

17.1. TOOLS REQUIRED (OVEN DETAILS)

An oven or platten heater is essential to conduct thermoforming.

The specification for a good thermoforming oven is fairly simple:

- It has to be designed so that the entire sheet is heated to the same temperature at the same time;
- The oven must be able to fully enclose the worktop piece to be heated;
- It needs to be equipped with a temperature control.

It is quite possible to use small domestic ovens for doing small parts such as corners and downturns.

To check the oven temperature, an infra red temperature measuring gun can be used.

Helpful Hints:

Do not use a heating process that does not provide constant heat to the whole of the work piece, such as a post former.

17.2. OVEN PREPARATION

Correct oven preparation and calibration is a crucial step in thermoforming.

DuPont™ Corian® should be heated to between 160°C and 165°C prior to bending for the majority of DuPont™ Corian® colours. If the thermoforming temperature is too low, it may be too stiff to form and may degrade the product. High temperatures, in excess of 190°C, may blister or discolour DuPont™ Corian® to an unacceptable level.

Heat-up times will vary depending on oven design and the size of the piece to be formed.

Note: The Illumination translucent DuPont™ Corian® colours require lower thermoforming temperatures due to its unique characteristics. These colours perform best at 145°C to 150°C. This temperature will minimise any discolourisation.

Refer to the table below as a guide to heating times in an oven:

SHEET THICKNESS	OVEN TEMPERATURE	HEAT-UP TIME*
6 mm	160°C – 165°C	15-30 min
12 mm	160°C – 165°C	25-45 min
19 mm	160°C – 165°C	35-50 min

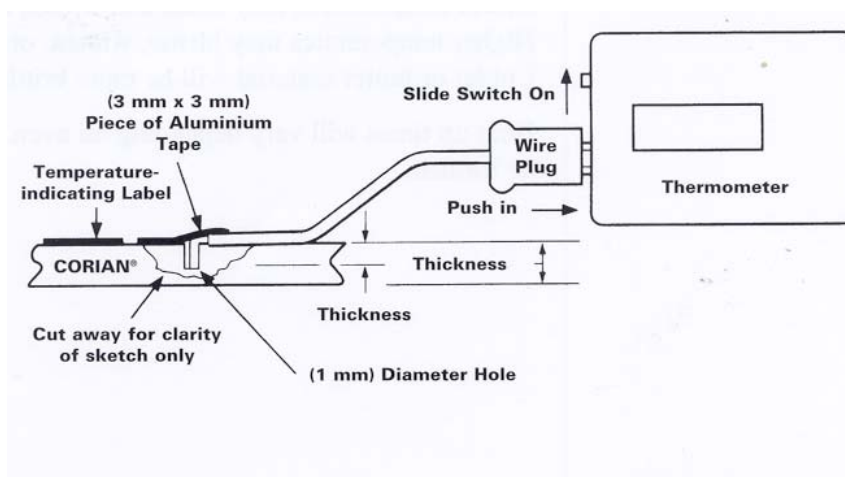
* Approximate time depending on heating equipment

Note: Oven temperatures exceeding more than 175°C may overheat the surface of the sheet before the inside of the sheet reaches thermoforming temperature. Do not exceed this temperature.

Before thermoforming commences, a test must be run to calibrate your oven to find the best time/temperature for thermoforming.

STEPS TO COMPLETION WITH OVEN

1. Drill a 1 mm diameter hole halfway into a test piece of DuPont™ Corian®.
2. Insert the thermocouple wire in the hole, bend it to fit and tape it in place.
3. Insert the wire plug into the thermometer. Turn on the thermometer, the meter temperature should now show the temperature of the sample.



4. Apply a temperature-indicating label near the end of the wire.
5. Turn the oven on and allow pre-heating to 165°C for 30 minutes.
6. Put the test sample in the oven and start the timer.
7. When the temperature on the thermometer reaches $\pm 160^\circ\text{C}$, write down the timer reading and remove the piece from the oven.
8. Inspect the temperature-indicating label and note which dots turned black. If the strip blackened above 160°C, your oven is too hot.
9. Apply a new temperature-indicating label and re-run the test with a reduced oven temperature until the strip doesn't blacken above the 160°C dot.

