## Overview

This instruction bulletin details methods for applying film to plastic sheeting, and thermoforming the applied film, be that on acrylic, PETG, or polycarbonate sheeting. Information provided includes temperature conditions, the film application process, the thermoforming process, and how to cut and weed formed film.

Users should read and understand this bulletin before starting to create thermoformed graphics. Reading the supporting product and instruction bulletins referenced in this bulletin, especially for any products they are using, will also help users create successful graphics.

## Table of Contents



## Compatible Products

Refer to the base film or substrate's product bulletin for complete details about graphic construction options, recommended uses, and durability.

- 3M™ Scotchcal™ Translucent Film Series 3630
- 3M™ Diffuser Film 3635-30
- 3M™ Diffuser Film 3635-70
- 3M™ Envision™ Translucent Film Series 3730
- 3M™ Envision™ Diffuser Film 3735-50
- 3M™ Envision™ Diffuser Film 3735-60
- 3M™ Chrome Graphic Film 3635-110
- 3M™ Day/Night Films 3635-91
- 3M™ Scotchcal™ Gloss Overlaminate 3658G
- 3M™ Scotchcal™ Matte Overlaminate 3660M
- 3M™ Scotchcal™ Translucent Mirror Graphic Film 7755SE-520

## Thermoformable Material Properties

**Table A.** Thermoformable Material Properties

| Material | Cast Acrylic | Extruded Acrylic | Polycarbonate Sheeting | PETG Sheeting (Copolyester/Polyester Glycol |
|---|---|---|---|---|
| **Thermoforming Guidelines** | • Easy to thermoform using an efficient air circulating oven and wood or composite shaping tools.<br>• Predrying is not necessary.<br>• Mechanical press forming may be necessary.<br>• **Shaping temperature:** 365°F (185°C) | • Ideally suited for vacuum forming, as it takes up any sharp definition in the mold and allows for fast cycle times.<br>• Fully automatic infrared heated vacuum forming machines are preferred.<br>• Predrying is sometimes required to help prevent surface damage.<br>• **Shaping temperature:** 365°F (185°C) | • Double sided infrared heated vacuum thermoforming machines are preferable.<br>• Must be predried prior to thermoforming<br>• **Shaping temperature:** 365°F (185°C)<br>• Generally more sensitive to temperature variations. | • Requires only simple tooling.<br>• **Shaping temperature:** 257°F (125°C) |
| **Light Transmission** | Available in a wide variety of colors, light transmission values, and degrees of opacity. | | | |
| **Weathering Performance** | Resists degradation from UV light and performs well outdoors. | Resists degradation from UV light and performs well outdoors, but not as well as the cast acrylic. | **Standard grades** become discolored and lose surface gloss over a number of years.<br>**High quality grades** have an additional surface layer that protect them from UV light, enabling better outdoor performance. | Both indoor grade and UV stabilized outdoor grade PETG materials are commercially available. |
| **Impact Strength** | Five times the impact strength of plate glass. However it is brittle and will break if struck hard. Impact modified acrylic sheeting is available for applications requiring improved impact performance. | **Standard grades:** Slightly more brittle than cast acrylic<br>**Impact modified grades:** Approximately six to 10 fold improvement in impact strength, though they can exhibit a reduction in rigidity and surface hardness. | Extremely resistant to impact damage.<br>Can be affected by the use of inappropriate cleaning chemicals. Always follow the manufacturer's cleaning recommendations. | Falls in between that of cast acrylic and polycarbonate sheeting. |
| **Chemical Resistance** | Resists most acids and some solvents, though it can be damaged by more reactive solvents including those used in screen printing. | Resists acids and alkalis.<br>More easily damaged by solvents than cast acrylic is. | Can be damaged by a number of chemicals including solvents and alkaline solutions. | Similar chemical resistances as cast acrylic materials. |
| **Sizes** | Available in a wide variety of widths and lengths. Users should consult their plastic manufacturer. | | | |
| **Thickness** | Available in a wide variety of thicknesses. Users should consult their plastic manufacturer. | | | |
| **Cleaning** | Follow the cleaning recommendations in 3M Instruction Bulletin Application: Substrate Selection and Preparation. | | | |

