STORAGE, HANDLING & DRYING

Handling

SWP extruded sheet products are supplied on pallets which are over wrapped with layers of polyethylene (PE) film which protect the sheet from dirt and act as a barrier to moisture absorption. This PE wrapping should be left intact until just prior to processing of the sheets – any remaining sheets should then be re-wrapped with the PE wrapping so as to afford maximum protection from airborne dust and moisture. Similar considerations apply to extruded film products also.

Some sheet products are supplied with a PE laminate film on the "A" surface that helps protect critical sheet surfaces from being scratched during storage and handling. This masking film should be left in place during the thermoforming process as it will help to protect the moulded surface from scratching during subsequent operations prior to installation of the moulded part.

Where sheets are supplied with adhesive-based PE laminate films care must be taken to ensure that excessive heats are not used otherwise surface defects may result from thermal degradation of the laminate PE film or the film may be difficult to remove when required.

Cleaning

Where sheet / moulded surfaces become dirty the surface can be washed with a solution of mild soap or detergent and lukewarm water using a clean soft cloth, applying only slight pressure. Rinse with clean water and dry by blotting with a damp cloth.

Grease or oil may be removed with washing up liquid. Window cleaning sprays, kitchen scouring compounds, or solvents such as acetone, petrol, carbon tetrachloride or lacquer thinners, should not be used as these can attack the sheet surface resulting in weakening and / or crazing (small surface cracks) of the sheet.

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Any airborne dust can be removed with a soft, damp cloth. Dry or gritty cloths may cause surface scratching in addition to creating an electrostatic charge which attracts dust particles from the air to the sheet.

Storage

SWP thermoplastic sheet and film products should be stored internally, under dry conditions, and not exposed to direct sunlight.

All plastic materials are susceptible to moisture pick-up, some more so than others. Extruded sheets readily absorb moisture from the atmosphere and this will cause problems at the elevated temperatures encountered during the thermoforming process. It is essential that sheet material is free from moisture as during the heating stage a small volume of water can generate steam which in turn can cause defects in the finished product. Typical defects include surface blistering, or pitting, of the surface and generation of voids, which can lead to a reduction in mechanical properties.

Most plastic materials absorb moisture and can be categorised as either non-hygroscopic or hygroscopic. Non-hygroscopic plastics are those materials where moisture tends to adhere to the surface only, e.g. polystyrene, polypropylene. Hygroscopic plastics, on the other hand, absorb moisture within the material. Such materials include ABS and PMMA.

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Typical moisture pick-up values for selected polymers are shown in the Table below.

Polymer Type	
Polystyrene (Crystal PS)	0.02
Impact-modified Polystyrene (HIPS)	0.05
ABS	0.2 to 0.4
PMMA	0.2
PVC	0.04 to 0.4
Polypropylene	0.02
High Density Polyethylene (HDPE)	< 0.01
Low Density Polyethylene (LDPE)	< 0.01

The extent to which a given extruded sheet will absorb water depends on the time the sheet has been exposed to a particular environment. Water absorption is a diffusion process in that the water molecules move from the moist environment (the air) into and through the dry plastic sheet. The rate of diffusion, or permeation, is dependent on the relative humidity (how much water is in the air) and the nature of the plastic. As materials such as ABS and PMMA have strong affinities to water these absorb water readily and to a relatively high extent.

Water Permeation and Relative Humidity

Freshly extruded sheet and film products are completely dry. Even if a sheet is submerged for a short period of time, the material should still be practically dry, because the water must first be absorbed at the surface and then permeate (migrate into) the centre part of the sheet, a very slow process. Although listed water absorption data are usually determined after 24 hours submersion at room temperature, saturation may occur only after weeks or months. It is the slow rate of water permeation that is the cause of difficulties during thermoforming. Although moisture in thin films, or on the surface of sheets, will rapidly escape during heating, the water in the centre of heavier sheets stays trapped and vaporises inside the sheet, forming bubbles of various sizes. Formed parts may also display surface blistering.