10. When $\pm 160^{\circ}\text{C}$ is reached on the thermometer without exceeding 160°C on the temperature-indicating label, record the heating time. This will be the most effective time/temperature for your oven.
11. Remove the piece from the oven and allow the piece to cool until the thermometer reads below 82°C .
Note the timer reading. This is how long each piece should be cooled in the mould. This allows for proper cooling, even in a warm mould.

17.3. PLATTEN HEATER

Platten heaters are faster and offer more accurate temperature control than radiant oven temperatures. To heat DuPont™ Corian® the platten heater will reduce the exposure time by 60% and offer a more consistent temperature control.

For further details regarding platten heaters, please go to www.elkom.de.



17.4. MATERIAL PREPARATION

Proper material preparation is essential for successful thermoforming. An essential part of successful thermoforming is the radius of the bend.

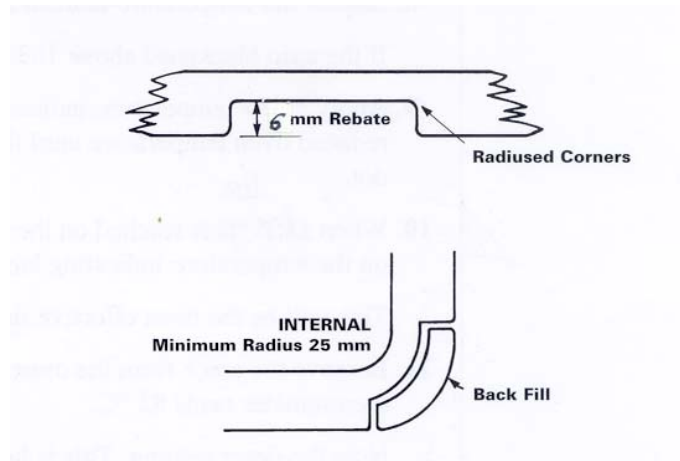
Refer to the table below as a guide to the minimum inside radius permitted when thermoforming standard DuPont™ Corian® thickness sheet material:

SHEET THICKNESS	MINIMUM INSIDE RADIUS
6 mm	25 mm
12 mm	50 mm
19 mm	127 mm

However, using the radius rebate technique, we can reduce the radius below these recommended guidelines.

The technique requires a rebate to be placed into the underside of the sheet adjacent to where the radius will be formed. This reduces the thickness of the sheet and thus allows a smaller radius to be formed.

Using 12 mm DuPont™ Corian® as an example, a rebate is placed in the back of the sheet 6 mm deep and extending along the full depth of the curve.



This reduces the thickness of the sheet in the internal radius section from 12 mm to 6 mm, and the radius can be reduced from 75 mm to 35 mm.

STEPS TO COMPLETION

Standard material preparation:

1. Cut all pieces to their required dimensions;
2. Remove any chips and scratches from edges.

Rebated radius technique:

1. Cut all pieces to their required dimensions;
2. Carefully calculate the area of each piece that requires the radius rebate technique and measure and mark the rebate on the sheet;

Calculate the length of the curve by calculating the circumference of the 90 degree curve: $(2 \times 3.14 \times \text{radius}) \div 4$.

3. Using a router and rounded trenching bit, remove the rebate section;
4. Sand all material to a smooth finish;
5. Remove any chips and scratches from edges;
6. Thermoform sheet as per instructions.

Helpful Hints:

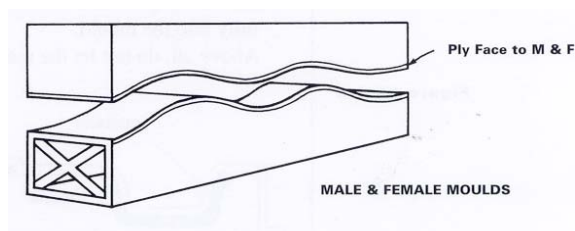
Be especially careful to ensure that all pieces are finished perfectly, free of any chips, deep scratches or any other imperfections.

