

# SAILSetc guide notes for making a hull plug

from which a hull mould may be made

## 1 Abbreviations

<b>fairing strip</b>	self adhesive abrasive paper stuck to 400 x 50 mm 6 mm plywood or regular abrasive paper bonded to timber using contact adhesive or doubled sided tape – more flexibility can be achieved by cutting the strip with the cross grain outer plies
<b>filler</b>	epoxy resin with a high content of microballoons used to add low density material to hollow areas that need filling
<b>hi build</b>	a coating system, usually epoxy based, that has a very high filler content and which is used to quickly cover a surface with an easy to fair/smooth layer of waterproof material
<b>locating studs</b>	sold in pairs for use patternmaking and foundry work – there is a male and a female part which engage to provide an accurate and repeatable assembly – alternatively use 6 mm rods and short pieces of tube with a precise 6.1 mm ID
<b>mdf</b>	medium density fibre board, typically used for making the unseen parts of furniture, available in various thicknesses that are normally very consistent
<b>plasticene</b>	non-hardening modelling clay
<b>plug</b>	also known as a master or pattern
<b>pva</b>	polyvinyl alcohol
<b>wax</b>	mould release wax – ensure it is a silicone free product

## 2 Materials

- abrasive papers (self adhesive preferred) – grades 60, 100, 200, 400, 800, 1000, 1200, 1500, 2000
- abrasive polishes
- brushes
- epoxy resin + hardener
- filler

- hi build
- locating studs
- mdf
- plasticene
- pigments
- release wax – carnauba based with no silicones – Simoniz car wax is a suitable UK brand
- solvent
- 3 x M10 x 50 mm screws + nuts + washers
- No 4 countersunk head woodscrews – length 1.75 x thickness of mdf
- 25 mm panel pins

### 3 Tools

- bandsaw
- draughtsman's curves
- fine felt tip drawing pen - 0.5 mm tip
- G cramps
- hammer
- jigsaw with carborundum coated blade
- large flat surface
- locating studs
- long straight edge
- nails
- oil stone
- pilot drill and countersink for woodscrews
- pliers
- screwdriver to match woodscrews
- set square
- small block plane
- spoke shave
- spoke shave (convex)
- try square
- 1+” chisel
- 2” block plane
- 12 mm Ø drill

### 4 Steps – in brief

- mark out material
- rough cut out one set of shapes
- nail each onto 2<sup>nd</sup> sheet

- fine cut out pairs of parts
- mark grid lines on 2<sup>nd</sup> set
- test assemble
- add locating studs to inner parts
- prepare inner layers of each half to provide connecting screws
- assemble with glue
- fit halves together
- shape halves
- test measure the hull
- finish halves
- surface finish halves
- make fence
- add fence to one half
- wax
- Make the first half of the mould
- remove fence
- assemble other half of mould
- wax
- Make the second half of the mould
- drill for fixing bolts
- de mould
- smooth moulds
- polish
- wax outside moulds
- wax inside moulds
- laminate hull

## 5 Steps – in more detail

### 5.1 Mark out material

- choose mdf of the same thickness as the spacing of the buttock lines shown on the plan – it may be necessary to have the plan prepared with spacing to match the mdf available – allow for the thickness of the glue joint
- mark out the shapes of the parts – normally these will be the shapes bounded by the buttock lines and the deck line – this permits a port side and a starboard side plug to be prepared in order to make a mould split down the centreline – this permits a deck edge flange to be provided in the hull mouldings as well as tumblehome if required
- mark out **only** the port (or starboard) side parts – leave about 10 mm between each part – it may be simplest to mark a grid on the mdf first that is at the same spacing as the plan – lay the plan over the grid, aligning it correctly, and use a large sewing needle to prick through the plan into the surface of the mdf – prick at 50 mm intervals on long curves and closer on tighter curves – mark the waterline too so that there is a vertical datum on each part