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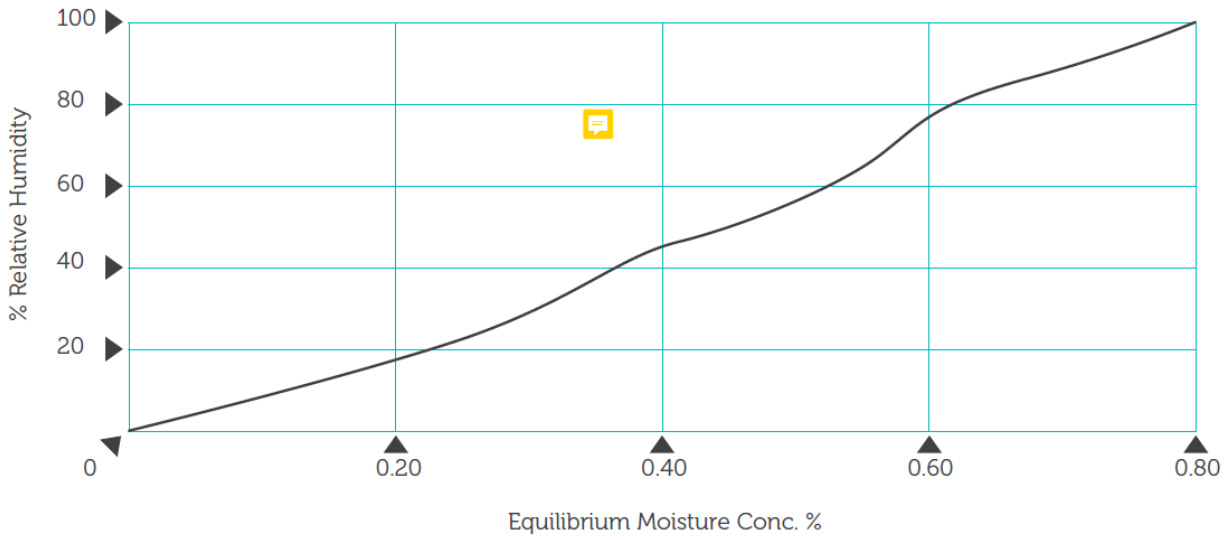
The key to understanding moisture pick-up in plastic materials is relative humidity (RH). Thermoplastic sheets will absorb water from the air, or lose it to the air, in direct proportion to the surrounding RH. For example if dry ABS sheet is exposed to 50% RH it will absorb moisture until it comes to equilibrium with the surrounding air, a process which at room temperature can take several days. At equilibrium the moisture content is uniform throughout the sheet. If the RH value is then increased to 75% more water will be absorbed. Conversely if the RH value is lowered to 30% then water will be lost - the process is fully reversible. The graph below illustrates the moisture content versus % RH relationship for ABS.

Moisture content versus relative humidity (RH) for ABS



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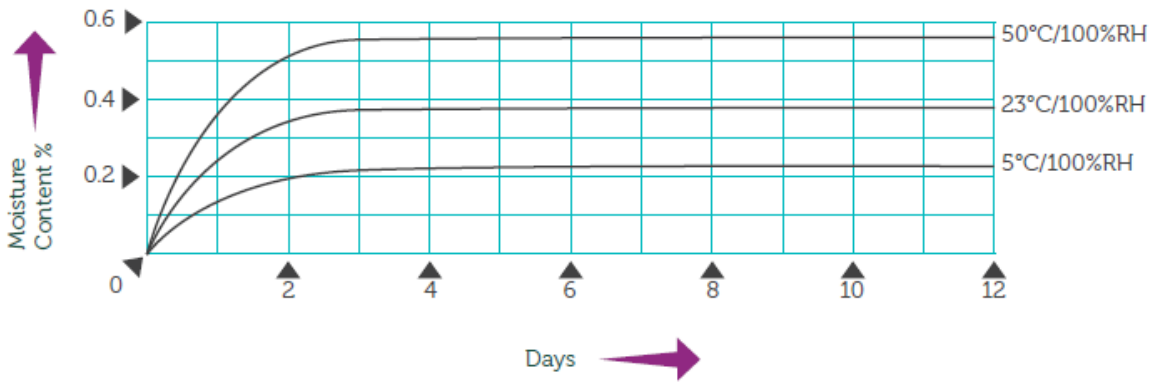
Storage Conditions