17.5. MOULD PREPARATION

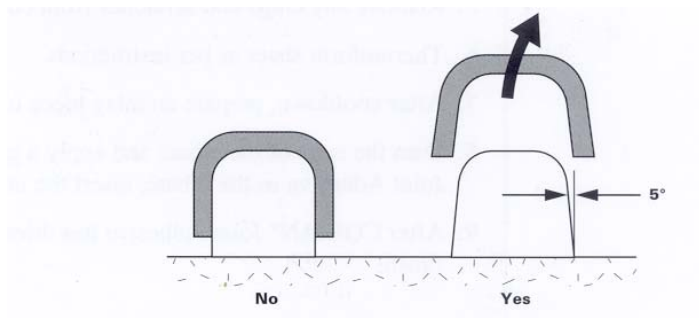
Design Considerations:

1. A recommended mould material is medium density fibreboard (M.D.F.)
 - low cost
 - isotropic
2. Male versus female mould

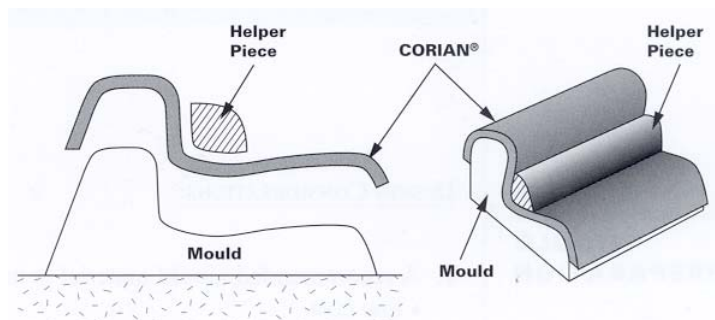
To reduce the risk of wrinkling when moulding deep shapes, a male mould is preferable to a female mould.



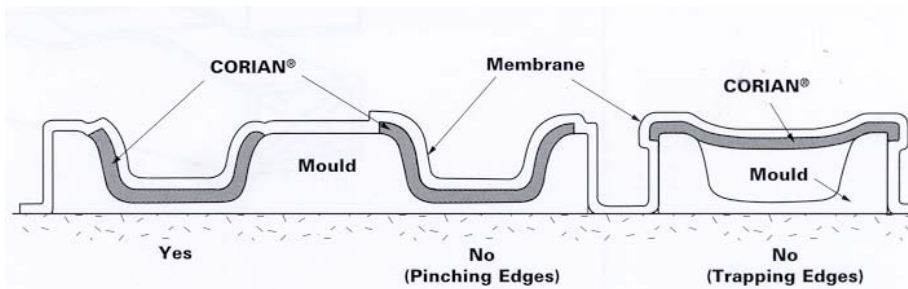
3. A deep and/or steep piece formed over a male mould will shrink around the mould as it cools, and may stick to the mould. Incorporate a 5 degree (minimum) release angle into the mould.



4. Use helper pieces in addition to the mould itself, to
 - do some initial shaping before vacuum membrane is activated
 - work with the vacuum membrane to help forming in difficult spots



5. An option is to use a male mould in combination with a female mould:
 - advantage : positive control over material in mould
 - disadvantage : more difficult to design initially and to change shape afterwards
6. When using a female mould, bevel the cavity edges to prevent the material from being trapped between the forming membrane and the edge of the cavity. Make sure nothing inhibits smooth motion of the material as the membrane presses it into the cavity. This will allow the material to move fully into the mould. Above all, do not let the material get caught over a sharp edge.



7. Coloured grades of DuPont™ Corian® turn white when stretched too far or too fast. If whitening is a problem, your options are to:
 - reduce curvature (increase radius) of the shape
 - slow the forming rate
 - use thinner material
8. Wrinkling most often occurs when material is compressed more than 10 %. Reduce wrinkling by adjusting mould design and perform shape. Under no circumstances should material undergo more than ± 25 % strain. Examine the formed piece to see what material will be cut away for the ultimate use, and cut away that material before you form the piece.
9. Making compound curves is the most difficult part of thermoforming. It helps if the design shape is symmetrical. Remember, maximum allowable stretch or compression is 25% (maximum stretch is reduced to 10 - 15% if whitening needs to be avoided).

STEPS FOR COMPLETION

1. Using a jig saw or router, cut the male and female shape in a good quality plywood or M.D.F. board. A good quality mould is essential as any defect within the mould will be transferred into the face of DuPont™ Corian® to be thermoformed.
2. Be sure that the internal supports of the male and female parts are close enough so that the mould is rigid when pressure is applied.

3. Face the male and female parts with 3 mm plywood or M.D.F. board, ensuring a perfectly smooth face.
4. Ensure that the male and female parts fit together neatly allowing a gap sufficient for the thickness of DuPont™ Corian® that is to be thermoformed.

