

Preparing to use the Vacuum-forming Kit

Kit, instructions and manual prepared by Tony Mander

Most of the material below has been reprinted from the Manual included with the Boat Vacuum-forming Kit.

This is being sent to you with the confirmation of your booking. There is much that can be done in advance of the Kit arriving, and these notes are to help you to ensure that your class have their boat hull formers ready for the Vacuum-forming Kit.

1 What the Kit supports

The Vacuum-forming Kit contains most of the special equipment and materials required to assist students with the Racing Yacht Challenge (page 4.41, notes pages 5.37–39, *The BP Technology Challenge File*, 3rd edition). It will enable them to mould a hull from styrene sheet using the hull formers they will have designed and made. After being used more widely, the vacuum former has been improved from the plan included in the *File* and most of the problems of using it identified and solutions suggested below. The size of the vacuum box provided tries to meet the conflicting needs of being easily formed (the technique used is best for small items), having a reasonably large yacht hull, and keeping the cost of materials as low as possible.

Hull formers and consumable materials are **not** included in the Kit.

This Kit also shows that vacuum-forming does not necessarily require expensive equipment when educational outcomes are the main purpose. In using this vacuum-former students will find the elements needing to be controlled for good moulding (and very good hulls can be produced when everything is properly done), *viz.* heating the plastic sheet to the required level of plasticity, having sufficient vacuum for adequate (atmospheric) pressure difference, the need for good task organisation and speed of action (as plasticity is lost if the plastic cools too much), and the need to identify and control all elements of the process if consistency of moulding is to be achieved.

2 Choose your levels for using this Kit

It is aimed primarily at Forms 1–4 (years 7–10); if you hope to use it with year 6 classes one of the limiting factors will be their ability to make the hull former. Ideally, it follows technology and science topics in previous years which have given students an understanding of:

- why things float
- how wind can be harnessed to provide a push (they should previously have made simple boats from walnut shells, polystyrene blocks, etc., and fitted with simple sails)
- how various shapes of boats suit particular purposes (e.g. a long thin rowing shell has low drag but is unsuitable for load carrying or rough water; high-speed motor racing boats are designed to skim the surface for least drag; cargo ships need to displace a large volume of water and to also survive rough seas; differences between canoes for particular purposes and why a canoeist is sealed in, etc.).

3 Consider a 'racing yachts' unit

Making hulls from vacuum-formed styrene can produce very professionally looking hulls, and because it takes several hours work spread over several days, it is worth incorporating this Challenge into a technology unit arising from other units of study in various curriculum areas. (These notes supplement those on pages 5.37–39, *The BP Technology Challenge File*, 3rd edition.)

Some theme suggestions for entry points to this Challenge:

- Yacht racing: (*check details on the various Web sites*)
 - 'Americas Cup' racing. What the specifications are, its history, how the yachts are constructed (hull, masts, sails, etc.), why it attracts so much attention in New Zealand, industries which have developed to support it, etc.
 - 'Whitbread round the world' race: What is involved, the route, how they navigate, how food requirements are calculated, safety equipment, how the yachts are constructed (hull, masts, sails, etc.), what crew members do, how progress

is calculated, where their weather information is from and how their forecasters obtain it, etc.

- Local yacht racing: classes of yachts, their specifications, performance tables in relation to hull size and sail area, etc.
- Exploring the world: how wind power was used by explorers from many nations over hundreds of years; development of navigation systems, maps, materials used then and now, how food was preserved then and now, etc.
- Weather: the changes in wind patterns which can be expected in changes of latitude, how poems such as Coleridge's 'The rhyme of the ancient mariner' recorded the 'roaring forties' and the 'doldrums' encountered by mariners (which could only be explained once we had developed a view of the world as a rotating sphere), how wind affects the sea surface (waves), etc.
- Making items from plastic: how plastic materials are produced, types of plastic, methods of forming, etc. Note that this vacuum former can be used for many items, from desk tidies to chocolate moulds. If you intend to make chocolate moulds use food grade 0.5mm Vivak®, a glycol modified polyethylene terephthalate, rather than styrene. A sheet of stainless steel is included to reduce the moulding area so smaller pieces of Vivak® can be used (it's more expensive than styrene).
- An element of the school's "Boat Day", perhaps to complement junior class activities.
- etc. ...