- after pricking through the shape of a part use the draughtsman's curves to join the dots
- number each part
- if the design is in the A Class it will be useful to locate and mark the QBL measurement points so that permanent locating points can be built in from the outset – at each point provide a hole passing through all the layers so that a piece of 1.5 mm Ø wire (equal to the quarter-beam dimension) can be bonded in to the plug at each point – the outermost layer should have a hole the same size as, or marginally larger than, the wire that will be used – the inside layers should all have a 4 mm diameter hole, plugged with plasticene, so that slight misalignment will not prevent the wire being added when the layers are bonded
- if the design is a 6M the measurement points are best added in a similar way but at a later stage

## 5.2 Rough cut out one set of shapes

- use the bandsaw to cut out each part, cutting about 5 mm from the marked shape

## 5.3 Nail each onto 2nd sheet

- use panel pins to nail each part firmly onto a 2nd sheet of mdf

## 5.4 Fine cut out pairs of parts

- use the bandsaw to cut out pairs of parts – this time cut to the outer edge of the line 'exactly'

## 5.5 Mark grid lines on 2nd set

- before separating the pairs of parts use a try square to transfer the grid lines across the edges of both parts and across the reverse side of the 2nd part – add the datum waterline too

## 5.6 Test assemble

- trial assemble the sets of parts to see that you have them all correctly cut and marked – the grid lines and waterline should allow accurate assembly – mark round each smaller part with a pencil so that its profile shape shows on the next part
- drill pilot holes for (at least two) screws to hold each part onto the next inner part – countersink for the heads - ensure these holes will be well away from the final surface of the plug or, alternatively, accessible when the whole half is assembled so that they may be removed before shaping starts – add screws and then remove them

## 5.7 Add locating studs to inner parts

- take the two inner parts from each half of the plug – replace nails in the original nail holes so that they are correctly aligned - at three places (near the bow, near the stern and midships) drill through both parts with the correct size hole so that the pairs of locating studs can be added to their inner faces – do not add the

studs yet but put plasticene into the holes so that they do not fill with glue in the next stage

### 5.8 Prepare inner layers of each half to provide connecting screws

- take enough inner layers from each half to give 12 to 20 mm thickness (each half) – assemble the layers of each half using the woodscrews – mark positions for connecting bolts or studding (M10 x 50 mm) one forward, one aft and one near the centre each at about half the local depth of the hull – drill through all layers 12 mm diameter – plug the holes with plasticene
- take as many of the next layers of each half as possible to create ‘wells’ each extending up to the deck to give access to the holes in the inner layers so that the bolts/studding, washers and nuts can be inserted/added to hold the two halves together at later stages – assemble with the woodscrews - mark out and cut the mdf to create the wells – remove the wood screws
- it is usually easier to use studding rather than bolts to connect the two halves as it removes the need to place a bolt down a well and into the hole

### 5.9 Assemble with glue

- prepare a large flat surface, a 30 mm worktop material as used for kitchens may be OK, for this stage – check that it is flat over the length you will be using – it needs to be raised off the bench so that G cramps can be used to hold the assembled parts down
- protect the flat surface with a sheet of paper, Mylar or polythene held in place with tape
- place the first part on the surface and paint resin thinly onto the area indicated by the line drawn round the next part – paint resin thinly onto the matching surface too
- add the 2nd part to the first- ensure it is correctly aligned – add the woodscrews to locate each layer – do not overtighten
- repeat with the 3rd and 4th layer
- use G cramps to compress the 4 layers together and remove as much resin as possible – protect the layers with blocks of similar scrap material to that their shape is not distorted – check the straightness of the surface - check the alignment of the layers for slippage which is easy once they are coated with resin – use many cramps closely spaced and lightly applied rather than few and far between
- allow to cure
- when cured, the cramps can be removed and this step is repeated until all the parts of this half have been assembled
- when this half is completed and cured, check the straightness of the centreline (actually it is the centreplane) with a long straight edge – if it is truly straight proceed as below – if it is not truly straight it may be best to assemble the 2nd half of parts onto the first half (with locating studs and a release layer between) so that the two halves match
- repeat this step with the set of parts for the other half - check you are making mirror image halves and not an identical copy ☺

- on an A Class plug, when the layer(s) with the 1.5 mm hole for the QBL is/are added, insert the wire ensuring the inboard end is on the hull centreplane
- when cured, remove the screws that are accessible

### 5.10 Fit halves together

- add the locating studs to the holes previously drilled in the inner layers of each half – add the male parts to one half and the female parts to the other
- test the assembly of the two halves – if the work surface on which the two halves were laminated was accurate and there was no distortion during cramping and cure, the two halves should match perfectly
- if there is a mismatch you will need to consider what action to take to rectify the situation taking into account the effect on the overall shape and size of the plug

### 5.11 Shape halves

- to enable each half to be held rigidly in a vice it will probably be necessary to screw a 300 x 50 x 50 mm block of timber to the inner face of each half
- use the 2" block plane and large chisel to remove the bulk of the material – keep their edges very sharp – work evenly over the whole surface rather than attempting to reach the final shape on any one area before moving to another
- as work progresses you will need to reduce the setting of the plane and perhaps use smaller planes to avoid removing too much material
- on an A Class plug, take care when approaching the design shape near the QBL points – the final surface should be exactly on the ends of the wire
- a convex spokeshave or plane can be a useful tool if there are any concave areas
- attend to the deck area as appropriate – if a flange is to be provided on the hull mouldings you will need to finish a wide enough strip around the deck edge – pay attention to the fairness of the sheerline – pay attention to the deck edge radius too – both the A Class and 6 Metre class rules penalise large radius deck edges
- continue until the indents left between each layer nearly disappear
- on a 6 Metre plug this is the stage where 1.5 mm diameter wires can be inserted at the design measurement points to permanently mark the intended points – the height above/below the waterline and/or offset from the centreline of the wire end will require careful positioning but, once done correctly, will avoid having to be repeated

### 5.12 Test measure the hull

- this is the stage when any checks on the overall size and shape of the hull should be made
- trial measurement can be taken to see that the hull will rate as it should or meet the class rules, as appropriate
- rectify any deficiencies

### 5.13 Finish halves

- make 60 grade fairing strips – these should be able to bend lengthwise easily to the typical radius of the hull surface at a 45 degree angle to lengthwise but will retain a fair shape – their thickness allows a good grip

- use the fairing strips to finish the shape of the plugs working along the hull and diagonally across the hull to ensure fairness in all directions
- ensure you use a good quality mask so that fine particles are not inhaled – clean the work area with a vacuum cleaner with a fine dust filter fitted – work outdoors if possible
- most of the time work will be carried out on one half at a time – final shaping needs to be done with both halves held together so that a truly symmetrical centreline can be achieved
- check the fairness of the surface with a 600 mm steel rule – it should be possible to hold the rule with its surface at about 60 degrees to the hull surface and bend it around the hull surface with its edge in contact everywhere
- areas of unfairness are removed by abrading the high points and, if necessary, filling the low points with filler- then move on to 100 grade fairing strips and repeat fairing process – continue checking fairness
- move on to 200 grade fairing strips for finishing this stage

#### 5.14 Surface finish halves

- clean the two halves of dust - use solvent to remove any grease – apply one only coat of epoxy resin to the matching centreline surfaces in order to protect them during the next stages – apply one coat of an ultra-thin epoxy resin (one designed for wood saturation) that will soak into the surface well – then coat with hi build following instructions concerning thinning as necessary – the hi build should be applied before the resin has fully cured – apply several coats of hi build to the hull surface with alternative coats pigmented to different colours – coat the deck area that will form the flange at the same time
- use 200 and then 400 grade fairing strips wet to achieve a fair surface – as before, work the strip along the surface and diagonally across the surface to ensure fairness in all directions – replace the grit paper frequently
- the different colour layers indicate how much material is being removed from the surface, will help avoid rubbing through to the mdf and will guide you in the fairing process

#### 5.15 Make fence

- use a single sheet of 6 or 9 mm mdf to make a fence around one half of the plug – place the plug on the mdf and draw around it - draw another line 50 mm from the plug edge – cut to this line and smooth the edges
- drill the fence in what will become the flange surrounding the plug half at 300 mm intervals for locating studs that will be added to the flange before the mould half is laminated
- wax the flange surface that will have resin applied to it and extend the waxed area at least 25 mm in from the edge of the plug so that resin does not travel between the fence and the plug and bond the two together – wax the centreline surface of the plug too

#### 5.16 Add fence to one half

- fix the fence to the plug at regular intervals with small diameter screws placed about 10 mm from the surface of the plug – this is far enough for the surface of the plug not to be distorted

#### 5.17 Wax

- mask off any areas of the plug that will not be used to make the mould – use thick paper and masking tape for this – this includes the deck area inboard of any flange and possibly the bow and stern transoms
- remove the locating studs and apply several coats of wax to all the remaining surfaces of the plug and the flange
- apply pva release agent too if preferred
- replace the locating studs

#### 5.18 Make the first half of the mould

- no attempt is made to describe the moulding process here – it is covered in more detail in the **SAILSetc mould and hull making notes** - but one important difference compared to moulding a hull is that it is wise to use two gel coats each pigmented to a different colour and with both these colours chosen to be different to any hulls that are planned
- the 2nd contrasting gel coat colour serves as a warning that the surface is being abraded too far during finishing and polishing of the moulds

#### 5.19 Remove fence

- when the first half of the mould has been cured, the fence can be removed
- clean the surface of the moulded fence taking care not to release the mould from the plug

#### 5.20 Assemble other half of mould

- wax the centreline surface of the 2nd half of the plug and assemble it firmly to the first half using the studding/bolts

#### 5.21 Wax

- apply several coats of wax to all the remaining surfaces of the plug and the flange
- apply pva release agent too if preferred
- add the matching parts of the locating studs

#### 5.22 Make the second half of the mould

- as for first half

#### 5.23 Drill for fixing bolts

- when the 2nd half of the mould has cured, the rough edges of the flange should be trimmed with a Carborundum coated blade, low speed jigsaw or a hacksaw blade held in a tool holder – ensure you wear a mask – smooth the flange edges with 200 grade grit
- holes in the flange can be drilled at 300 mm intervals for the 6 mm bolts that will hold the two halves together



#### 5.24 De mould

- carefully de-mould the moulds from the plugs

#### 5.25 Smooth moulds

- Sharp edges within the working surface area of the mould should be kept sharp
- start with nothing coarser than the grade used to finish the plug surface
- Only go onto the next grade abrasive paper when the surface is evenly abraded with no relatively large marks
- Follow with 800 grade, 1000 grade, 1200 grade and 1500 grade papers
- Abrade along the mould or in circular movements
- Do not abrade in a direction across the mould
- Always use the abrasive paper with water
- Initially place the abrasive paper on suitable long flexible pieces of hard plastic (200 x 25 mm) or medium PVC foam depending on the area you are working on
- On the flatter areas use small plastic blocks e.g. 50 mm x 20 mm so that the sharp edges do not cut into the curved surface of the mould
- PVC or similar foam blocks can be slightly larger e.g. 75 mm x 30 mm and should be used on areas of greater curvature
- Avoid abrading through the 2nd gel coat into the reinforcement in those areas which will be visible parts of the hull when finished

#### 5.26 Polish

- use abrasive polishes, finishing with fine metal polish
- if using mechanical means to polish the moulds beware of building up heat in the surface of the mould as this may damage the surface finish you have already achieved
- wash with warm, soapy, water

#### 5.27 Repairs

- where any air bubbles in the gel coat have been exposed, or where damage or scratches have occurred, use pigmented epoxy gel coat to fill them slightly proud of the surrounding surface
- ensure good adhesion by grinding out the area to be filled first
- when the resin is cured, protect the surrounding area with thin adhesive tape
- use 800 grade abrasive paper followed by finer grades to restore the finish.

#### 5.28 Wax outside moulds

- apply wax to the outside of the moulds to avoid anything sticking to them

#### 5.29 Wax inside moulds

- apply wax to the working surfaces of the mould and polish

#### 5.30 Laminate hull

- mould the hull – again no attempt is made to describe this process here – see **SAILSetc mould and hull making notes** describing this process in more detail

end

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