17.6. THERMOFORMING WITH STANDARD OVEN AND CLAMPING SYSTEM

STEPS TO COMPLETION

1. Calibrate the oven with a sample piece, as per instructions in Section 17.2.
2. When you are confident of the scale of time/temperature, pre-heat the oven to the desired temperature.
3. Place the piece(s) of DuPont™ Corian® in the oven and start the timer.
4. At the expiration of the specified calibrated time, remove the piece(s) from the oven using hand and arm protective gloves.
5. Place the piece(s) in the mould(s) and clamp securely.
6. Reset the timer and wait until the calibrated cool-down time is expired.
7. Remove the piece(s) from the mould(s) with hand and arm protective gloves, allow cooling to room temperature then fabricating as required.

Helpful Hints:

Heat the entire piece. Spot heating may cause problems; therefore it is important to heat the sheet uniformly.

Never attempt to thermoform a piece of DuPont™ Corian® that has a seam in it. If using a veneer or platten press, place the DuPont™ Corian® into the heating equipment with a setting of 160°C to 165°C.

If using a veneer press, set the pressure at 0° and lower the plates onto the DuPont™ Corian®.

Because the heat to the DuPont™ Corian® is directly onto the surface of the sheet, the exposure time in the press will be reduced greatly to that of an oven.

DuPont recommends you use trial pieces of DuPont™ Corian® to determine exposure time.

17.7. THERMOFORMING WITH HEATED PLATENS AND VACUUM MEMBRANE PRESS

These guidelines are based on experience in thermoforming sheets of DuPont™ Corian®, 6 to 12 mm thick.

Tools required:

1. Clamps, etc. for two-part mould
2. "Laser sight" or equivalent infrared temperature measurement device for checking material temperature (indirectly, by measuring surface temperature of membrane)
3. Template material (can be cardboard for research & development works, but should be masonite etc. in production)
4. Forming equipment:
 - www.elkom.de
 - Moulds (male, female or both) of medium density fibreboard (M.D.F.) or wood.
 - Hot-air oven as alternative to heated platen press
 - Low pressure press or hand clamps as alternative to vacuum membrane press

STEPS TO COMPLETION

1. Forming Process

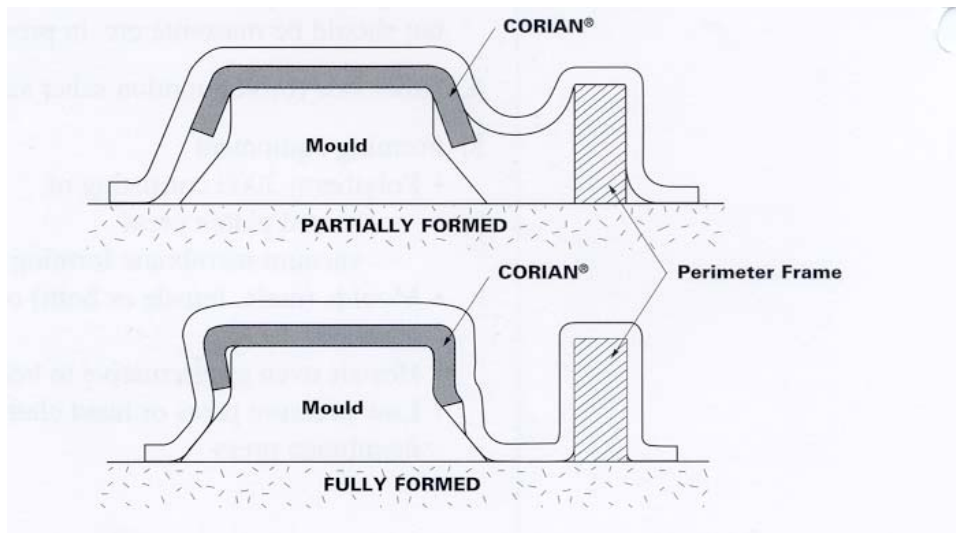
- a. **Pre-heat temperature** of material to be formed: 160°C to 175°C
- b. **Heat-up time:**
 - **in heated platen press:** approx. 1 minute per mm
(E.g. 6 minutes for a piece of DuPont™ Corian® of 6 mm thickness)
 - **in hot-air oven: much longer**
(E.g. 6 mm thick piece requires 25 minutes approx.)
- c. **Mould temperature:** starting from initial room temperature and going up to 50°C after several pieces have been formed.

Note: The first piece of the day will cool and set more quickly than subsequent pieces. Wrinkling is easier to correct with a warmed-up mould.