# Graphic Construction Considerations

## Point of Shape and Multicolor Applications

Acrylic sheets are usually of uneven thickness. Variations of up to 25% in either direction are relatively common, causing the sheet to elongate unevenly in the forming process. This can also affect the applied graphic, including initially straight lines curving due to uneven elongation, and changes to the fit or shape of pre-cut text and logos. See Figures 1 and 2. Sheets will elongate unevenly on text and logos. How much and in which direction depends on the shape, draft depth, and amount of graphics on a given sheet. Graphic manufacturers are able to compensate for this in the initial design, but the uneven elongation between sheets can be difficult to predict.

Applying the second color following thermoforming is the only reliable method for achieving a near perfect match between colors. In the following example:

1. Apply the background color film to the entire sheet.
2. Thermoform the film to the sheet.
3. Allow the sheet to cool to room temperature.
4. Cut around the letter and weed the film within 24 hours of thermoforming. (See Figure 3.) Leaving the film any longer can make removal difficult and increases the risk of leaving adhesive residue behind on the substrate.
5. Apply film onto the text (see Figure 4) by either the wet or dry application method. (The dry method is only suitable for smaller text or logos.)
6. Allow any wet applied text to dry and build adhesion.

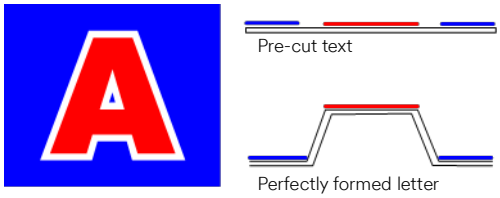


**Figure 1.**

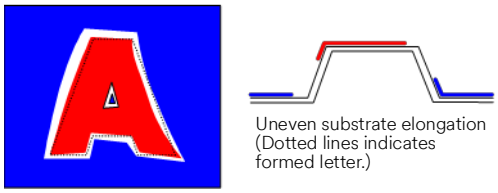


**Figure 2.**

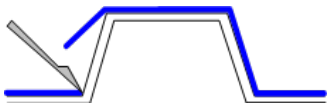

**Figure 3.** Applying Background Color and Cutting Around the Letter

**Figure 4.** Applying Film to the Text

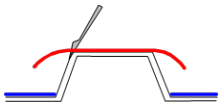

**Figure 5.** Cutting Around the Edge

## Installing Multiple Film Panels

3M does NOT recommend butt joint seams, as the substrate will elongate in the forming process, separating the films and creating a light leak. Instead, overlap the film panels by a minimum of 0.12 in. (3 mm), with the darkest film on top. Follow the recommendations in 3M Instruction Bulletin Application: Backlit Signage.

## Film Color Performance

Darker films accumulate heat faster than lighter films and film elongation will vary slightly between colors. Practically, this means black films may crack or tear easier than lighter colored films. This doesn't necessarily mean black films cannot be used, just that graphic manufacturers will have to find the proper time and temperature balance to prevent black film from cracking or tearing. These differences between film colors will only be noticed when films are stretched or heated close to the limit, not during ordinary process operations.

## Color Uniformity

Stretching film distributes its pigments over a larger area, affecting color density when the film starts getting close to its physical limits. This is more obvious on darker films, which will lose color density faster than lighter films. A similar effect is seen when using pigmented acrylic, an effect that cannot be avoided. However, the effect can be minimized if it is taken into consideration during the initial sign design and mold construction. Relaxed curves and reduced draft depths inside letters may help maintain a film's color uniformity, and reducing the draft depth inside letters can also save the acrylic without negatively impacting the text visually.

