tendency to draw thick lines in the belief that this is necessary to be able to see the set out under all working conditions. Fine dark lines will be just as easily seen and permit a much greater degree of accuracy. Where a template has been traced the member should be dressed down to the template side of the pencil line, as the thickness of the pencil line may increase the size of the member too much.

Jigs and forms must be accurately made and strong enough to stand up to all necessary hammering. Any inaccuracies in the jig will be transferred to the part to be formed. It should not be assumed that the floor is flat, and the jig must be carefully squared, plumbed and braced.

Fittings

Lockers, fastenings, machinery, linings, safety equipment, electrical installations and other fittings should be fixed so that they can be removed readily and without causing any damage, to permit regular and thorough inspection and maintenance of the interior of the craft.

Strip Plank Construction

Strip plank construction involves the use of parallel strakes. Material costs are lower and wastage through cutting is less than for orthodox forms of construction. Strakes can be produced ready planed and spindled to size. The strip plank system gives a good appearance, has added strength and because of the thickness, a good fastening system for deck or covering board may be planned.

It is usual to spindle mould the strips with a round on the bottom edge and a corresponding radiused hollow in the top edge. This affords a larger gluing or bedding surface and enables moderate transverse hull curvature to be negotiated without the necessity of lifting plank bevels. Where the curvature is sharp, it is necessary to plane the inside faces of the strakes to fit the timbers and also to modify the hollowed or rounded top and bottom edges so that they are in close contact when fitted.

In addition to edge fastening, the strips are usually bonded to each other with a waterproof adhesive which must be used in accordance with the manufacturer's instructions. These bonds must be kept under pressure while curing.

Serrated fastenings, driven into closely spaced pre-drilled holes as tight as the material will allow without splitting, are suitable for this job. They can be obtained in various lengths and gauges and must be of **non-ferrous** metal.

With any glued-edge form of single skin construction the problem arises of hull form distortion or frame breakage through stress exerted by the planking swelling when it is wet. To reduce this, material used for planking should not be of lower moisture content than the maximum allowed for satisfactory bonding by the adhesive used and the manufacturers' advice on this point should be taken. Some boatbuilders prefer to use timber strips at 10 to 14 per cent moisture content so that any increase in moisture content will cause swelling and thus compressive stresses in the sheathing, which may be more acceptable than cracking due to shrinkage. This Strip Plank method of construction involves a large area of timber being bonded into one piece and such planking has been known to crack open as much as 3 mm.

Elastic seam-filling compounds may overcome the swelling stress problem where sheathing is used. These compounds may be used instead of other adhesives for underwater joints. The advice of the manufacturers should be sought on the application of these compounds. Due to the necessity for edge fastenings, strip plank construction is only suitable for shell thicknesses of 12 mm and over. One difficulty in this system is the number of feather edges that occur at the shear line. This can be overcome if a thicker and wider sheer strake is fitted and rebated out to cover and seal the feathered edges.

Plywood-Chine Construction

Plywood-chine construction can be used by amateur boat builders without difficulty. The design of a single chine craft is prepared in such a way that the side and the bottom are both conical projections of flat sheets of plywood; in the most direct method, frames are erected to hold the chines in place, the plywood bottom is fixed and finished flush with the chine, then the side plywood is added, capping the plywood of the bottom. A strip is then added at the chine to seal the end grain of the side plywood. Plywood decks are laid over beams in the normal way. The frames can be left in as bulkheads, buoyancy compartments, etc.

Double chine and three-strake clinker constructions have been developed to improve the performance of sailing dinghies and runabouts. Here a third flat sheet of plywood is added as a conical projection so that the sides are made up with more shape, but the principle is the same. On some craft a third sheet is added at the chine, as for clinker planking, giving a more curved effect to the midships section but adding very little to the difficulties of construction. The centre plank is relatively narrow compared with the upper and lower strakes.

Double or Multi-Diagonal Planking

Double or multi-diagonal planking consists of two or more skins fastened at varying angles to each other. Synthetic resin glues make it possible for planking to be glued together on faces and edges to form a uniform construction, eliminating the use of oil fabric between the skins. Only gap filling adhesives should be used and sufficient pressure must be applied to ensure that the faces of the planking are held in contact until the bond cures.

Hot Moulding by Vacuum Pressure

The hot-moulded veneer hull sprayed with polyester resin paint is said to require a minimum of maintenance. A timber mould, mounted on a trolley with a flat metal plate top, is used to form the hull.

Planks about 150 mm wide x 2.5 mm thick are layered over the mould. Wads or bundles of planks are cut to templates and stored in racks ready to use. The first layer is put on dry and the second and subsequent layers are glued, on one side only, by passing them through the rollers of a glue spreading machine. As the second and subsequent skins are applied the staples holding each previous skin are removed.

Stems, hogs, keels and transoms of preformed, laminated construction may be integrally moulded into the hull.

A rubber bag is then lowered over the hull and secured and a vacuum applied to stretch it tight. The whole assembly is now wheeled into an autoclave where steam heat of over 100° C and 350 kilopascals of pressure are applied. After about half an hour the hull is removed and allowed to cool and is then ready for further construction work. This method is suitable for quantity production but involves considerable capital investment for tooling, jigs and autoclaves.

Cold Moulded Construction

This is a comparatively simple method of construction using temporary fastenings for applying pressure to the skins during setting of the adhesive.

Advantages:

(a) The mould is simple to construct as little pressure is required.

(b) Although it is an advantage to use a close planked mould, good hulls can be constructed by using stringers spaced at about 75 to 100 mm centres.

(c) Because of the simplicity of the mould, alterations to the shape and design of the hull are easily made.

Application:

Pressure to hold the skins together while the adhesive is setting is obtained by the temporary use of staples or panel pins. Since pressure is localized, the width of the strip to be glued must be limited to allow even distribution of the adhesive and dispersion of any air pockets between the panels. Although the width of the strips is largely controlled by the curvature required, it is recommended that the strip should not be more than 100 to 125 mm wide.

A fast setting combination of adhesive and hardener can be used as the closed assembly time required is comparatively short. Each skin, however, must be cleaned before the next skin is bonded to it.

Materials—Veneer or Plywood?

In general three skins of veneer are used but it is possible to use two skins of plywood or a combination of plywood and veneer. The thickness of the veneer ranges up to 2.5 mm and the plywood from 1.5 mm to 3 mm. Except in special instances the final skin thickness should not be less than 6 mm.

Laying of skins:

(a) Using three skins:

- (1) Three layers of diagonal planking—the inner and outer skins laid in the same direction.
- (2) The inner and outer skins laid diagonally and the middle skin fore and aft.
- (3) The inner and middle skins laid diagonally and the outer skin fore and aft.