In order to minimise moisture intake with extruded sheet and film products they should be stored in a dry, warm environment - the ideal situation is that there should be a way to control RH values in the storage area. In creating as dry an environment as possible sheet will always revert to the lower moisture content of the surrounding air.

The temperature within the storage area is also a key factor - increasing the ambient temperature not only speeds up the diffusion of water from the interior of the sheet to the surface where it can escape, but it also creates a relatively dry environment resulting in an automatic decrease in RH values. Figures below demonstrate the effect of storage conditions with respect to moisture pick-up in high-impact polystyrene (HIPS) polymers.

Effect of storage conditions on moisture take-up in HIPS polymer:

(a) Moisture content versus temperature (RH constant)



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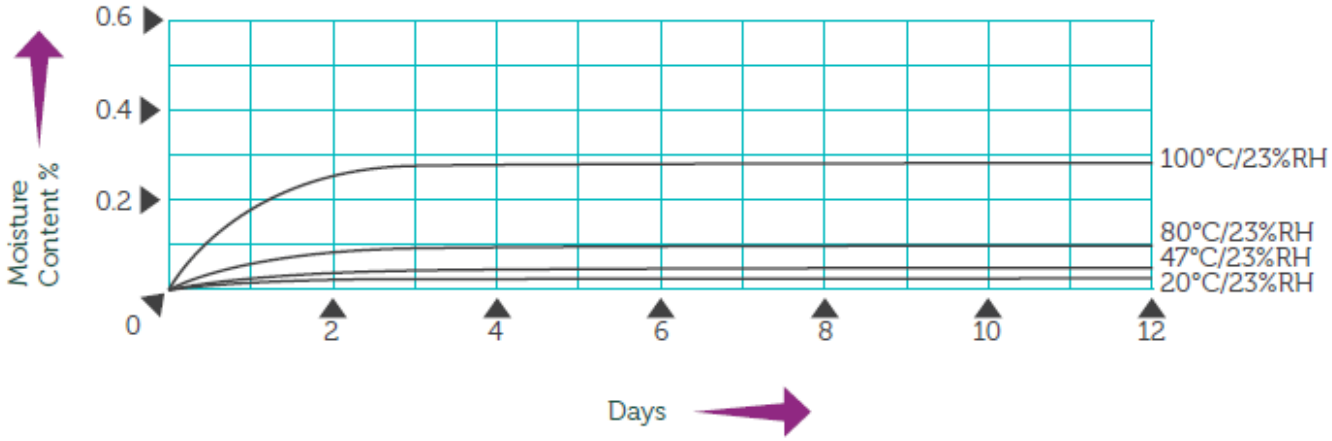
(b) Moisture content versus RH (temperature constant)



SWP thermoplastic sheet products

SWP thermoplastic sheet products are supplied with protective PE outer wrap. Under consistent dry, warm storage conditions (about 20°C, 30% RH) our products can be stored for up to 6 months or more without requiring any pre-drying operations prior to processing. Good manufacturing practices should be followed in adhering to rotation of stock on a 'first-in, first out' basis and sheets should be kept tightly wrapped in moisture-proof packaging when not being used. Stacking of sheets together will also limit water permeation and it may be that if problems arise with moisture, then this will be limited to only the top or bottom sheets in a stack.

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Although the temperature of the storage area is not critical there is the danger of condensation of moisture on the surface of the sheet when it is transferred from a cold store to a warm workshop. It is therefore recommended that pallets of extruded sheet are brought into the workshop for at least 24 hours before being opened to permit the material to reach ambient temperature. Otherwise transfer of sheets to the moulding operations should be done immediately prior to use so that the sheet has no time to absorb moisture.

