PLASKOLITE

DRYING POLYCARBONATE FOR FORMING

Most plastics, including polycarbonate (PC), are hygroscopic meaning they adsorb moisture even from ambient air.

DRYING PC FOR EXTRUSION

In Plaskolite's process, polycarbonate resin is dried using highly specialized desiccated air drying equipment to achieve extremely low moisture content prior to extrusion. Due to the high extrusion melt temperature, the PC resin must be near perfectly dry. Any remaining moisture in the resin is volatized and vented off resulting in an essentially purely dry, crystal-clear extruded sheet. Immediately following extrusion, the sheet has essentially no moisture or volatiles. The extruded sheet will then begin re-absorbing moisture over time. Time, temperature, and ambient humidity all play a role in how quickly the sheet reaches maximum moisture equilibrium and is a process that can take weeks or months.

DRYING PC FOR THERMOFORMING

Thermoforming PC has the potential to boil/volatize moisture in the sheet resulting in bubbles within the formed part. Several variables are involved in whether a sheet can be formed without encountering moisture bubbles. They include moisture content, peak sheet temperature/ rigid/soft state and duration of exposure at an elevated temperature.

How dry is dry enough?

Not very dry- At low forming temperatures (<310F) the sheet remains semi-rigid and can often resist the vapor pressure of moisture that wants to volatize and form a bubble.

Moderately dry – Medium temperature thermoforming (310F-330F) will require a well-dried sheet.

Very dry - At higher forming temperatures (>330F) the sheet is softened significantly and any residual moisture can most easily volatize resulting in a bubble. This forming requires the sheet to be very dry. Conventional drying methods may struggle in high humidity conditions.

DRYING OVEN CONFIGURATIONS – Conventional and Desiccating

Pre-drying sheet is a necessary step to prevent bubble formation during the thermoforming process. Drying sheet enough to form without bubbles can often be achieved with a simple hot air oven. The higher the temperature of air, the more moisture it is able to absorb. Higher temperatures also increase the mobility of moisture and expedite movement of moisture from a wetter environment (the sheet) to a dryer environment (the hot air) until they both are of equal moisture levels.

A dehumidifying, desiccating air circulating oven is often required for pre-drying sheet, especially during peak humidity and for higher temperature forming. For optimal drying, oven temperatures should be maintained near 250°F and be monitored for consistency. Recommended pre-drying times are based on sheet thickness.

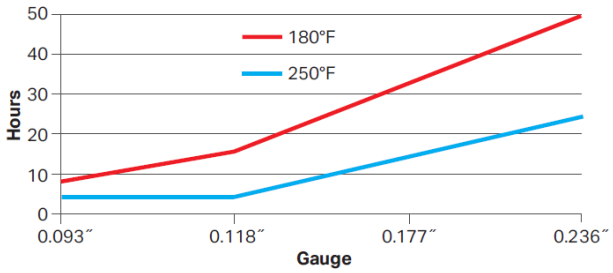
BUBBLES DURING THERMOFORMING

When moisture bubble issues persist in a thermoforming application, a desiccating dryer unit is required. The PC sheet was fully dry after extrusion and unless there are visible bubbles in the sheet prior to forming, the sheet is simply not dry enough for the thermoforming process.
Polycarbonate sheet will only expel as much moisture as the drying process will allow. High humidity/high dew point ambient air will remain at an elevated moisture level when pulled through a conventional hot air heating unit. This hot, wet air may not adequately dry PC that is to be subjected to moderate or high temperature thermoforming processes. A desiccating drying unit is likely needed to draw out any remaining moisture in the PC sheet.
PC can contain variable moisture content from batch to batch based on the conditions it has been exposed to since extrusion. This inherent variation can translate to one batch forming without bubbles while another encounters

bubbles. Still, all PC sheet can be dried to a level that is thermoformable even at extreme forming temperatures. The drying process is the key factor in reaching a moisture level that allows it to be thermoformed.