(b) Using two skins:
   (1) Both diagonally laid, crossing at an angle of about 45°; with this construction the use of plywood only is recommended.
   (2) The inner skin laid diagonally and the outer skin fore and aft, the inner skin being plywood and the outer skin veneer.

Cold Moulded Construction Using a Bag for Applying Pressure by Vacuum

Requirements:

(a) The mould must be more robust than the type used when pressure is applied only by temporary fastenings.

(b) The surface of the mould must be close planked.

Advantages:

In some instances wider strips can be used and the number of temporary fastenings can be reduced considerably as they are required only to hold the skins in position before final pressure is applied under vacuum.

Application:

Since the pressure is applied only after all the skins have been laid it is necessary to use an adhesive with a reasonably long assembly time.

In either process adhesives must conform to British Standard 1204, *Synthetic resin adhesives (phenolic and aminoplastic) for wood. Pt. I Gap-filling adhesives.*

TIMBER BENDING

The main considerations involved in the bending of timber are:

- Selection of suitable stock.
- Softening the timber.
- Reaction of the timber to the stresses arising from the bending process.
- Drying after bending so that the bent piece will retain its shape without failure.

Selection and Preparation of Suitable Stock

Choose stock from a species known to have good bending properties and which in addition is straight grained and free from such failure producing defects as knots, checks, shakes and brittle wood.

Brittle wood may be detected by digging into the surface with a sharp pointed instrument. A tough timber will yield a strong splinter which tends to run along the grain. If the timber is brittle, the splinters will be short and "carroty".

The timber should be reduced to the smallest possible size before bending and should be dressed all round. Saw marks on the surface of a piece of timber assist failure and therefore should be removed by planing.

Too high moisture content may cause crumpling on the compression side of the timber and the timber will also be more difficult to dry after bending. On the other hand if the moisture content is too low more force will be required to make the bend and the strapping must be very efficient to prevent failure on the tension side of the curve.

It is generally considered that timber dried to a moisture content of 15 to 20 per cent is in the best condition for bending, but suitable moisture content for dense, hard, strong timbers may be somewhat in excess of 20 per cent.

Softening

The most common method for softening timber before bending is to steam it. This is most frequently carried out at atmospheric pressure, although higher pressures are sometimes used.

For steaming at atmospheric pressure the usual time allowance is up to one hour per 25 mm of thickness. Steaming at from 70 to 110 kilopascals reduces the steaming time but the equipment is more expensive and there is a loss of time while the pressure is released.

Steam chambers for steaming at atmospheric pressure may be made of wood, sheet metal, concrete, brick or asbestos cement sheeting, depending on the working life required. All chambers should be built so that condensed moisture can drain away. The steam chambers, if other than of a temporary nature, should be painted inside with a bituminous paint.

A simple steam chamber of a temporary nature would consist of a 20 litre can to boil the water, connected by means of a hose to a length of 75 mm (inside diameter) galvanized iron or asbestos cement pipe. The wood to be bent is placed in the pipe and the exhaust end of the pipe is partially closed, to reduce the rate at which the steam can escape. The exhaust end of the steam chamber should be slightly lower than the inlet end, to drain the condensed moisture.

Drying After Bending

It is necessary for the bent piece to set and dry before it may be used. Setting is usually completed by the time the timber has cooled to atmospheric temperature but drying will take much longer. Individual pieces should be so stacked that there is a uniform circulation of air throughout the stack.

Bends generally straighten out slightly when released from restraint so they should be slightly over-bent. Bent pieces should not be wetted again as they will tend to open out, and if restrained may fracture. They should be sealed with a suitable coating to prevent an increase in moisture content, once the necessary drying has taken place.

Laminated construction may be necessary where a severe bend is required in a thick member, the laminations being up to about 3 mm in thickness.

Bending Equipment

Heated timber will accept a lot of compression but will not stretch very much. To make use of these facts in bending timber, strapping is applied to the outside of the bend to prevent the timber from stretching and to force the inner edge to compress.

The end blocks, to which the strapping is fixed must be firm and strong and must not allow any "give" during the bending process. The reversed lever type of equipment is said to be the most efficient and the lever should be about as long as the stock being bent.

Bends, in which the ratio of the thickness of the piece to the radius of curvature is less than one-thirtieth, can often be made without taking any special precautions but tighter curves will require assistance from the strapping.

The form about which the bend is to be made should be as strong as possible and must be firmly fixed to prevent any rotational movement. Screw presses, hydraulic presses and steam heated presses are often used for mass production of bent pieces when the bends are not severe.

MASTS AND SPARS

Masts and spars are usually designed specially to suit the boat. Masts of solid or built up sections are made from a relatively light timber which is straight grained and strong in relation to its density.

The built up section may be a full section or a hollow section. The built up sections will usually have all grooves machined prior to assembly, and the timber selected should be one that will glue readily.

All the timbers recommended for masts and spars in the list in this publication are suitable for use in glued or laminated sections. The timbers to be used must be completely free of all faults which would adversely affect the utility of the piece and be straight and true. Knots, sloping grain, shakes and compression wood must be regarded as "not acceptable," though where large sections in solid masts are to be used some knots may be allowed. Mast steps should be shaped, patterns made from the plan or the loft drawing being used to shape and notch them correctly. The tenon socket for the heel of the mast should have drain holes, so arranged that the socket will drain completely when in position. The mast steps are usually made of hardwood.

The socket may be cut so that the rake of the mast may be adjusted.

Driven wedges in the socket are used to adjust the rake of the mast. The wedges should be tacked with a nail, after being driven, to hold them in place. The tenon on the mast should be long enough to cope with all possible adjustments of rake.

Sapwood is permissible only if it has been treated to a suitable loading with an approved non-leachable preservative.

REPAIRS

Tingles are patches used to repair the hull of the boat. Patches may be used to repair defects on timber or plywood hulls. The patches can be screwed or nailed and may be applied on the inside or the outside of the hull. Small repairs on plywood craft may be made by fitting a "doubling" piece to the inside skin and then letting a plywood section in from the outside.

Correct scarfing methods should be used. The patch should be bedded in with a suitable compound and sufficient overlap should be provided for fixing. Large areas of damage may be repaired using sheets of marine grade plywood, which may be screwed, nailed or bolted in place. Diagonal planking may be used to make temporary repairs where the hull is curved two ways. Where possible, the tingle should be fixed through to the frame. All edges should be "faired in" to aid the flow of water over the surface.

Resin Repair Kits

Epoxy resin repair kits have been developed to allow quick repairs of wooden craft, and if correctly applied can continue to cure in the water. The repairs may be made on either the inside or the outside of the hull.

This type of repair work is applicable where only limited damage has occurred.

Carrying Out Repairs

The damaged inner skin of timber should be built up approximately to its original thickness by filling the fracture or indentation. The following are some of the means which have been employed for this operation:

1. Fitting a piece of wood or plywood and bedding in with resin mix.
2. Filling with epoxy resin putty.
3. Fitting a piece of wire gauze over the fracture.
4. Filling with an expanded foam material.
5. Filling with a dough of shredded glass fibre reinforcement and resin mix.