4 Plan your programme

The stages in making the yachts

Each of these stages would probably be carried out on successive days, each step taking around 1.5–2 hours. Decide when you wish to start vacuum-forming (i.e. how soon after the Kit arrives) and plan the pre-Kit sequence.

Needing to be done before the Kit arrives (i.e. at least 3 days in advance):

- 1 If not using the hull outlines provided (Appendix 1 of these notes): Investigate hull shapes and draw a final outline (not more than 21 cm long nor wider than 7 cm, so the resulting former will fit the vacuum box; maximum of 4 cm deep). Measure the thickness of corrugated card being used and calculate the number of layers required (details below). Draw the number of layers within the outline.
- 2 Cut out the outlines, glue together. When they have dried (probably needing at least 20 minutes depending on the glue) put the first layer of filler on it, leave overnight (*details next page*).
- 3 Smooth the first filler layer, add more filler, leave overnight.
- 4 Smooth the former to the final shape.

When the Kit arrives:

- 5 Begin moulding the hulls, using the formers. Note that the formers need to be completely dry before vacuum forming. Cut and fit the keel, rudder, mast, sail, etc.

The Kit is not needed for this stage:

(but you might like to allow time to redesign hulls and to make new hulls...)

- 6 Test and race the yachts. Testing could take considerable time and a log book needs to be kept of the changes made and why.

5 Collect the items you will need which are not supplied in the Kit

Materials for making boat hull formers:

- corrugated card
- Polyfilla®, plaster of Paris, or similar rigid filler (but not flexible fillers)
- PVA (or similar) glue
- sandpaper

Basic hand-tools:

- scissors and/or trimming knives (and desk protectors or cutting boards if knives are used)
- small spatulas for applying filler (old dining knives or ice-block sticks work well)
- coarse files for smoothing the filler on the hull formers

Other equipment:

- a vacuum cleaner (if hose end is greater than 32 mm, will need a tapered end fitting)
- extension cord of suitable capacity, if required (the Vacuum-forming Kit needs the heat gun and vacuum cleaner close to each other and to be either switched on together or, if your classroom circuit can't handle the 2kw heat gun and vacuum cleaner together, for the cleaner to be switched on as the heat gun is switched off).
- safety glasses (recommended)

Rigging materials:

- drinking straws for masts, booms
- plastic sheet, Tyvek®, etc. for sails
- thread to attach the lower corner of the mainsail to the hull to adjust the sail angle
- Plasticine or similar waterproof modelling clay (with wire, nails, or lead shot to embed in it) to weight the keels

Facilities:

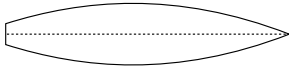
- paddling pool or swimming pool, preferably sited so wind over the surface is not turbulent (if you intend to use a paddling pool inside and to use a fan to generate a wind, you will need to devise something to straighten the rotating airflow from the fan)
- testing tank, e.g. guttering (optional)

6 Details of making the hull formers

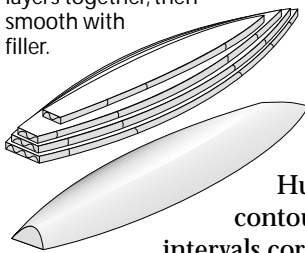
This step does not require the Kit.

This explanation is restricted to describing in more detail the method shown on page 5.38 of the *The BP Technology Challenge File, 3rd edition*. You may wish your students to devise other methods.

This method involves cutting a series of layers from corrugated card where the layer outlines have been traced from folded paper outlines, making it reasonably easy to make hulls which are bilaterally symmetrical (each side a mirror image of the other).



Cut a pattern from a folded piece of paper. Use it to mark the card. Cut the card. Trim the paper pattern, mark another piece of card, etc. Glue the card layers together, then smooth with filler.



Hull layer outline masters (with instructions) are provided on page 5.

Copy as many as required. There is no particular significance in their shapes, being provided only as a starting point. Your students should research full-size yacht hull shapes and model yacht hull shapes.

Hull layer outlines are merely contour lines at regular vertical intervals corresponding to the thickness

of the cardboard. Corrugated card is used as its thickness reduces the number of layers required, it is easy to obtain (from old cartons), is relatively easy to cut and is light and strong. It doesn't matter if scissors are used as the edges don't need to be cut cleanly, the filler will cover them. (Max. 21 cm long, 7 cm wide.)

The thickness of the corrugated card to be used needs to be measured so that the depth of the hull can be calculated. Hulls of greater depth than 4 cm will be difficult to mould; that depth includes about 3 mm allowance for the thickness of filler.

Before divulging this method, your students may like to attempt to devise other methods, trying to meet the criteria of using the least amounts of the most expensive material (the filler) and making as much as possible from the cheapest material (the corrugated card), of making a former which is bilaterally symmetrical, making it strong enough to withstand the crushing pressures of the moulding process, able to withstand the hot plastic and to not adhere to the hot plastic. This method is similar to one used in industrial design, but do not tell your students about it immediately. Discuss the *pros* and *cons* of various methods of making formers, applying such criteria as cost and difficulty when selecting a method (e.g. dough is cheap but difficult to make it into a bilaterally symmetrical former). You do not want to foster the idea that there is only one correct solution, but rather **several** solutions depending on the criteria.

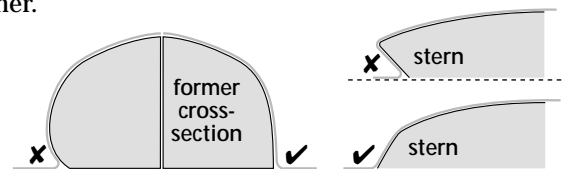
The steps are:

- 1 Cut outlines from corrugated card, having every third layer with the corrugations at right angles to the orientation of the other layers (which should run lengthwise) to provide additional strength.

- 2 Glue the outlines together, taking care to keep them centred. When the glue has dried, push down the edges of the card so there are no cardboard ridges to protrude through the filler.

The hull needs to have its 'deck' as the largest part of it, otherwise when moulded the plastic would trap the former, making it impossible to remove.

- 3 Smear filler over the card, pushing it into the corrugations. Try to make it smooth, although it's not the final layer. It doesn't matter at this stage if some card edges protrude. It is better if the filler mix is thin (runny) rather than firm so it flows better into crevices. Leave it to dry overnight.
- 4 File or sand off the worst of the bumps in the filler. Add the final layer of filler, making it as smooth as possible. Avoid a thin (runny) filler mixture (use less water so it is firm) and use a wet blade to make the filler as smooth as possible. Leave overnight. Ensure that the hull former is shaped so that there are no parts of it which become smaller at the deck-line, otherwise it will be impossible to remove the former.



No part of the former at the deck-line is to be smaller than the largest part of the hull

- 5 Sand the former as smooth as possible. (If it is going to be kept and used many times it will benefit from a protective layer made of tissue glued on with a PVA, water and filler mixture, sanded smooth after drying.) A microwave oven is effective in speeding up the drying provided it is used only in short bursts and that the former becomes only warm, not hot. Too much 'cooking' (especially when wet) will distort a hull former made this way and can ruin it. The former must be dry before moulding.

7 Store the formers until the Kit arrives

The Kit should be available at the time you booked it (provided of course that the previous school returned it promptly, complete, and in good condition).

8 Consider other topics

Other shapes: Plastic moulding is a useful technique for many items. You may for example wish to mould covers for electronic items your class have made (or may be about to make), or 'desk tidies', model car bodies, model aircraft canopies, or similar. The formers will need to be prepared in advance and the plastic sheet purchased (e.g. Vivak®, available from your nearest plastic sheet supplier). If you have plenty of time, formers can be made from clay or even baked dough. You could make a smaller vacuum box (see the original size, page 5.39, *The BP Technology Challenge File*).

Chocolate moulding:

You may also wish to mould chocolate, if so you will need to make simple 'chocolate melters'. A suggested design is to use 500g round containers for the chocolate (Payless Plastic: 500g pot & lid, item 101677, or similar) suspended in hot water in 2L plastic ice-cream containers (the chocolate container is held through a hole in the lid). An insulating base is needed from closed-cell foam or 'corrugated plastic' (Corflute). Three containers allow the use of three colours of chocolate (white, milk, dark).

Use chocolate 'melts' for the chocolate.

You will need to prepare clean areas for this and to purchase the chocolate, plastic and perhaps latex gloves for hygiene. Access to a refrigerator is useful.

Use 0.5 mm Vivak® plastic sheet, it is transparent (and easier to see whether the chocolate fills the mould) and is easier to form.

Happy moulding!

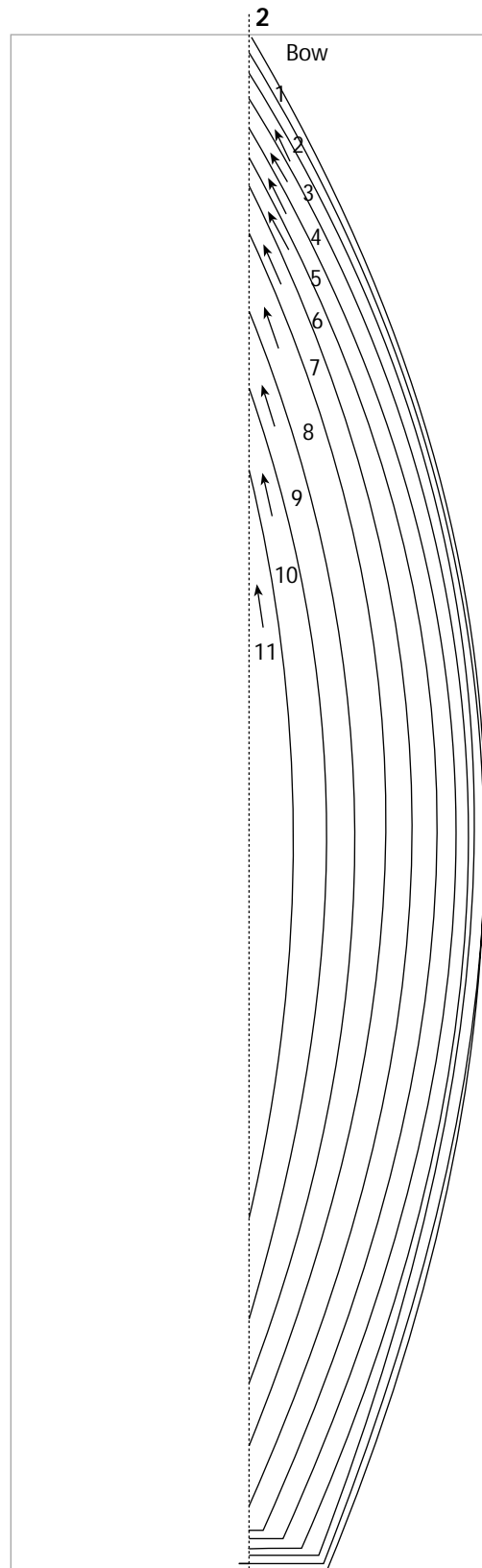
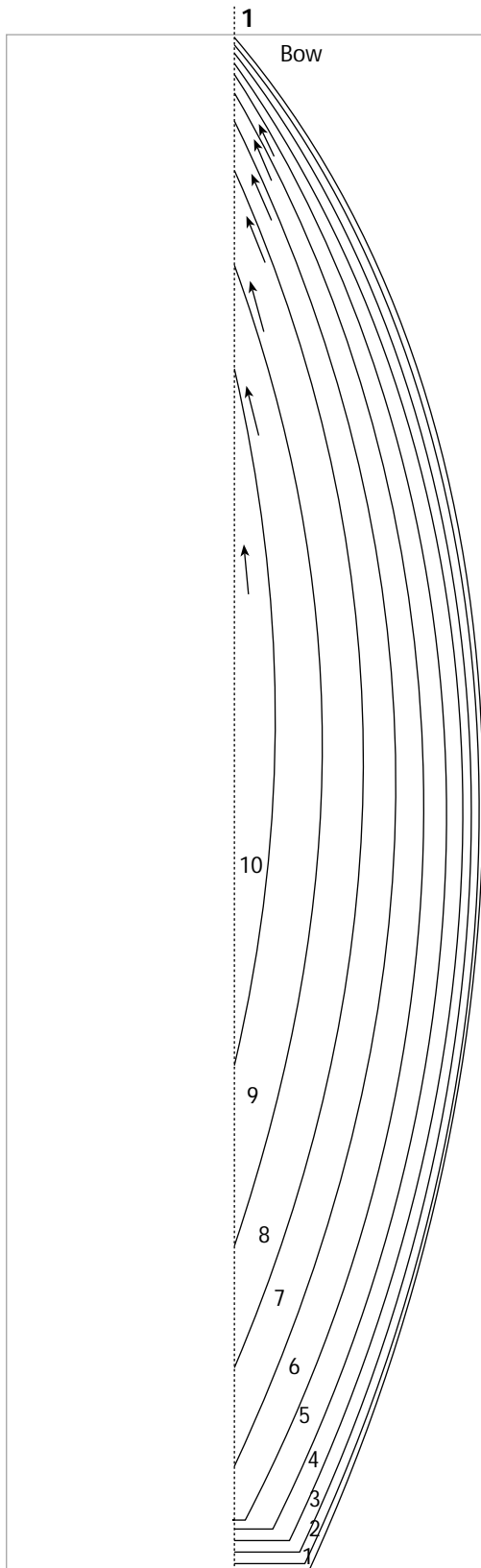
Important

Read the Manual enclosed with the Kit on how to use the Vacuum-forming Kit when it arrives. Do not use it unless you have read the Manual and are thoroughly familiar with the operation of the Kit.

Boat hull Vacuum-forming Kit contents

- The Kit container, with:
- 1 vacuum box
- 2 clamping frames, each frame (which is in two parts) clamped with six 5 mm wing-nuts
- 1 heat gun (electric paint stripper)
- 2 hot-glue guns (1 standard, one mini)
- 2 glue gun stands
- 1 desk protector sheet
- 1 multi-plug powerboard (Note: 10 amp load maximum)
- 1 pair leather gloves
- 2 sharpened dowels
- Kit Manual for teachers which also contains the inventory list, hull former layer outline masters and introductory notes on plastics.
- The inventory sheet
- Consumables pack/s will be included, depending on what you ordered.

Racing Yacht: hull outlines



Making the former

Use one of the two outlines of the hulls above for laminating with (approx.) 2.5 mm corrugated cardboard (use every second shape with thicker card). Cut out a rectangle with the shapes, fold in half along the dotted line, cut around the outside line, unfold. Use a fine felt-tip pen to trace around the shape on to one layer of card. Fold this paper again, trim around the next line, unfold, place on card and trace. Number each piece of card and especially mark the bow end of each piece. Continue folding, cutting, unfolding,

tracing. Cut out each layer of card and glue together in a stack; press down the edges of the card when the glue is dry. Spread a filler (such as Polyfilla®, plaster of Paris, etc.) over the outside, pushing it into the spaces in the card. Sand smooth when dry, repeat the filler layer if necessary. If it will be used many times, mix a slurry of filler, water and PVA glue and use it to attach a layer of tissue over the former. Sand smooth when dry; the glue and tissue will give a tough smooth surface able to withstand many vacuum forming operations.



The BP Technology Challenge

Yacht Hull Vacuum-forming Kit

Pre-hire Notes

Supporting

The BP Technology Challenge File
(3rd Edition)

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*Enquiries should be addressed first to the organisation from
which you are hiring the Kit, otherwise to:*

*The BP Technology Challenge
c/o The Royal Society of New Zealand
P O Box 598
Wellington*

Enclosed is an original copy of the 'Pre-hire Notes'. Use it to make copies to send to schools booking the Kit. Sending schools the 'Pre-hire Notes' in advance will enable them to make more efficient use of the Kit.

Also enclosed is an original of the Inventory Sheet. Photocopy it on one side of yellow or buff paper first, then print again on the second side and cut the page in half.

A new Inventory Sheet must be included with the Kit each time it is used.