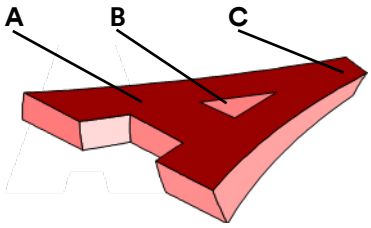


**Figure 6.** Critical Areas

**Figure 7.** Sharp Angles and Steep Draft Depths

**Figure 8.** Modified and Relaxed Angles and Draft Depths

Area B is the most likely place the film and substrate will lose color density, as film and substrate from the surrounding areas have to fill the space. This creates substantial stress on the substrate and film, changing the color density and potentially causing the film to crack.

Modifying the design from Figure 7 to Figure 8 helps support color density. Modifying the draft depth by as much as 50% inside letters such as A, B, P, R, etc. is usually not seen as a negative modification, as it is not noticed from an ordinary viewing distance.

### Substrate Cracking Problems

Undamaged film may cover cracks on the corners of the substrate. These cracks may fill with water and dirt, and the water will freeze in winter conditions which may further damage the substrate and cause the film to crack as well.

This cracking occurs when only the non-film side of the sheet is heated and when this heating is insufficient.

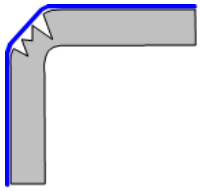

**Figure 9.** Substrate Cracking

## Substrate Preparation

Proper substrate preparation is essential to a successful application. High thermoforming temperatures amplify the size of any trapped air or application imperfection, making the formed sheet's final appearance unacceptable.

### Predrying the Substrate

Outgassing is the release of gas that was dissolved, trapped, frozen, or absorbed in a material. When film is applied to substrates with the potential to outgas, bubbles may form behind the film over time. These bubbles form when heat from direct sunlight, ovens, or other sources produce gases that leach out of the substrate and the resulting gas cannot escape the film either through the film material itself or via designed structures such as air egress channels (i.e. 3M™ Comply). It may be days, weeks, or months before these gases are released.

**NOTE**

Most cast acrylic sheeting and high temperature copolyester sheeting does NOT require pre-drying. Consult with the plastic's manufacturer for details.

Pre-dry the plastic sheet to avoid moisture outgassing during the thermoforming process. Moisture content is dependent on the substrate's age and storage conditions. Always test whether the substrate requires pre-drying prior to film application. Failure to properly dry the plastic can cause bubbling within the plastic sheet and under the applied film during the heating stage of the forming process.

Follow these recommendations to pre-dry the substrate prior to applying film:

1. Remove any protective layer from the material's surface.
2. Pre-dry the sheet according to the instructions in Table B.
3. Wipe the material with an antistatic rag or blow deionized compressed air over the sheet to remove any electrical charge and/or dust.

**NOTE**

Apply the film immediately after the substrate returns to room temperature after flash drying, following the recommendations in the "Film Application" section on page 5.

**NOTE**

Failure to properly dry the plastic may cause outgassing, resulting in bubbling within the plastic sheet and under the applied film during thermoforming. Always consult the plastic manufacturer's recommendations for more specific pre-drying instructions. Table B only provides general guidelines.

**Table B.** Material Predrying Guidelines

| Substrate | Drying | Recommendation |
|---|---|---|
| **Cast Acrylic** | Follow the manufacturer's recommendations | N/A |
| **Extruded Acrylic** | Drying may be required | 185°F (85°C) for 1 hour |
| **Polycarbonate** | Drying required | **0.12 in. (3 mm) thick:** 257°F (125°C) for 4 hours<br>**0.16 in. (4 mm) thick:** 257°F (125°C) for 6 hours |
| **PETG (Copolyester/ PolyesterGlycol)** | Follow the manufacturer's recommendations | N/A |

# Cleaning

All surfaces must be considered contaminated. Even sheets supplied with a protective covering must be cleaned after the covering is removed. Clean the substrate according to the recommendations in 3M Instruction Bulletin Application: Substrate Selection and Preparation.