Unless excessively large, holes produced by clenches need not be filled. Wooden plugs or putty can be used if filling is considered necessary.

Following the flushing or filling of the inner skin and without waiting for resin or putty utilized for this purpose to set, the full repair can be effected.

The outer skin of the hull should be cut away to expose some 30 mm of sound inner skin, leaving the damaged inner skin alone. All edges should be well bevelled to allow adhesion of the reinforcement. Any oiled calico used between skins should be removed and the area thus exposed should be thoroughly dried before applying the resin and reinforcement.

A thick layer of resin mix should be applied over the whole of the inner skin which has been exposed by the cutting back of the damaged outer wooden skin. The first piece of reinforcement which has been cut to size should be placed in position on top of the wet resin, and the resin mix worked through the reinforcement, if of glass fibre, by rolling. This operation is normally carried out by serrated washer rollers which are easily cleaned. Mohair paint rollers may be preferred as they minimize the possibility of damage to the glass fibre.

Application of the resin and reinforcement should continue until the repair has been built up flush or just proud of the original hull form. A polythene sheet can be laid over the final application of resin and skin and rolled with a non-serrated roller to produce a smooth external finish. After gelation and cure of the repaired surfaces, an application of a standard marine primer followed by the final hull finish will complete the repair.

The resin must be mixed in strict accordance with the manufacturer's instructions.

SHEATHING

Types of Sheathing Material

(a) Timber.

(b) Plywood.

(c) Copper.

(d) Plastics.

Timber Sheathing

The timber used should be of species known to have a high natural resistance to marine borer attack, or timber which has been pressure impregnated with an approved preservative.

The timber should be straight, sawn to the dimensions ordered and free of knot clusters, splits, shakes and fractures. Moisture content of the timber sheathing should be in the range of 20 per cent to 30 per cent at the time of fixing.

Planks should be 19 to 25 mm thick. The adhesive is usually a rubber based solution with good drying properties and should not deteriorate when in contact with salt water. Metal sheathing may be used over the keel, stem and stern. Copper should be not less than 22 gauge.

Copper or galvanized iron fastenings may be used but it is advisable to use the same type of metal throughout so that no electrolytic corrosive action takes place due to different metals being used in close proximity.

Wherever practicable, the heads of major hull fastenings should be sunk about 3 mm below the surface of the hull and covered with a paste made of white lead and zinc oxide in oil. All seams should be properly caulked, payed and filled. Where metal sheathing is to be applied all sharp edges of timber should be rounded off.

The metal sheathing should be so laid that a tuck of at least 20 mm is covered by the timber sheathing and any galvanized fixings should be at least 50 mm away from the metal sheathing. A coat, 1.5 mm thick, of the adhesive should be applied between the wood and metal sheathing.

The hull is generally sheathed to a line 150 mm above the loaded waterline of the vessel. The distance between fastenings should not exceed 450 mm in any one plank and end fastenings should be within 150 mm from the butt of the plank.

Butt blocks should be fastened over hull-plank butt-joints to give access to the joints for caulking purposes. Kraft paper or felt should be placed over the adhesive before fixing the butt block.

Where the keel has been sheathed with metal, a false keel at least 30 mm thick of solid timber may be fixed.

Plywood Sheathing (See also Plywood for Marine Craft).

Plywood, preferably rot-proofed, may be used to sheath the hull of a light craft. The adhesive is usually a rubber-based solution with good drying properties and should not deteriorate when in contact with salt water. The edges of the plywood sheets must be properly sealed to restrain the plywood from absorbing moisture. Hull construction and the thickness of the sheathing will determine the spacing of edge nailing or screwing but spacing should not exceed about 150 mm because greater spacing will permit the plywood to lift between fixings.

Plywood sheathing may be used to repair an old hull or to strengthen a light hull which is to be used in severe operational situations.

Copper Sheathing

Generally the same requirements apply to metal sheathing as were mentioned for timber sheathing. Refer to Standards Association of Australia's Interim Specification 98–1945, *Sheathing of Wooden Vessels with Copper.*

Sheathing should be of hot rolled or cold rolled annealed sheets 1 200 mm x 356 mm x 4.3 kg/m^2. Nails should be copper of not less than 16 gauge.

The sheathing underlay should be a suitable adhesive. The hull should be sheathed so that all timbers including planking, keel, stem and stern posts and rudder (if timber) are covered to 150 mm above the loaded water line. All sheets should lap adjacent sheets by 25 mm.

Edge nailing should be done on a centre line 12 mm from the edge with nails spaced at not more than 25 mm centres. All sheets should be nailed in addition to edge nailing on a diagonal pattern at 75 to 100 mm centres.

All sheets should be punched before nailing and the nails should be dipped in the adhesive. The length of the nail should be such that when driven home the total penetration is 20 mm. Where the hull is less than 25 mm thick the penetration should be 6 mm less than the thickness.

Types of Plastic Sheathing

1. Nylon.
2. Fibreglass.

Plastic sheathing has the advantage over metal that no electrolytic action can take place.

Nylon

A specially woven nylon cloth which can be stretched over two-way curves is bonded to the wooden hull with a resorcinol-type adhesive. Adhesives are used to impregnate the nylon cloth and thus complete the water proofing process; colouring agents may be incorporated in the adhesive to give the desired appearance.

Knowledge of how to stretch and form the nylon is very important and the manufacturer's advice should be sought before commencing work. In the event of damage, the nylon sheathing can be easily repaired. The same material can be used for deck and roof covering.

Fibreglass

Two general methods of application are used:

(a) a pre-formed sheet of polyester reinforced with glass fibre is bonded to the hull,

(b) liquid resin and glass fibre reinforcement are applied to the hull.

The basic resin components must be accurately measured before mixing, as the wrong proportions will upset the curing process. Such materials as bitumen, which contains phenol, will seriously interfere with setting or curing of polyester resins.

Polyester/fibreglass is stiffer than nylon and therefore is more likely to crack or part from the hull. Repairs to polyester/fibreglass are made with an epoxy resin repair kit.

New plastic materials and improved application techniques are being developed all the time so thorough enquiries should be made prior to selecting a material for use as sheathing.

Adhesives

Adhesives are used in a wide variety of applications and require careful preparation and mixing. Instructions should be followed closely and where any problems arise the manufacturer should be contacted. Those containing formaldehyde or amine hardeners may cause dermatitis, thus making special precautions necessary, such as removal of the adhesive from the skin before setting takes place. Barrier creams may be used as a protective measure. The adhesives should be mixed in clean containers and kept covered to exclude all dirt.