- d. **Forming pressure:** ambient to 1 atm (max. with vacuum membrane)

2. Forming aids

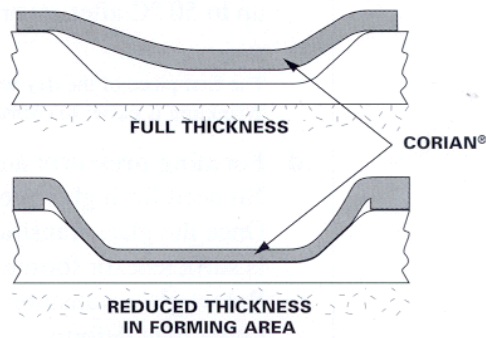
- a. To allow DuPont™ Corian® to slide into a female mould cavity, lubricate the surface with a light layer of talc (no lumps). This also helps the piece release from a male mould.
- b. Insulated gloves must be used.
- c. Auxiliary forming pieces (example dowels) to concentrate membrane force. Placing the piece prior to deploying the membrane will "pre-tuck" the sheet into the mould.
- d. Perimeter frame is a technique to relieve forces on the edges of the formed material. Properly placed perimeter frame will cause the membrane to droop catenary-style over the material rather than "break" over its edges.



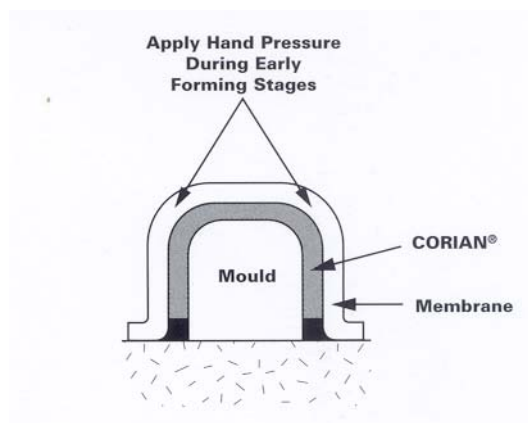
3. Forming Techniques

- a. Drawing/stretching rate will influence whitening tendency - slower is better.
- b. Keep material constrained until it cools below 82°C, measured at membrane surface, then release it to reduce stress.
- c. The thinner the material, the smaller radius to which it can be bent and avoid whitening.
- d. Generally, thinner material thermoforms better than thick.

If a thick piece is required, try reducing its thickness by machining in critical areas to improve thermoforming performance (e.g. change tray).



- e. To avoid wrinkling: constrain material first where it is most likely to wrinkle. The usual method is to apply hand pressure on the forming membrane at the spot in question. This approach works best with a warm mould (warning: wear insulated gloves).
- f. For best results, the piece should be cut as nearly as possible to its final outline before it is shaped. Determining ideal pre-form shape is a trial-and-error process: make templates (or save the cut-out holes in parent material) and number your trials, both the template or the cut-out and the formed piece, so you learn what works.



Index of problems and solutions:

SOLUTION SECTION		PROBLEMS				
		Wrinkling	Whitening	Failure to release	Not Conforming to mould shape	Safety
Mould Design	17.4.	2,8	7	3		
Process	17.6.		-	-	-	a, b, c, d
Aids	17.6.	-	-	a	a, c, d	b
Technique	17.6.	e	a, c	-	b, d, f	-

Note: DuPont products warranty is limited to the products made by DuPont (i.e. its range of sheets, shapes and accessories). The installed warranty is limited to installations made in accordance with the technical stipulations mentioned in the technical literature.
DuPont warranties DuPont™ Corian® sheet performance in sheet-like applications.

17.8. 3-DIMENSIONAL THERMOFORMING

3-Dimensional Thermoforming

Due to the thermoplastic nature of DuPont™ Corian®, it is possible to create many wonderful objects which will push the design limits to new heights. Thermoforming DuPont™ Corian® into 3-dimensional shapes is one of the best and quickest ways to add value and increase profitability. Making single or one piece vanity bowls in the bathroom segment gives the added benefit of using all the Colour range available in our DuPont™ Corian® palette.