# Film Application

## Wet Application

1. Apply the film wet according to the recommendations in 3M Instruction Bulletin Application: Backlit Signage.
2. When using a wet application method, re-dry the rigid plastic sheet after applying the film.
   - **One film layer:** Oven dry for about two hours at 170°F (76.7°C), or one to two days on a rack at a temperature of at least 70°F (21.1°C).
   - **Two film layers:** Oven dry at least four hours at 170°F (76.7°C).
   - Drying times may vary depending on whether the film is applied with a roll laminator or with a squeegee.

## Roll Lamination

1. Use firm pressure and laminate at a rate of 6.6 ft/min (2 m/min) or slower.
2. Store the sheet and applied film at room temperature for about eight hours post-lamination to ensure the adhesive has flowed out. Alternatively, place the film in an oven at 104°F (40°C) for four hours.

## Dryness Test

To check whether a plastic sheet is sufficiently dry:

1. Make a small test face using the same method and construction as the original face.
2. Dry the sample face and the original face.
3. When the sample face seems dry, place it in the thermoforming oven for a full temperature warm-up cycle. If the sample does not bubble, the original face is ready for forming.

# Forming Considerations

## Profile Design

The maximum depth of draw achievable is dependent on draft angles, radii sizes, substrate selection, equipment performance, and the complexity of the formed shape.

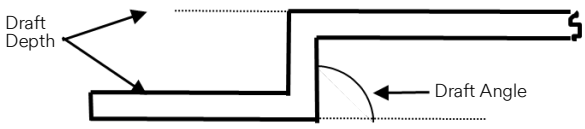


**Figure 10.** Profile Design Considerations

## Tool Selection

Film applied to the tool side of the substrate may rip and tear as it contacts the tool or when the formed substrate is removed from the tool.

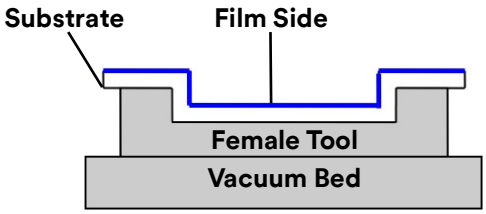


**Figure 11.** Correct Tool Selection

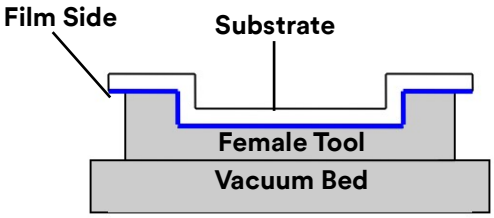


**Figure 12.** Incorrect Tool Selection

## Forming Conditions

### Temperature

Ensure the shop air flow does not cause drafts that may cool the heated plastic sheet before it has been formed.

Excessive heat can cause film to degrade and may result in the film changing color or failing prematurely when exposed to the outdoors. Film failure caused by overexposure to heat during the thermoforming process is NOT covered by the 3M™ MCS™ Warranty.

Special heat-sensitive indicators can measure the temperature on the surface of the film and plastic sheet during heating. An infrared laser thermometer (such as 3M™ Infrared Thermometer IR-500) also works well.

**NOTE**

Double sided heaters are required for sheets with a thickness of 0.18 in. (4.5 mm) or greater.

### Exposure Time

Do NOT heat the applied substrate for longer than eight minutes during the forming process. The surface gloss of rigid plastic may be altered by long periods of high heat, which may be unacceptable for some applications.

**⚠ CAUTION**

Do NOT heat the film to more than 380°F (193°C) during the thermoforming process.

Extreme exposure (temperature or time) will degrade the film can result in operator overexposure to film decomposition emissions.

### Draft Depth

3M recommends a maximum draft depth of 3.1 in. (8 cm). However, users should consider all factors when determining the feasibility of a project, as certain projects may have lower maximum draft depths. If the draft is too deep, film may lose its color uniformity or, in extreme situations, crack.