UREA FORMALDEHYDE

	A	B	C	D
Form	White viscous liquid with liquid or powder hardener.	As for A together with wheaten flour extender.	White powder, sometimes with liquid or powder hardener.	As for C together with wheaten flour extender.
Preparation	Mixing of resin and hardener, or separate application*.	Mixing of resin, hardener, flour and water, or separate application*.	Mixing with water and sometimes hardener or separate application*.	Mixing of resin, hardener, flour and water or separate application*.
Shelf life at 20° C in suitable closed container.	Resin 3–6 months. Hardener no limit.	As for A.	Hardener no limit.	As for C.
Assembly time at 20° C ..	Cold-set glues up to $\frac{1}{2}$ hour, hot-set glues up to 12 hours or more.			
Pressing time and temperature..	2–24 hours at room temperature. Several minutes at 90–125° C.			
Setting mechanism	Polycondensation.	Polycondensation and loss of water.	Polycondensation.	Polycondensation and loss of water.
Time to develop ultimate strength.	One week for cold setting. Stacked after hot setting.		48 hours if block.	
Gap-filling properties	Poor, but may be improved by use of gap-filling resin or hardener.			
Weather resistance	Unprotected glue line withstands weathering for at least 1 year.	Weather resistance lowered by extension.	Unprotected glue line withstands weathering for at least 1 year.	Weather resistance lowered by extension.
Applications	Plywood, particleboard, assembly gluing, R.F. gluing.			
Remarks	Setting temperature for cold-setting formulations should be above 12° C. Weather resistance of liquid mixes may be improved by addition of melamine or resorcinol. Flour extensions of more than 50 parts by weight of flour to 100 parts of liquid resin may cause the glue to weaken and possibly fail after several years. *With separate application the resin is spread on one face to be glued, and the hardener on the other. Hardening then takes place when the two faces are brought together.			

MELAMINE FORMALDEHYDE

Form	Solid thin film.	White powder—usually with powder hardener.
Preparation	No preparation required.	Mixing with water and hardener.
Shelf life at 20° C in closed container	Up to 3 months.	At least 2 years.
Assembly time at 20° C	Equal to shelf life.	Up to 24 hours.
Pressing time and temperature	Several minutes at 90° C.	
Setting mechanism	Polycondensation (cross linking and splitting-off of water).	
Time to develop ultimate strength	After block stacking for 48 hours.	
Gap-filling properties	Poor.	Good.
Weather resistance	Unprotected glue line will withstand weathering for several years.	
Applications	Veneering using light and permeable veneers.	

CASEIN

Form	Ready-mixed cream powder.	Granules of lactic casein.
Preparation	Mix with water.	Mix with water and alkaline materials.
Shelf life at 20° C in closed container	9–12 months.	Up to 2 years.
Assembly time at 20° C	Up to 40 minutes.	
Pressing time and temperature	2 to 4 hours at room temperature.	Several minutes above 100° C.
Setting mechanism	Chemical action combined with loss of water.	
Time to develop ultimate strength	1 week.	
Gap-filling properties	Good.	
Weather resistance	Moderate.	
Applications	Assembly gluing, plywood production, laminating.	

RESORCINOL FORMALDEHYDE AND RESORCINOL PHENOL-FORMALDEHYDE

Form	Viscous reddish-brown liquid with liquid or powder hardener.
Preparation	Mixing of resin and hardener.
Shelf life at 20° C in closed container	Resin: 3 months or more. Hardener: 6 months or more.
Assembly time at 20° C	Up to 60 minutes.
Pressing time and temperature	24 hours at temperature above 20° C. Several minutes at 90° C.
Setting mechanism	Polycondensation.
Time to develop ultimate strength	1 week at 20° C.
Gap-filling properties	Good.
Weather resistance	Excellent.
Applications	Laminating, assembly, R.F. gluing.
Remarks	Setting temperature should be above 20° C and for maximum wet strength with some hardwoods, above 60° C.

EPOXY RESIN

Form	Honey-like liquid or coloured paste, with liquid hardener.	Solid sticks, powder.
Preparation	Careful mixing with hardener.	No preparation: resin melted onto surface to be glued.
Shelf life at 20° C in suitable closed container ..	Resin at least 6 months, hardener at least 1 year.	At least 2 years.
Assembly time at 20° C	Several minutes to 1 hour.	Equal to shelf life.
Pressing time and temperature	Up to 48 hours at 20° C; approx. 1 hour at 90° C.	48 hours at 110° C; 30 mins at 200° C.
Setting mechanism	Polymerization.	
Time to develop ultimate strength	Up to several weeks.	
Gap-filling properties	Excellent.	
Weather resistance	Moderate to good.	
Applications	Wood-to-metal, metal-to-metal, universal glue. High chemical resistance glue.	
Remarks	Adhesive not soluble in water, hardeners may be severe on unprotected skin. Shrinkage during setting negligible.	

CONTACT

Form	Viscous cream or coloured liquid.
Preparation	No preparation required.
Shelf life at 20° C in suitable closed container	Greater than 1 year.
Assembly time at 20° C	10–20 minutes (longer with special formulations).
Pressing time and temperature	Several seconds to several minutes at room temperature.
Setting mechanism	Loss of solvent.
Time to develop ultimate strength	Several weeks.
Gap-filling properties	Good.
Weather resistance	Fair.
Applications	Universal adhesive, but copper and its alloys unsatisfactory with many formulations.
Remarks	Bond can be achieved by hammer blow without pressure, but orthodox pressure application gives higher strength. At best, strength lower than other wood glues, still lower under permanent load. Adhesive will deteriorate after prolonged period. Inflammable.

BONDING PRESERVATIVE TREATED TIMBER

CASEIN ADHESIVES: Use in dry situations only. Like alkaline conditions.

UREA RESIN ADHESIVES: For water resistant uses. Urea resin adhesives should not be used on greasy surfaces. Like acidic conditions.

RESORCINOL ADHESIVES: May be used in situations exposed to chemically polluted atmospheres etc. Resorcinol adhesives usually contain industrial methylated spirit and thus can "wet" surfaces which are water repellent. Set under neutral conditions by chemical action initiated by the addition of a hardener.

Problems to be Considered

1. Moisture content of timber.
2. Adhesive penetration.
3. Curing temperatures.
4. The alkaline character of casein adhesives.
5. The acid setting conditions of urea resin adhesives.
6. The neutral setting conditions of resorcinol resin adhesives.
7. The special preparation of the surfaces to be bonded.

Types of Preservatives

(a) TAR OIL types such as creosote.

(b) Types requiring ORGANIC SOLVENTS such as chlorinated naphthalenes, copper and zinc naphthenates, pentachlorphenol.

(c) WATER BORNE types such as copper/chrome, copper/chrome/arsenic, copper sulphate.

To Bond Tar Oil Preservative Treated Timber

(Tar oils are mainly used in applications which do not call for bonded sections.)

Wipe the joint surfaces clean with a solvent such as acetone, using rags.

Timbers which have a tendency to bleed may be steam cleaned. Use a resorcinol resin glue which in this case will require elevated temperature curing.

To Bond Timber Treated With an Organic Solvent Preservative

Casein glue is satisfactory; however, the alkaline properties of the adhesive may cause the preservative to be deleteriously affected.

Urea resin adhesives set as the result of introduction of an acid hardener. Small changes in acidity will alter the setting time. Acid will accelerate, alkali will retard. This is particularly noticeable with gap filling urea resins.

Resorcinol resins set best under neutral conditions. Acid will retard, alkali will accelerate.

The physical compatibility of the adhesive and preservative will depend on the nature of the vehicle. A light volatile solvent will present no difficulties provided sufficient time is allowed for evaporation of the solvent.

Degreasing treatment will be required where heavy oils have been used and crystalline blooming should be removed by brushing, sanding or planing.

Pentachlorphenol and copper naphthenate can be applied using a variety of solvents of which naphtha and light mineral spirits give good results. Fuel oil solvents are unsatisfactory.

It is often beneficial to spread the adhesive two or three times to obtain uniform coverage.

Waxes or water repellents will interfere with adhesion.

To Bond Water Borne Preservative Treated Timber

Timbers treated with a waterborne preservative are often put into service at a high moisture content, as this is the nature of their end-use position. However the moisture content of the timber must be reduced to a level indicated by the adhesive manufacturer if it is to be glued satisfactorily.

Satisfactory bonds are obtainable with timber treated with fluor/chrome/arsenic/phenol when using resorcinol resin cured within the temperature range of 25° to 90° C. The harder timbers require the higher temperatures. Copper-chrome-arsenic treated timber may require higher temperatures.

Preservative Treatment of Already Bonded Timbers

Casein adhesives will not withstand this treatment. If urea resin adhesives have been used consult the manufacturer to ensure that the particular grade of adhesive will withstand the treatment in the pressure chamber, and subsequent drying. This glue may fail during kiln drying.

Resorcinol resin adhesive is satisfactory when preservative treatment is to be carried out after gluing and subsequent drying, but the adhesive must first be allowed to cure for 5–7 days at 15°–20° C.

Dipping or other surface treatments will probably not affect any of the more waterproof adhesives if the treatment and the adhesive are chemically and physically compatible.

PLYWOOD FOR MARINE CRAFT

The decay hazard to which marine plywood is subjected varies greatly with the use to which it is put, and it should be noted that a durable adhesive does not impart its qualities to the wood and cannot prevent its decay. The use of rot-proofed plywood should be considered if boats will be in the water for long periods.

Careful sealing of end grain or panel edges and the provision of good drainage together with good ventilation and the avoidance of damp pockets and excessively high humidities will help to keep decay hazard at a minimum.

In boatbuilding it is often difficult to avoid a construction that is likely to lead to the growth of wood-destroying fungi. In situations where water entry into the plywood cannot be entirely prevented, the use of permeable coatings or the omission of paint on the dry side will allow it to dry out. If decay hazards are relatively low these constructional techniques, combined with the use of suitable brush or spray preservatives, can give protection.

Plywood which has been completely impregnated with approved fixed preservatives is very resistant to wood decay. All timber that is susceptible to lyctid borer attack should be immunized in accordance with Australian Standard 1604–1974: *Preservative-treated sawn timber, veneer, and plywood,* if it has not been otherwise preservatized.

Scarf joints through the full thickness of sheets are permitted by agreement between the manufacturer and the purchaser. The slope of the bevel of the edges to be joined should be not less than the following:

For sheets under 13 mm in thickness, 1 in 10.

For sheets 13 mm and over in thickness, 1 in 8.

Scarf joints should be bonded with an adhesive of quality and type at least equal in durability and strength to that used in the manufacture of the sheets.

Plywood sheets must be stored flat on a level bed to prevent distortion, in a well-ventilated place and shaded from sunlight through windows, which will cause changes in colour.

Marine grade plywood should be used for the hull, decking, all stressed components, and any other exposed parts.

Some Hints for Plywood Users

- Buy your plywood from a reputable, well-known dealer or manufacturer, whose name depends on selling a quality product.
- All hull and deck cladding must be marine grade plywood—refer Australian Standard 086–1964: *Plywood for Marine Craft.* Exterior plywood with Type A waterproof bond may be used for linings, cabinets, etc., not of primary structural importance—refer Australian Standard 087–1963: *Plywood for Exterior Use.*
- Sound, adequate interior framings are essential.
- A heavily-built transom (back of the boat) and hull-bracing are "musts". Outboard designs should feature a partitioned-off motor well, rather than a low-cut transom which can ship water in heavy seas.
- Check inside the hull to see that any exposed plywood edges are fully sealed against moisture.
- There is no need, however, for the superstructure to be too heavily built. In fact, lightweight construction helps lower the centre of gravity for improved stability and performance.

PERMISSIBLE TIMBER SPECIES FOR USE IN MARINE PLYWOOD

Reference: AS 086–1964: *Plywood for Marine Craft*

Standard trade common name †	Botanical name
Agba	*Gossweilerodendron balsamiferum*
Alder, brown	*Ackama paniculata*
Alder, rose	*Ackama australiensis*
Ash, silver, northern	*Flindersia pubescens*
Ash, silver, Queensland	*F. bourjotiana*
Ash, silver, southern	*F. schottiana*
Birch, white	*Schizomeria ovata*
Blackwood	*Acacia melanoxylon*
Coachwood	*Ceratopetalum apetalum*
Guarea	*Guarea* spp.
Mahogany, brush	*Geissois benthamii*
Mahogany, brush, northern	*G. biagiana*
Makore	*Tieghemella heckelii*
Maple, Queensland	*Flindersia brayleyana*
Maple, scented	*F. laevicarpa*
Pine, hoop	*Araucaria cunninghamii*
Pine, klinki	*A. hunstenii*
Sapele	*Entandophragma cylindricum*
Silkwood, bolly	*Cryptocarya oblata*
Silkwood, New Guinea	*Palaquium* spp.
Silkwood, red	*Palaquium galactoxylum*
Silkwood, silver	*Flindersia acuminata*
Sycamore, satin	*Ceratopetalum succirubrum*
Sycamore, silver	*Cryptocarya glaucescens*
Teak	*Tectona grandis*
* Meranti, dark red	*Shorea* spp.
* Sassafras	*Doryphora sassafras*
* Sassafras, southern	*Atherosperma moschatum*
* Taun	*Pometia* spp.

† The standard trade common names are those given in AS 02: *Nomenclature of Australian Timbers*, or AS 1148–1970: *Nomenclature of Commercial Timbers Imported into Australia.* Where there is no standard trade common name, common names have been used.

* These species are permitted for core veneers only.

WOOD DECAY

Causes of Decay

Troubles arising from fungal decay are usually due to faulty design, the use of unsuitable or infected timber or the lack of adequate preservative treatment.

Wood decay is caused by fungi and will only occur when moisture is present in sufficient amounts to raise the moisture content of the wood above 20 per cent and maintain it thus for lengthy periods. Wetting does not harm timber provided it can dry out quickly. For this reason, the incidence of decay in open boats is slight when compared to decked boats.

How does moisture find its way into the timbers of decked boats?

1. **Use of unseasoned timber.** Large size members such as stern and stem posts are often inadequately seasoned.
2. **Leakage of water.** It is the leakage of fresh water that encourages most decay. Direct wetting by sea water does not appear to encourage decay. However, moisture evaporating from sea-water in the bilges can condense as fresh water on the timbers above.

Leakage is most serious when it occurs at the edge of the deck and finds its way into the ends of beams and frames. If there is a lining to the hull, such leakage could go on for a long time before being detected. It is an advantage if parts of the lining are screwed so that portions can be removed for regular inspection.

Leakage and decay often occur at the junction between coamings and decks and when bulwark stanchions pass through covering boards. When surveying or refitting a vessel, a careful inspection should be made of these areas.

Faulty plumbing around lavatories and sinks can be a source of fresh water leakage and regular inspections should be made of these areas.

The absence of adequate ventilation, leading to condensation of moisture from the air, is a very common cause of timber decay in cabin boats which lie at moorings for long periods. The ventilation provided for little used places such as the forepeak, lockers, etc., is often totally inadequate and generally blocked by the goods stored in them.

Recognition of Decay

It is sometimes difficult to detect incipient decay in boats as the decayed wood may hold its shape as long as it is in a damp condition. Often the only indication is a wrinkling of the paint on the surface. Usually, distortion of the timber only occurs when decay is at an advanced stage.

The most satisfactory method of detecting decay is to prod the suspected timbers with a sharp pointed tool. On testing an area of incipient decay, it will usually be found that the texture of the wood has been softened and it is impossible to prise up a long splinter. The fibres break off short owing to the loss of toughness. Obviously you cannot prod every piece of timber in the boat; but you should examine those parts where leakage of water may have occurred and around ends and joints.

Treatment of Decay

1. Eliminate the source of moisture that caused the decay.
2. Completely remove the decayed wood, cutting back to sound clean timber some inches beyond the furthest sign of attack.
3. Liberally apply a suitable wood preservative to bare timber exposed during the work and to new timber used for replacement.

Common Preservatives

Copper naphthenate

Copper naphthenate is sold as a green coloured solution and should contain at least 3 per cent copper. Any recommendations by the manufacturer to reduce the copper content below 3 per cent should be disregarded. Copper naphthenate usually takes 2–3 days to dry, after which it can be painted over.

ELECTROCHEMICAL CORROSION OF METALS

The Process of Corrosion

Corrosion is essentially electrochemical. The most common examples are the rusting of iron and the corrosion of dissimilar metals when in contact in the presence of moisture. When iron comes into contact with air, a thin, patchy film of oxide forms on it. A voltage difference exists at all times between the iron and the oxide coat, and should the surface of the iron become wet, an electric cell will be formed resulting in the formation of rust deposits. Corrosion of dissimilar metals, or bi-metallic corrosion, is a process essentially similar to the rusting of iron. When dissimilar metals are adjacent in a damp situation, moisture will provide an electrolytic link between them. When electric cells are formed in this manner, the metals constitute the positive and negative poles, and the severity of the corrosion depends on the voltage difference which exists between dissimilar metals. The rusting of iron is a more active process at the seaside than in ordinary atmospheres because moisture containing salt is a more efficient electrolyte.

Electrochemical Series

The Galvanic table is very useful in predicting which metal will corrode in any bi-metallic pair and the probable severity of the corrosion. In the table the metals and alloys are listed in order of the voltages they develop while freely corroding. The metal closer to the negative end of the scale (i.e., less noble) will corrode while the other will not, and the further apart on the scale the metals are the more severe will be the corrosion.

GALVANIC SERIES OF METALS AND ALLOYS

More negative end (Base end)	Metal or alloy
	Magnesium alloys
	Zinc
	Cadmium
	Aluminium
	Aluminium alloys
	Iron and mild steel
	Stainless steels (active)
	Soft solders
	Lead
	Muntz metal
	Manganese bronze
	Naval brass
	Nickel (active)
	Nickel-chromium alloys (active)
	Copper
	Red brass
	Aluminium brasses
	Composition bronzes
	Admiralty brass
	Phosphor bronze
	Silicon bronze
	Gunmetal
	Silver solder
More positive end (Noble end)	Nickel (passive)
	Stainless steels (passive)
	Monel

Note: Nickels and stainless steels have varying positions in the scale according to their composition and the state of the coatings of oxide films.

Protective Coatings

The oxide coating which rapidly forms on aluminium in the atmosphere protects it from further corrosion. By promoting this process artificially by anodizing, aluminium can be given a protective coating of pleasing appearance. However, zinc and aluminium suffer attack from the alkalis present in seaside atmospheres, the results being rather unsightly but not usually serious unless the metal is very thin or of unsuitable alloy. Bearing greases, which are really sodium soaps, should not be used to lubricate or "protect" aluminium components.

Copper alloys are more noble than most other metals and are therefore not so likely to corrode from electrochemical attack. Copper, bronze or brass should not be used in association with aluminium.

Sacrificial Coatings

Corrosion will usually be restricted to the less noble metal. A common instance of sacrificial protection is where the zinc coating on galvanized iron corrodes in preference to the steel.

Steel boat hulls may be protected by attaching blocks of zinc at regular intervals along the hull below the waterline. These blocks corrode in preference to the steel and must be replaced from time to time.

Electrical Systems

Fully insulated electrical systems are desirable, but where of necessity earthed, a negative earth is to be preferred. The use of lead-covered cables is inadvisable. Wiring should not be run through bilges.

The setting up of undue resistance in wiring or at terminals must be avoided (e.g., the use of too small a cable, or dirty or loose connections). Such conditions give rise to a voltage drop over a part of the system which may in turn cause a potential difference between underwater metal parts. Defective insulation on the live side of a circuit may apply battery voltage to otherwise isolated metal parts.

If wires to electrical fittings are inadvertently cross-connected the fittings may still operate satisfactorily but heavy leakage of current may occur. Such leakage does not necessarily require a metallic path but may flow for long distances through wet wood.

Failure of the battery to hold a charge properly is a common indication of a leakage. It does not necessarily mean that the battery is worn out.

Screws and nails should, where possible, be of the same metal as the item to be fixed. This is very important in regard to the fixing of sheathing or other metal parts below the waterline as unseen corrosion may take place rapidly.