Drying

Where extruded sheets need to be pre-dried the drying time required will be dependent upon the sheet thickness. An approximate rule of thumb is to allow 75 - 90 minutes per mm of sheet thickness at a temperature below the heat distortion temperature (HDT) of the material to be dried, e.g. for PMMA-ABS sheet materials this is typically 75°C.

Pre-drying is normally carried out in an air circulating, temperature controlled oven where the sheet material is individually supported in a rack system (this allows the hot air to circulate between the sheets for the most effective drying). The drying time will depend on the moisture content, sheet thickness and the efficiency of drying.

Dryer variables include the temperature and velocity of the air in the dryer - a slight increase in either of these two can easily reduce drying times by a factor of two or more. Increasing the air temperature has the combined effect of lowering the RH value of same and increasing the sheet temperature which allows for faster diffusion of internal moisture to the sheet surface where it can be taken away.

Where smaller quantities of sheet need to be pre-dried it may be sufficient to store these in a small room over a 24-hour period, close to a heat source, or a small dehumidifier unit. If only a few forming's are required, and no oven or other means of drying is available, then pre-drying of sheets may be accomplished in the thermoforming equipment by use of repeated brief heating cycles to drive the moisture from the sheet.

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Processing Defects

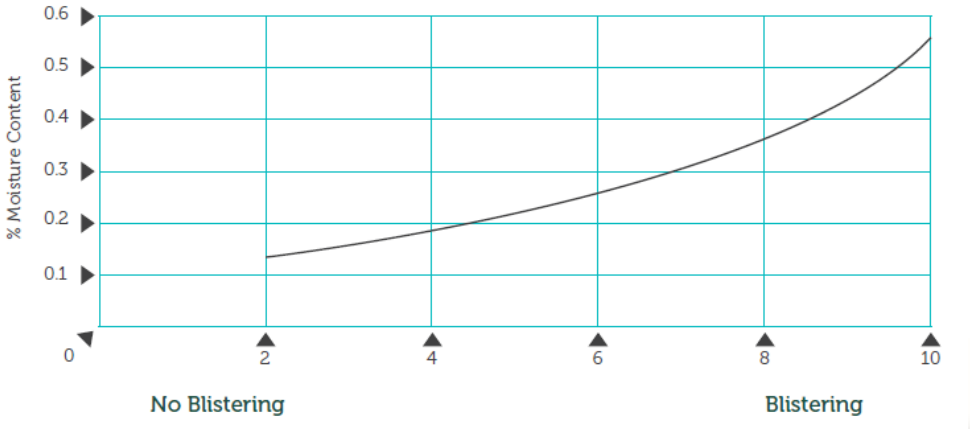
Where extruded sheets have absorbed moisture this can manifest itself in two forms during the heating stage of the thermoforming process:

- Small bubbles within the sheet
- Surface 'blistering' on the sheet surface

As the sheet is heated, moisture trapped within the sheet will vaporise leading to the formation of bubbles of various sizes. The result is that the heated sheet appears foamy and the formed part will display a rough surface or pock marks / blistering. The blistering effect can range in intensity from very slight bubbles below the surface of the sheet to large craters that mar the entire surface.

The key factors involved in processing sheet that has absorbed moisture are the moisture content and the intensity of the heating used. Definite correlations have been established between the moisture content of the sheet and the intensity of blistering. This is demonstrated for PMMA-ABS sheet in the graph below.

Moisture content versus temperature



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Where sheet temperatures during thermoforming are on the higher end of the scale then the tolerable moisture content allowable before the onset of blistering occurs will be reduced - higher processing temperatures will generate larger volumes of steam. If moisture is a problem then heat intensities should be reduced and the sheet allowed a longer ‘soak time’. This will have the effect of not only reducing the volume of steam generated but also allows for a slower rate of diffusion of steam through the sheet, the result being fewer defects.

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