## Forming Process

- Vacuum thermoforming is the best method for processing sheets decorated with 3M™ Scotchcal™ films.
- Press forming can be used, but use of this method should be limited since the film contacts the tool.
- Pressure forming is not common. Users should be cautious to ensure the process does not damage the film if used.
- If possible, do NOT trap the film between the surface of the mold and the plastic sheet, as doing so may damage the applied film. If the film must be trapped, round and smooth the edges of the mold for the best results.
- Make a test face before beginning production to confirm that the film performs satisfactorily with the forming equipment and for the intended application.

Vacuum forming machines fitted with only one heater perform adequately on decorated PETG and extruded acrylic sheeting. In general, processing of decorated cast acrylic sheeting and polycarbonates requires machines with both top and bottom heaters. Applying the majority of the heat from the non-film side greatly reduces the risk of film overheating.

### Forming of Film Applied to Acrylic or PETG Sheeting

Most thermoforming equipment can be used to form film applied to acrylic or PETG sheeting.

### Forming of Film Applied to Polycarbonate Sheeting

- Use extra care when forming film applied to polycarbonate sheets since such sheets have higher heat requirements. It may be difficult to bring such sheets to a proper forming temperature before burning the film.
- Using double-sided heaters with the top heaters turned down focuses the heat on the bottom side of the sheet and away from the film.
- Periodically check the temperature during the heating cycle to ensure the film is not being overheated. Failure to follow these instructions may result in poor film performance and overexposure to film decomposition emissions.
- Always dry polycarbonate sheets.

### Forming Chrome 7755SE-520

- 3M recommends using a high temperature copolyester sheet or PETG when using 3M™ Scotchcal™ Translucent Mirror Graphic Film 7755SE-520 (“7755SE-520) due to its low thermoforming temperature.
- Diffusers, day/night film, or black film can be used to provide the desired visual effect. Block out film does NOT work well for thermoforming.
- 7755SE-520 can be laminated to the first or second surface via the wet or dry method.
  - When used in combination with other compatible films, 7755SE-520 must be laminated to the first surface, with the other film laminated to the second surface.
  - For dry lamination, use 80 to 100 lbs (36.4 to 45.5 kg) of pressure on air loaded laminators.
  - Do NOT use excessive braking to prevent overlap separation.
- 7755SE-520 must be baked at 150°F (65.6°C) for three hours prior to thermoforming.
- Thermoforming for 7755SE-520 can be done using standard molds and equipment.
- When 7755SE-520 is heated from one side, the sign face temperature should reach between 310°F to 340°F (154.4°C to 171.1°C) on the hot side. (The cooler side can measure up to 100°F [55.6°C] cooler.)
- When the product is heated from both sides, temperatures should reach between 290°F to 310°F (143.3°C to 154.4°C).
- Temperatures of 340°F (171.1°C) or more can cause an extensive loss of reflectivity in the film.
- Higher reflection is obtained when 7755SE-520 is applied to the unheated side of the sign face.

## Handling Formed Faces

- Faces formed of rigid plastic with the film applied usually remain at elevated temperatures for some time after forming. Handle carefully to avoid damaging the film.
- Copy and graphics may be cut and weeded from the applied film only when the faces have cooled enough to permit handling.

# Thermoforming Methods

## Vacuum Forming

1. Place a sheet of plastic material in a metal frame and clamp it into place along its edges.
2. Move heaters into position above and below the sheet at the required temperature. (See Figure 13.)
3. Heat the film until the material softens and reaches the required temperature.
4. Remove the heaters.
5. Raise the table, pushing the tool into the softened sheet.

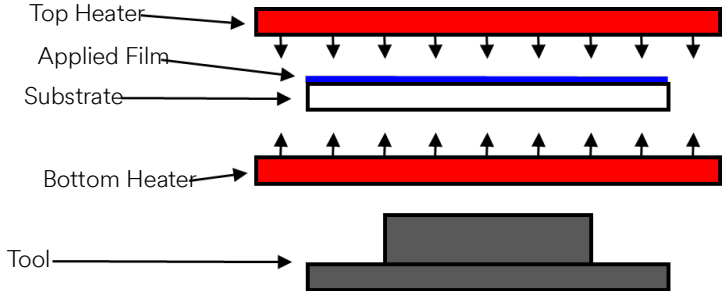


**Figure 13.** Heating the Substrate

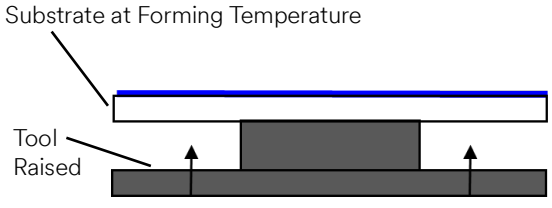


**Figure 14.** Raising the Tool Into the Heated Substrate

6. Turn on the vacuum pump to remove the air from between the material and the table. This conforms the softened material to the tool.
7. Allow the plastic material to cool and set.
8. Turn off the vacuum.
9. Lower the table and release the formed material from the clamps.
10. Trim off any excess material.

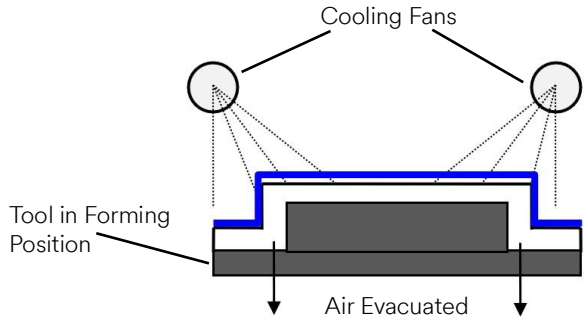


**Figure 15.** Vacuuming Out Air and Cooling the Formed Substrate

**Figure 16.** Final Formed Substrate

## Press Forming

**NOTE**

Press forming is NOT suitable for sheets with applied film, as the film will likely tear during the process.

1. Place a sheet of material on a shelf or hang it in an air flow oven.
2. Heat the material until it reaches the desired molding temperature.
3. Place the sheet in a metal frame situated above the female part of the tool. See Figure 17.
4. Clamp the sheet into place.
5. Position the male part of the tool above the material, then lower it to press the softened sheet into the female tool. This conforms the material to the tool's contours. (See Figure 18.)

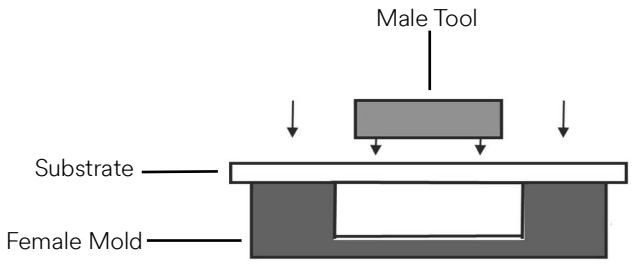


**Figure 17.** Lowering the Male Tool

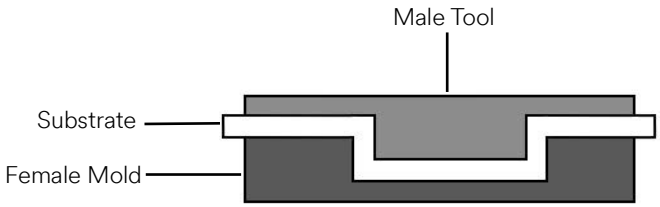


**Figure 18.** Press Forming the Substrate

6. Allow the material to cool and set.
7. Raise the male part of the tool to release the formed material.
8. Trim off any excess material.

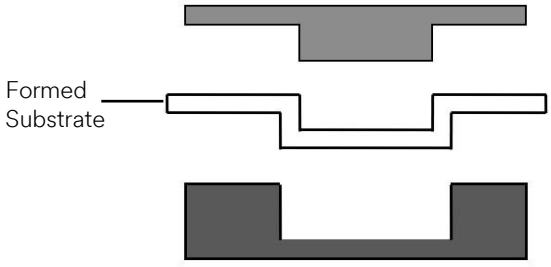


**Figure 19.** End Result of Press Forming the Substrate

## Pressure Forming

1. Place a sheet of material on a shelf or hang it in an air flow oven.
2. Heat the material until it reaches the desired molding temperature.
3. Place the sheet in a clamping frame situated above the female part of the tool. See Figure 20.
4. Lower the table to pinch the edges of the sheet between the table and the tool.

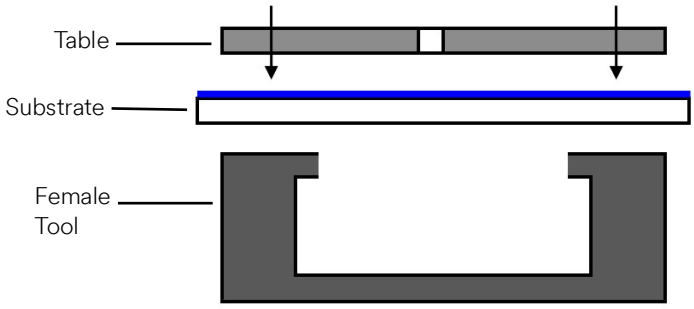


**Figure 20.** Lowering the Table

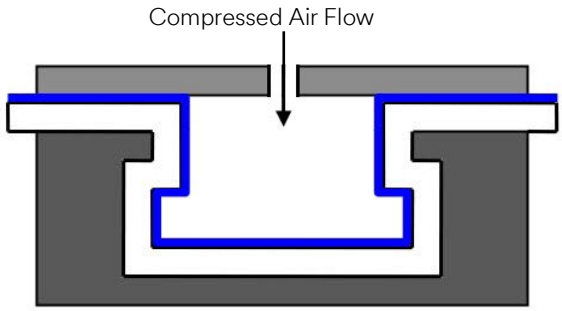


**Figure 21.** Blowing Compressed Air Through the Table Hole

5. Open the air hole positioned in the center of the table above the material. This blows compressed air into the tool, conforming the material to the tool. See Figure 21.
6. Allow the material to cool and set.
7. Raise the table to release the formed material. See Figure 22.

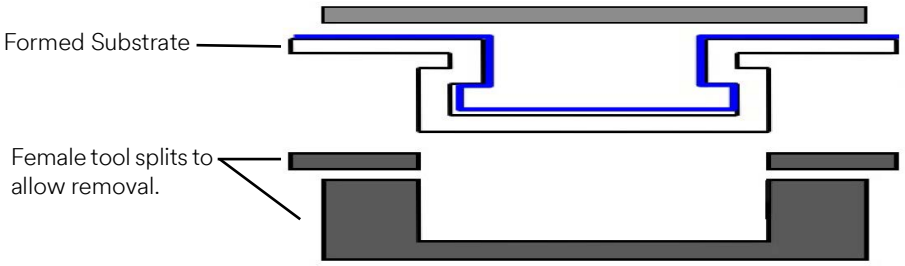


**Figure 22.** Removing the Pressure Formed Substrate

8. Trim off any excess material.

## Cutting and Weeding

The adhesive on 3M's translucent films is designed to have a low initial adhesion when applied to plastics so cutting and weeding can be easily completed after thermoforming. Cutting and weeding of the film should be completed as soon as possible after forming.

**NOTE**

3M recommends weeding films with red pigments prior to thermoforming. The red pigments available to film manufacturers today can stain plastic when thermoformed.

- Patterns may be made directly on the flat areas of thermoformed faces by embossing or by using chalk or carbon dust. Do NOT use carbon paper or marking pens as these may leave permanent marks on the film.
- Cutting may be done with conventional sharp-bladed graphic knives. Use minimum pressure to avoid cutting or scoring the plastic sheeting.
- Avoid overcuts at the corner of letters and graphics to prevent light leaks. Overcuts may continue to lengthen or expand, creating noticeable light leaks. Whenever possible, the inside corners of letters and symbols should use rounded corners with the largest radius consistent with acceptable appearances.
- To weed the film, carefully hold a corner of the film and pull it with sharp, short jerks at about an 145 degree angle. Whenever possible, pull the weed away from, rather than toward, the portion of film that is to remain on the surface. If adhesive transfers to the surface during removal, warming the surface slightly during removal can reduce the amount transfered. Varying the angle at which the film is removed also helps minimize adhesive transfer.
- Any adhesive residue left on the surface may be removed by rubbing it with a thumb or finger.

## Coatings

### Top Coatings

3M™ Scotchcal™ Overlaminates 3658G and 3660M may be laminated over translucent films and then thermoformed. This provides additional color durability.

### Diffuser Coatings

- A diffuser coating may be applied to the second surface of a clear, formed plastic face.
- Clean the surface to remove dust, dirt, and other contaminants prior to applying diffuser paint.
- Apply the diffuser coating to a test panel to test compatibility and proper results.
- 3M™ Diffuser Films 3635-30 and 3635-70 and 3M™ Envision™ Diffuser Films 3735-50 and 3735-60 may be used with formed faces.

### Spray Painting

Spray painting any 3M translucent film before or after the thermoforming process is NOT recommended and may result in application failures.

## Distortion Cut Graphics

- Distortion-cut graphics can be applied and formed in a similar manner to distortion-screened faces.
- Cut graphics are intended for reverse application to second surfaces.
- The registration procedures used for distortion-screened faces can be used with distortion-cut graphics.
- 3M™ Diffuser Films 3635-30 and 3635-70 and 3M™ Envision™ Diffuser Films 3735-50 and 3735-60 may be used with distortion cut graphics.
- For flat thermoformed faces where only copy will be applied, the copy should be applied after the faces are formed, if possible.

## 3M Related Literature

Read the most current 3M product and instruction bulletins before starting any job.

The information in 3M product and instruction bulletins is subject to change. Current bulletins are available at 3M.com/graphics. The techniques described in these bulletins are required when applying a 3M warranted graphic, but are also practical recommendations when using promotional materials for non-warranted graphics. Additional bulletins may be needed as indicated in the 3M Related Literature sections of the product bulletins of all 3M components used.

- 3M Instruction Bulletin Production: Cutting
- 3M Instruction Bulletin Production: Backlit Signage
- 3M Instruction Bulletin Application: Backlit Signage
- 3M Instruction Bulletin Application: Substrate Selection and Preparation

## Health and Safety

### Tools and Equipment Usage

When using any equipment, always follow the manufacturer's instructions for safe operation.

### Chemicals

When handling any chemical products, read the manufacturers' container labels and the Safety Data Sheets (SDS) for important health, safety, and environmental information.

Follow this link to obtain SDS sheets for 3M products.

Follow this link to obtain information about substances of very high concern (SVHC) for EU products.

### Ventilation

Always provide adequate ventilation to remove film emissions resulting from thermoforming. Failure to provide adequate ventilation can result in operator overexposure to film decomposition emissions.

Consult with your heating and cooling contractor and a certified industrial hygienist to ensure air flow is sufficient.

## Warranty Information

### Technical Information

Technical information, guidance, and other statements provided by 3M are based upon records, tests, or experience that 3M believes to be reliable, but the accuracy, completeness, and representative nature of such information is not guaranteed. Such information is intended for people with knowledge and technical skills sufficient to assess and apply their own informed judgment to the information. No license to any intellectual property rights is granted or implied with respect to this technical information.

### Product Selection and Use

Many factors beyond 3M's control and uniquely within user's knowledge and control can affect the use and performance of a 3M product in a particular application. Customer is solely responsible for evaluating the product and determining whether it is appropriate and suitable for customer's application, including conducting a workplace hazard assessment, reviewing all applicable regulations and standards, and reviewing the product label and use instructions. Failure to properly evaluate, select, and use a 3M product in accordance with instructions or to meet all applicable safety regulations may result in injury, sickness, death, and/or harm to property.

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