Drying times/hours

Gauge	250°F	180°F
0.093″	4	8
0.118″	4	14
0.177″	12	30
0.236″	24	50



DRYING ROOMS

Larger scale drying rooms are an innovative way to remove moisture from PC sheet and reels for high volume, variable production. Desiccated dry air pumped into the dry room at a lower temperature slowly dries sheet/reels and keeps them ready to use. The concept of a dry room is moisture will migrate from a high concentration environment (the sheet or reel) to a low concentration environment (the dry room). The removal of humidity from the room air is achieved through desiccating hot air supply units from manufacturers noted below.

Time, temperature, humidity level and air flow are the critical to the final drying results. Only through careful monitoring and testing of the process can repeatable and acceptable conditions be established.

DRY ROOM CONSIDERATIONS

- Storing PC in a low humidity room will prevent the moisture content from increasing within a sheet or reel ~~form~~, however in order to understand the actual drying capabilities, if any, conditions must be carefully documented through testing of material as it spends time within the room.
- Four components of drying polycarbonate resin are time, temperature, humidity and airflow. Recommended conditions for drying polycarbonate resin are:
    - Time - resin dried for 4 hours
    - Temperature - resin is dried at 250°F-280°F
    - Dew point – resin is -20°F to - 40°F
    - Airflow – airflow is maintained through the resin at 1 cfm per lb/hour.

- Realizing that it's entirely impractical to create a dry room with the above conditions, practical conditions should include:
    - Time – Sheets and reels may need weeks or months to fully remove hygroscopic moisture.
    - Temperature - 100°F, higher temperatures facilitates migration of water out of the polycarbonate, however, maintain a temperature level that's tolerable to your employees.
    - Dew point – +15°F to +20°F (as low as economically practical)
    - Airflow – determined through testing.
- Dry rooms need to be insulated and sealed with an appropriate vapor barrier.
- Access to the room needs to be controlled with either an airlock or air curtain or both.
- When the room is not in active use, an airtight door must be present to control the inflow of humid air.
- Dehumidification and heating equipment needs to be properly sized for the proposed space.
- Understanding the masking film performance after spending extensive time within the dry room needs to be documented.
- Adopt a practice of validating moisture removal from the material by rapidly heating a small sample (12" x 12") of material to 340-360°F and visually examine the sample for moisture bubbles.

RESOURCES

Below are a few walk-in oven manufacturers with a range of standard and custom options.

- https://www.grievecorp.com/product-category/walk-in-ovens/
- https://www.wisoven.com/products/walk-in-ovens/normal-duty-walk-oven-swn?gclid=Cj0KCQjww4OMBhCUARIsAILndv7WQZLSp7YdazyjnUJcIWGcyb04rMU2-RfiBmKKwxGZLgCNIRiSm7IaAjmMEALw_wcB
- https://www.epconlp.com/products/process-heating-equipment/industrial-ovens/?keyword_session_id=vt~adwords|kt~walk%20in%20oven|mt~e|ta~&_vsrefdom=wordstream&keyword_session_id=vt~bing_ads|kt~walk%20in%20oven|mt~be|ta~76828425900721&_vsrefdom=wordstream&msclkid=8afb37dec6281905267a565fac44c263
- https://www.jpwdesign.com/walk-in-ovens/

Dehumidifying equipment manufacturers:

- https://www.conairgroup.com/products/drying/
- https://unadyn.piovan.com/en this link isn't currently working but decided to include them for reference.
- https://www.shinjusa.com/2016/07/26/everything-you-need-to-know-about-desiccant-drying/
- https://www.stulz.com/fileadmin/user_upload/STULZ_DESICAiR_Series_1000_Engineering_Manual.pdf

For construction, advice and information of dry room's requirements:

- Process Air Systems - (402) 598-5468
- 9112 Charles St, Omaha NE 68114

For information on dehumidification equipment:

- Munters-Cargocaire - 1-800-843-5360
- dhinfo@munters.com
- http://www.munters.us/en/us/Division-start-pages/Munters-Air-Treatment/