"Nail sickness" is a term used to describe the action of acids, present in many timbers, on a nail or screw which has been driven into the timber. Assisted by moisture, the acid can corrode the nail or screw and this in turn may cause chemical deterioration of the timber surrounding the nail. The net result of this is that the nail or screw will eventually fall out or fail to hold. The possibility of nail sickness occurring may be reduced by using galvanized or brass or copper nails and screws and by keeping the timber as dry as possible, e.g., by painting or sealing with bitumen or caulking materials.

Where two different metals have to be used close together, they may be separated by a thin layer of bitumen or other suitable material, but regular careful inspection should be made to ensure that corrosion is not taking place.

TERMS AND DEFINITIONS

This short list is appended as a useful guide to potential boat builders. A more comprehensive list is contained in the Standards Association of Australia's Standard AS01–1964: *Glossary of Terms used in Timber Standards.*

TIMBER TERMS

Backsawn: Sawn so that the wide face of the piece is a tangential plane to the growth rings.

Batten: A piece of sawn or dressed timber of rectangular cross-section, usually between 19 mm and 40 mm thick, and between 25 mm and 75 mm wide.

Beam: A structural timber, supported at two or more points along its length.

Board: A relatively thin piece of sawn or dressed timber, of width greater than thickness.

Bow: A curvature from the plane of the wide face in the direction of the length.

Cover Strip: From 10 mm to 20 mm thick and various widths, used to cover joints to prevent entry of rain or to improve the appearance of the joints.

Dressed: Planed smooth, straight and square.

DAR: Dressed all round.

DBF: Dressed both faces.

DD: Double dressed or dressed both faces.

D_1F_1E: Dressed one face and one edge.

D_2E: Dressed two edges.

D_1E: Dressed one edge.

Flitch: A large segemnt of log with saw cuts on at least two surfaces.

Growth rings: Rings visible on the transverse or cross-section of a trunk or branch which mark a cycle of growth.

Lagging: Timber, of small section, used to cover the surface of a jig or mould.

Milled timber: Timber which has been passed through a machine to shape it to a desired profile.

Nominal sizes: The named size, or ordered size, which may vary from the actual size of the piece because of variations due to sawing, shrinkage and dressing and the tolerances allowed on these operations.

Plank: A piece of timber sawn or dressed to rectangular section 40 to 75 mm thick and more than 150 mm wide.

Quarter sawn: Sawn so that the wide face of the piece is a radial plane of the log. Trade practice in Australia is to class timber as quarter sawn when the average inclination of its growth rings to its wide face is over 45°.

Rough sawn: Surface condition of wood as it leaves the saw.

Round timber: Items such as piles, poles and posts utilized in the natural form of the tree.

Scantling: Timber of rectangular cross-section and of dimensions used in construction. Usually 35 to 100 mm thick and up to 150 mm wide.

Scarf joint: A joint made by bonding together two matching bevelled ends or edges.

Spring: Curvature from the plane of the edge, or narrow face, in the direction of the length.

Surfaced: Planed or dressed on one or more faces.

Timber: Wood in a form suitable for construction or manufacturing purposes.

Veneer: (a) A thin piece of wood produced by slicing or rotary cutting.
(b) Rotary cut: cut from a log by turning the log against a knife.
(c) Sliced: produced from a flitch by slicing with a knife.

Wane: The original underbark surface with or without the bark.

Want: The absence of wood other than wane from corner or edge of a piece.

Warp: Any variation from a flat surface. It may consist of bow, spring, twist or any combination of these.

TERMS USED IN BOATBUILDING

ACCOMMODATION PLAN—The drawing showing the interior layout of a vessel.

AFT—Astern, or towards the stern.

AHEAD—Forward, or in front.

AMIDSHIPS—The central portion of any boat, or neither to port nor starboard.

ANTI-FOULING PAINT—A specially prepared paint containing various poisons which discourage the attachment of marine growth to a vessel's hull.

APRON—A strengthening timber placed behind the stem.

ASTERN—Behind.

BALLAST—Weight, usually lead or iron, added to a vessel low down either internally or externally to provide stability.

BEAM—The maximum width of a vessel. Also a timber laid athwartships to support the decking; this is known as a deck beam.

BEARERS—Longitudinal supports for an engine.

BERTH—A sleeping place or bed aboard a vessel. Also refers to a place at a jetty where a vessel may moor.

BILGE—The lower part of any hull. Can refer to either inside or outside.

BILGE KEEL—A rubbing strip, usually fixed to the bilge of dinghies and small boats to stop chafe to the planking.

BITTS—Posts fitted in the foredeck to take the aft end of a bowsprit, which are also used for making fast an anchor warp or chain.

BODY PLAN—A drawing showing the shape of various sections of a boat if it were cut athwartships.

BOOM—A horizontal spar to which the foot of a sail is set.

BOW—The front of a vessel.

BOWSPRIT—A spar projecting beyond the bow from which a jib is set.

BREASTHOOK—A knee, either wood or metal which is fastened to longitudinal members such as stringers, deck shelves, etc., and to the stem, thus tying them together strongly.

BRIDGE DECK—The decking which separates the cockpit from the main cabin.

BRIGHTWORK—Woodwork on a yacht which is finished with varnish.

BULKHEAD—A partition below decks which separates one section from another. Used commonly to give extra strength to a vessel.

BULWARKS—A continuation of the planking, often above the deck to prevent the loss of gear or people overboard.

BUMPKIN—A spar which extends beyond the stern to which a standing backstay is attached.

BUNKBOARD—A canvas or timber bulwark fitted so as a sleeping person will not be thrown out of a bunk by the vessel's motion.

BUOYANCY TANKS—Airtight compartments in small vessels to give added buoyancy in case of the vessel becoming water-logged.

BUTT—The squared end of a piece of timber. Planks are butted when the squared ends are placed together.

CAMBER—The amount of curve athwartships in a deck.

CARLINE—Fore and aft members which support the cabin sides or cockpit and to which the deck and cabin top beams are secured.

CARVEL—A method of planking where the planks are fitted to lie alongside each other, presenting a smooth exterior finish.

CAT RIG—A sail rig which has one mast right for'ard and only one sail.

CAULK—To fill the seams between planks with caulking cotton so as to make them leakproof.

CENTREBOARD—A central keel which can be raised or lowered at will.

CHINE—The angle formed where the topsides meet the bottom in a V bottom or hard chine boat. Also refers to the longitudinal timber which runs fore and aft at this point.

CLEAT—A fitting to which a line may be easily fastened.

CLENCH—Term used when referring to copper nails which are turned back into the timber.

CLINKER (or clincher)—Type of construction where hull planking overlaps.

COACH HOUSE—The raised cabin of a boat.

COACH ROOF—The roof of the coach house designed to give extra height below.

COAMING—The raised sides of a hatch or cockpit.

COCKPIT—The well, usually placed aft, from which a yacht is steered.

COVERING BOARD—The plank running around the outer edge of a deck.

DEADWOOD—The strengthening piece which joins the keel to the sternpost.

DISPLACEMENT—The actual weight of the vessel.

DOGHOUSE (or dodger)—The raised cabin aft which gives added headroom or protects the helmsman.

DRAUGHT (Draft)—The depth of water necessary to float a vessel.

DRIFT—A tool used for driving plank fastenings home.

DRY ROT—Rot in timber which seems to flourish in badly ventilated, damp spots. Fungus attack. The term "dry rot" is not really correct: all decay results from damp conditions.

FALSE KEEL—A piece added to the main keel often used to fair in with the ballast keel.

FASTENINGS—Nails, screws, bolts etc., which are used to hold components together.

FIDDLE—A removeable strip of wood, which when in place prevents crockery etc., from falling off a cabin table, shelf etc.

FLARE—The outwards curve of a vessel's sides above the waterline.

FLOOR TIMBER—A transverse piece of either metal or wood which is fastened to the planking and timbers and to the keel, tying the construction together strongly.

FORECASTLE—The accommodation in the bow.

FOREFOOT—The section of bow between the waterline and the keel.

FOREPEAK—That section below deck which is right in the bow. A very cramped space used for stowing anchors, warps etc.

FRAME—A large rib of boat which is usually laminated, sawn or of metal, used particularly in plywood construction.

FREEBOARD—The height of a vessel's side above the waterline.

GAFF—The spar to which the head of a quadrilaterial sail is set.

GARBOARD (or garboard strake)—The plank which lies adjacent to the keel on each side. Often said to be the most difficult to fasten, yet the most important.

GRAVING—Taking the boat from water to repair.

GUNWALE—The upper edge of the topsides on a boat.

HACK KNEE—A knee bracket cut out of a solid piece of timber about 30 mm thick.

HALF BEAM—A partial deck beam or one that does not extend the full width of the boat.

HALF BREADTH PLAN—The drawing showing the shape of waterlines and level lines.

HATCH—A deck opening usually covered by a hinged lid.

HEADROOM—The height of the cabin roof from the cabin sole.

HEEL—The lower end of a mast or the aft end of the keel.

HELM—The wheel or tiller by which a boat is steered.

HORN TIMBER—The fore and aft timber between the stern post and transom.

JOGGED FRAME—A section is cut away to take transverse members.

KEEL—The back bone of a boat upon which the rest is built.

KEELSON—Inside the planking, above the keel, but separate from the keel.

KING PLANK—The centre plank of decking.

KNEE—A shaped piece of timber, preferably with the grain running with the shape, which is used to the together such parts as deck to topsides, cabin roof to cabin sides etc., now replaced by plywood.

KNIGHTHEADS—Timbers supporting the bowsprit and giving additional support to the planking just abaft the stem.

LAMINATED—Made up of thin strips glued together.

LANDS—The ledgers which overlap in clincher planking.

LAP STRAKE—A method of sheeting a boat.

LEE BOARD—Used to increase the height of the side.

LEVEL LINES—Lines drawn at regular intervals on a lines plan which are parallel to and above the L.W.L.

LIMBER HOLES—Holes drilled in floors and frames to allow bilge water to run to the lowest part so it may be pumped out. Drainage holes between the sheeting and the ribs.

L.O.A.—Length over all, or the extreme length.

LOCKER—Boating term for cupboard.

LOFTING THE PLANS—Laying down the lines or drawing the plan of the boat full size on the floor.

L.W.L.—The length of a boat measured in a straight line at the waterline where she floats.

MAST STEP—The timber on which the mast is stepped.

OAKUM—Fibrous material used for caulking.

OFFSETS—Measurements supplied with a plan which enable the builder to lay the boat out to full size.

OVERHANG—That part of a hull which extends beyond the extremities of the L.W.L.

PARTNERS—A strong wood framework to support a mast as it passes through the deck.

PAY—To put pitch in the joints and seams of the boat.

PLANK STEALERS—Short planks used to make up the total length.

PORT—The left hand side of a boat when looking forward.

PRAAM—Refers to a dinghy which has a transom at both ends.

PULPIT—Strong safety rail fitted around the bow.

RABBET (Rebate)—A groove cut in the stem, keel etc., to receive the edge of a plank.

RAIL—A narrow plank fitted to the top of a bulwark. Often finished bright for effect.

REVERSE SHEET—A deck line which in elevation is higher amidships than at either end.

RIBBAND—A light, flexible timber used in fairing the hull shape. (A fairing batten).

RISER—A fore and aft timber which supports the thwarts in a dinghy.

ROVE—Cup-shaped copper washer used in boat building to rivet copper nails.

SAMSON POST—A strong post in the foredeck to which anchor or mooring chains are secured. May also be placed after for towing etc.

SCARF—A long diagonal join between two pieces of timber.

SCUPPER—Drain hole in bulwark which allows water on deck to drain overboard.

SHEER—The shape of the vessel at deck level when viewed from one side.

SHEER STRAKE—The top plank on each side.

SHELF—The longitudinal member which supports the outer end of deck beams.

SKEG—An extension beneath the hull which protects the propeller, also called a shoe.

SOLE—The cabin floor.

SPALL—A supporting secondary timber.

SPLINE—A thin wedge-shaped piece of wood which is glued between planks in place of caulking.

STARBOARD—The right hand side of a vessel when facing for'ard.

STEM—The most for'ard timber in the hull to which the for'ard end of planks are fastened.

STOPPER—A plug.

STOPPING—Material for filling gap.

STOPWATER—A softwood plug which is driven across joins which cannot be caulked.

STRINGER—A longitudinal strengthener fastened to the frames or timber.

STRAKES—The boards used to plank the hull of a boat. Usually comparatively thin in relation to width.

TAFFRAIL—A raised rail around the stern.

TINGLE—A patch repairing a hole in the hull.

TOPSIDE—The sides of the hull above the waterline.

TRANSOME—The single board etc., used to make up the stern.

TRENAIL (or trunnel)—A wooden "nail", not often seen today.

TUMBLE HOME—The opposite of flair, i.e., the inwards curve of the topsides from the waterline, or some place.

WALE—A horizontal protecting strip.

WET ROT—Fungus attack. The term "wet rot" is not correct. *See* "dry rot" also incorrect.

The Forestry Commission's Timber Inspection Services are located at Bega; Casino; Coffs Harbour; Grafton; Newcastle; Wauchope; Wollongong. Regional office addresses are listed under Forestry Commission of N.S.W. in State Government sections of relevant telephone directories. The principal Sydney office address is Box 100, P.O., Beecroft 2119.

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