Plastic Barrier Properties Comparison

Comparison of plastic film or enclosures to keep out the transmissions of low molecule gas, (such as $O_2$, $CO_2$, and $N_2$), water vapor, fragrance and other types of organic solvents.
Barrier performances of plastics are typically described as the capability of the plastic film or enclosures to keep out the transmissions of low molecule gas, (such as O2, CO2, and N2), water vapor, fragrance and other organic solvents. The index of this barrier capability is determined by the transmission volume or weight of a small molecule substance through a thick plastic film under some certain pressure, temperature, and moisture per minute per square meter. To interpret these barrier performances; the lower the transmission rate, the better the barrier performance.

**Note:** Most of the information below refers to tests done on plastic films, rather than plastic enclosures. For quality results, Comar suggests that our customers test their products in actual enclosures to ensure barrier performance capability.

### Plastic Glass Transition Temperature

<table>
<thead>
<tr>
<th>Material</th>
<th>*O2 Gas Transmission Rate (cc/m²/24hrs)</th>
<th>*CO2 Gas Transmission Rate (cc/m²/24hrs)</th>
<th>*N2 Gas Transmission Rate (cc/m²/24hrs)</th>
<th>Moisture Vapor Transmission Rate (g/in²/24hrs)</th>
<th>Impact Resistance</th>
<th>Clarity</th>
<th>Glass Transition Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polypropylene (PP)</td>
<td>860</td>
<td>200</td>
<td>3,000</td>
<td>0.5</td>
<td>Fair</td>
<td>Poor</td>
<td>-10°C / 14°F</td>
</tr>
<tr>
<td>High Density Polypropylene (HDPE)</td>
<td>600</td>
<td>220</td>
<td>3,000</td>
<td>0.5</td>
<td>Excellent</td>
<td>Poor</td>
<td>-110°C / -166°F</td>
</tr>
<tr>
<td>Polyethylene Terephthalate (PET)</td>
<td>60</td>
<td>25</td>
<td>420</td>
<td>2.0</td>
<td>Good</td>
<td>Good</td>
<td>73°C / 163°F</td>
</tr>
<tr>
<td>Polystyrene (PS)</td>
<td>5,500</td>
<td>880</td>
<td>14,000</td>
<td>10.0</td>
<td>Poor</td>
<td>Good</td>
<td>90°C / 194°F</td>
</tr>
<tr>
<td>Polyvinyl Chloride (PVC), rigid</td>
<td>150</td>
<td>56</td>
<td>442</td>
<td>3.0</td>
<td>Good</td>
<td>Fair</td>
<td>60°C / 140°F</td>
</tr>
<tr>
<td>Polyvinyl Chloride (PVC), soft</td>
<td>320</td>
<td>80</td>
<td>790</td>
<td>3.0</td>
<td>Good</td>
<td>Fair</td>
<td>-50°C / -58°F</td>
</tr>
<tr>
<td>GLASS**</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>Excellent</td>
<td>-5°C / 23°F</td>
</tr>
</tbody>
</table>

* Oxygen Transmission Rate (OTR) and Carbon Dioxide Transmission Rate (COTR) and Nitrogen Transmission Rate (NTR) in cc/m²/24hr. OTR and COTR are measures of the amount of gas that passes through a substance over a given period. The lower the readings, the more resistant the plastic is to letting gasses through.

** Please note that while glass typically does not allow any type of transmissions to pass through the barrier; the finish surface on glass can be uneven; which when fitted with a closure, being plastic or other material, could allow some Gas/Vapor transmissions to leak into the enclosure. However, those transmissions would be difficult to quantify.

### Material Properties Explanation

**Carbon Dioxide Transmission Rate (COTR)** - Identical to the OTR, except this rate is in regards to the amount of carbon dioxide that permeates per unit of area and time in a packaging materials. The same can also be said for Nitrogen Transmission Rate (NTR), which rate is in regards to the amount of nitrogen that permeates per unit of area and time in a packaging materials.

**Impact Resistance** - The resistance of a material to fracture by a blow, expressed in terms of the amount of energy absorbed before fracture. The results are expressed in energy lost per unit of thickness (such as ft·lb/in or J/cm) at the notch. Alternatively, the results may be reported as energy lost per unit cross-sectional area at the notch (J/m² or ft·lb/in²). Izod impact testing is an ASTM standard method of determining the impact resistance of materials.

**MVTR** - The Moisture Vapor Transmission Rate in g/in²/24hr. MVTR is a measure of the passage of gaseous H2O through a barrier. The lower the rate, the longer the package protects its contents from moisture and ensures the moisture content of the product remains the same.

**OTR, COTR, and NTR** - Measures of the amount of a specific gas that passes through a substance over a given period. The lower the readings, the most resistant the plastic is to letting gasses through.

**Oxygen Transmission Rate (OTR)** - Oxygen barrier property of a packaging container. The oxygen barrier is quantified by the oxygen permeability coefficients (OPCs) which indicates the amount of oxygen that permeates per unit of area and time in a packaging materials (cc/m²/24hours).

**Plastic Glass Transition Temperature** - The point where a polymer experiences a significant change in properties. The polymer structure turns “rubbery” upon heating and “glassy” upon cooling. The reported glass transition temperature point is generally the middle temperature point of the range. Glass Transition Temperature is measured in °C and °F. The most usual test method to determine Glass Transition Temperature of plastic is ASTM E1356.
Plastic Resin Definitions

High Density Polyethylene (HDPE)
Used to make many types of bottles. Unpigmented bottles are translucent, have good barrier properties and stiffness, and are well suited to packaging products with a short shelf life such as milk. Because of the good chemical resistance, it is used for packaging many household and industrial chemicals such as detergents and bleach. Pigmented HDPE bottles have better stress crack resistance than unpigmented HDPE.

Properties:
- Excellent resistance to most solvents
- Higher tensile strength compared to other forms of PE
- Relatively stiff material with useful temperature capabilities

Polyethylene Terephthalate (PET)
PET is clear, tough, and has good gas and moisture barrier properties. This resin is commonly used in beverage bottles and many injection-molded consumer product containers. Cleaned, recycled PET flakes and pellets are in great demand for spinning fiber for carpet yarns, producing fiberfill and geotextiles.

Properties:
- Clear, optically smooth surfaces for oriented films and bottles
- Excellent barrier to oxygen, water, and carbon dioxide
- High impact capability and shatter resistance
- Excellent resistance to most solvents
- Capable of hot-filling depending on process

Polypropylene (PP)
Good chemical resistance, strong, with high melting point making it good for hot-fill liquids. It is found in flexible and rigid packaging, fibers, and large molded parts for automotive and consumer products.

Properties:
- Moderate impact resistance
- Low moisture vapor transmissions
- Inertness toward acids, alkalis and most solvents
- Hotfill capable

Polystyrene (PS)
A versatile plastic that can be rigid or foamed. General purpose polystyrene is clear, hard, and brittle. It has a relatively low melting point. Typical applications include protective packaging, foodservice packaging, bottles, and food containers. PS is often combined with rubber to make high impact polystyrene (HIPS) which is used for packaging and durable applications requiring toughness, but not clarity.

Properties:
- Poor barrier properties
- Excellent optical clarity
- Highly rigid material

Polyvinyl Chloride (PVC)
In addition to its stable physical properties, PVC has good chemical resistance, weather-ability, flow characteristics and stable electrical properties. The diverse slate of vinyl products can be broadly divided into rigid and flexible materials.

Properties:
- High impact strength, and good clarity
- Resistance to grease, oil and chemicals
- Moderate barrier properties

References: