

## Fibreglass Hand Lay-up

Hand lay-up is the most widely used fabrication technique employed in the reinforced plastic industry. It is normally used for relatively short runs, but it has also been adapted successfully for series production. It is a production method which takes full advantage of the two most important characteristics of [Polyester resin](#) i.e. that it cures without heat and without pressure.

Briefly the mould surface is prepared by polishing to whatever degree of surface finish is required, then a [Release Agent](#) is applied. The next step is to apply a resin rich surface ([Gelcoat](#)). After this has cured sufficiently liquid [Polyester Resin](#) is brushed onto the gelcoat surface, [Glassfibre Mat](#) is placed on the top and each layer is then impregnated with resin. The laminate is then allowed to cure at room temperature and dependant on conditions and the type of the resin used, the cure time can vary from 1 hour to 4 hours – see [Catalyst Mixing Chart](#).

1. The first step is to prepare a suitable mould.
2. Apply a film of [Release wax](#) polish (silicone free) to the mould surface, keeping the quantity to a minimum. This is then polished out with a fine cloth to a high polish. Some types of wax used to be left to harden but all waxes must be used to manufacturer's recommendations.
3. A film of polyvinyl alcohol solution ([PVA](#)) is applied evenly, by spray or sponge, over the whole of the mould surface and allowed dry at room temperature. Because of its low viscosity, a [PVA](#) solution will drain from vertical sections and accumulate in sharp corners where it may take a long time to dry. If this is not prevented and the moulding is laid up too soon, it will almost certainly stick and some damage may be done to the mould.
4. The durability of GRP moulding is mainly dependant on the quality of its exposed surface. Every possible precaution must be taken to prevent fibres from coming too near the surface where they be liable to be attacked by moisture. This is achieved by providing a resin rich area on the working surface of the laminate.
5. The next step in the process is the layup of the glass fibre reinforcement ([Chopped Strand Mat](#)) with the [Polyester resin](#). Laying up can be started as soon as the gelcoat has hardened sufficiently to withstand solvent attack from the laminating resin. The simplest way of checking this is to touch the back of the [Gelcoat](#) lightly with a clean finger. If the [Gelcoat](#) feels slightly tacky, but the finger comes away perfectly clean, then the gelcoat is just at the right stage for laminating. Sometimes a [Glass Tissue](#) may be laminated next to the gelcoat in anti-corrosion applications. This also helps to cut down the risks of the glass fibre pattern showing on the [Gelcoat](#) surface.
6. [Chopped strand fibre glass mat](#) is the most usual reinforcement although [Woven Roving](#) can be used. Woven Roving however should have at least 2 layers of the reinforcement mat between them and the gelcoat otherwise the 'chequered' pattern of the rovings will show through. Woven rovings should not be used adjacent to one another because they have poor inter laminar adhesion. Consequently at least one layer of the reinforcement mat between the layers of woven rovings is recommended. The reinforcement should be prepared before the laminating begins. It can be cut to size and tailored if necessary with a scissors or a sharp knife. The amount of resin required can be calculated by weighting the glass fibre to be used for the moulding. For chopped strand mat the resin: glass ratio is usually between 3:1 and 2:1 by weight. (25-33% glass by weight) – see [Material Calculator](#).

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7. At this stage **Pigment** is added to the resin (if desired). A quantity of pigment paste is mixed into the resin preferably with a mechanical mixer to achieve even dispersion. The majority of resins used are pre-accelerated and only require the addition of **Catalyst** to activate them before use. The quantity of **Pigment**, will have been obtained from information supplied with the resin, which will give quantity of catalyst for a given working temperature to achieve the desired pot life.
8. A liberal coat of resin is brushed over the gelcoat as evenly as possible and the first layer of the glass is pressed firmly into place and consolidated with a **Brush** or **Paddle Roller**. The resin will impregnate the glass mat quite rapidly and dissolve the binder which holds the fibres together. The mat will thus conform readily to the contours of the resin should be applied on top of the mat until it is fully impregnated because this may lead to air bubbles being trapped. When the laminate contains air bubbles it is a milky colour (this is true only of course if the laminate is made using unpigmented resin). As the air is being released the colour of the laminate will change to the natural colour of the resin. When a **Brush** is used, or impregnated it should be worked with a stippling action not moved sideways across the surface. The normal brushing action will displace the fibres and distribute them unevenly. Consolidation of the laminate is quicker with a **Paddle Roller** than a brush. Adjacent pieces of **Chopped Strand Mat** should be overlapped by tearing rather than cutting.
9. Subsequently layers of resin and glass mat are applied until the required thickness has been built up (see **Material Calculator**), taking care that overlaps are staggered to prevent local excessive thickening, causing uneven cure and shrinkage. Each layer must be worked until it is completely impregnated. Where a thick layer of laminate is required no more than four layers of the resin and glass mat should be applied without allowing the resin to reach the state of gelation and most of the exotherm to take place. This is to avoid a build-up of exotherm which may result in either cracking on the surface of the gelcoat, pre-release of the moulding due to excess shrinkage or discolouration of the pigmented resin.
10. During the layup operation, it is possible to incorporate wood and metal straighteners, also fitting and sandwich materials such as paper honeycomb, Polyurethane Foam or balsa wood. This lamination should not take place until the main laminate has passed the 'green stage' i.e. cured to a certain degree, otherwise the addition of ribs etc. will cause localised excess shrinkage and on mould release there will be found to be a 'ripple' on the gelcoat opposite the fitting.
11. When a smooth finish is required on the reverse side of the moulding i.e. the working side, a suitable **Glass Tissue** can be used as the final layer of reinforcement. This will give a finish which is not as coarse as **Chopped Strand Mat** and can look attractive when painted.
12. After the resin, has gelled it is in a soft rubbery state and green for a limited period. In this condition the laminate can be quickly trimmed by hand with a sharp knife to the dimensions of the mould and suitable trim edges can be built into the mould for this purpose.
13. The moulding is allowed to cure either at normal room temperature (20°C) or in a warm room (30-40°C).
14. After removal from the mould the moulding should be allowed to mature for a few days or given a post cure, after 24 hours at ambient, at approximately 60-100°C from 1-4 hours dependant on the final environment of the finished moulding. In many cases, it is advisable to post cure in a jig to avoid distortion.
15. The polyvinyl alcohol film (**PVA**) is finally removed by washing from the surface of the moulding using soap water.

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