Examples of 3D-Thermoforming:

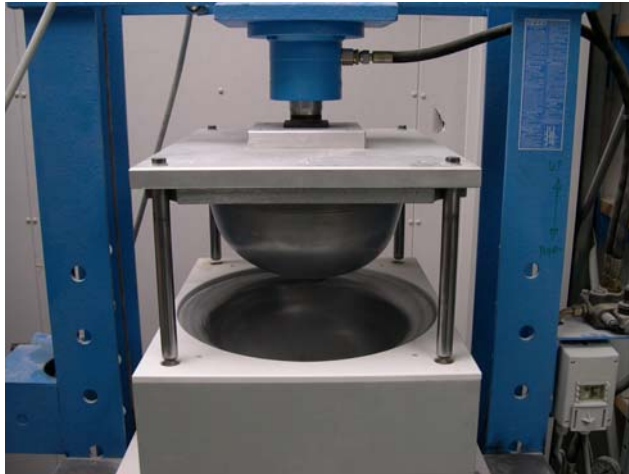


In the segment we will explain the two most common techniques when making three dimensional designs. We will explain the use of a two part moulds and hydraulic press plus how to create pressure via a vacuum table.

Hydraulic press

When using a hydraulic press the ram which exerts down force will provide the pressure needed to bring the two part mould together. The hydraulic press is measured in tonnage capability normally starting at 10 tonne and upwards.

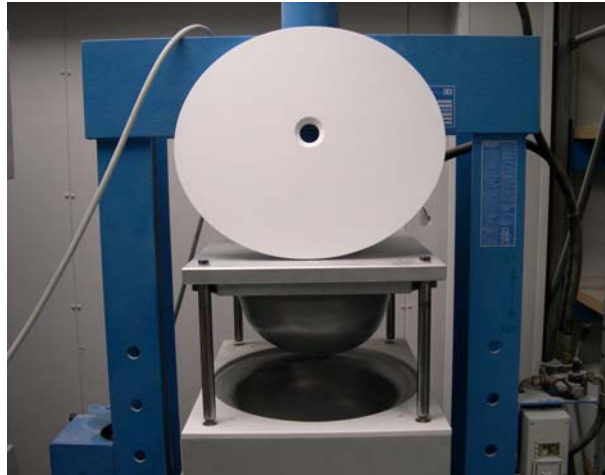
To get the best use from the hydraulic press and make the press more adaptable for different size moulds. The frame support around the hydraulic ram should be as large as possible to allow multi sized moulds to fit within the framework.

**Mould Design**

Mould design and materials for forming the required shape can range from simple **MDF**; it can be useful for development work and small series production. **Re-enforced polyester** will give good results and medium series quantities, and aluminium mould for high quality high series production.

Re-enforced Polyester mould

Aluminium mould and blank



Aluminium moulds can also have an integrated water cooling system to improve cycle time. When making the mould to the required design it must be limited to the physical capability of DuPont™ Corian®. The depth and radius sizes need to be considered also any plastic deformation needs to be calculated.

The DuPont™ Corian® blank for the required design needs to be the correct shape and dimension; this is one of the most important aspects when making 3D-shapes. The blank needs to be the correct shape and dimension, not too large or small, and be configured to fit the mould.

The two part mould need to have a large lead in radius to allow the rubbery DuPont™ Corian® blank slide into the lower mould. When the two part mould is fully compressed the DuPont™ Corian® blank should have space to move within the mould when cooling. The space must be minimum 0,5 mm more then the thickness of the DuPont™ Corian® shape being pressed between the two elements of the mould.

DuPont™ Corian® Blank



Vacuum moulding

Using a vacuum table to make 3D-shapes is probably the most common practice in the DuPont™ Corian® fabrication world. Some of the advantages for using a vacuum press are the fact the vacuum table can be used for other material, it also eliminated the need to use a two part mould and is relatively inexpensive to purchase. A vacuum table requires a silicone membrane due to the high temperature needed to thermoform DuPont™ Corian® (160°C).

Vacuum Table

Vacuum is restricted to the atmospheric pressure at the time of use, this will only be 1 bar at best, (atmosphere = 1.01325 bars). Due to the restricted atmospheric pressure deep and small radii will be limited, softer more organic shapes are best suited to vacuum forming. One piece tops with a 3D form are also possible and such designs save a substantial amount of fabrication time.

Note: 3-dimensional thermoformed shapes (e.g. shower tray, bowl, etc.) made with DuPont™ Corian® and resulting from an additional production process on a DuPont™ Corian® sheet/shape as produced by DuPont, do not carry the product warranty of DuPont.