Have More **Freedom** in Optical Design
Have **Clearer** View of the Future.

APEL™, cyclic olefin Copolymer of Mitsui Chemicals product, is amorphous and transparent resin with excellent optical properties.

APEL™ has been contributing to "smaller and lighter lens design", with its highest refractive index and lowest birefringence among amorphous polyolefins, and enables replacement of conventional lens materials such as glass or PMMA.

APEL™ maintains its performance in the severe environment such as high humidity, high temperature, hence it is suitably adopted for new applications such as lenses for Automotive Camera and Head Mounted Display (HMD).

In addition, APEL™’s excellence in moisture barrier, electric properties, and chemical resistance has been perfectly fit for food and medical packaging.

APEL™ stays innovative and is fitting to various advanced market needs.

Have Freedom in Optical Design, Have Clearer View of the Future” is the key message of APEL™ to the industry and society.

**Characteristics of APEL™**

- Low Birefringence
- High Refractive Index
- High Transparency
- High Moisture Resistance
- Easy Moldability
- High Heat Resistance
- Electrical Characteristics
- Dimensional Stability

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*APEL™ is Cyclic Olefin Copolymer (COC) produced by copolymerization of ethylene and cyclic olefins. APEL™ has the highest refractive index and lowest birefringence among amorphous polyolefins.*
**Enhances Optical Design Freedom**

**Multi-functional, Transparent Resin.**

APEL™ realizes clear image without bleeding and distortion in optical lens application. The contribution derives from APEL™’s excellence in high refractive index, low birefringence that enables engineers to make more various optical design.

- **High refractive index, superior aberration correction.** Flexible lens design.
- **Low Birefringence**
- **Forms a clear image from small lenses.**
  - Improves image quality.
  - Controls lens curvature, Enhances design freedom.
  - Contributes to thinner lens units.
  - Excellent dimensional stability with little moisture adsortion.

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**Example of Smartphone Camera Lens Module**

- **Object side**
  - Smartphone camera lens modules consist of several concave and convex lenses. APEL™ is mainly used for convex and sensor-side lenses.

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**Weld reduction**

- **APEL®**
  - APEL® is a material that is suitable for welding of lenses, making lens shape which is easy to find.

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**High Refractive Index**

**High Transparency**

**Low Birefringence**

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**Excellent Transparency.**

- **Less distortion,** **Clearer image.**
High Heat Resistance

Resists yellowing, and deformation even at high temperature.
Achieve highly sensitive, and precise lenses.

Reliable lenses perform well on autonomous camera.

- Retains transparency with little yellowing under actual environment.
- Resists lens distortion even at high temperature.

Medical packages that is not allowed to degrade under long-term storage condition.

- Little effect on drugs due to low elution.
- Has low moisture permeability coefficient.
- Provides good barrier performance.

<table>
<thead>
<tr>
<th>Type of Test</th>
<th>Parameter</th>
<th>Standard</th>
<th>APL6015T (Low Tg grade)</th>
<th>APL6015T (High Tg grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials Test (JP compliant)</td>
<td>Residue on Ignition</td>
<td>0.10% or less</td>
<td>○ +</td>
<td>○ +</td>
</tr>
<tr>
<td></td>
<td>Heavy Metals</td>
<td>Lower concentration than control solution</td>
<td>○ +</td>
<td>○ +</td>
</tr>
<tr>
<td></td>
<td>Pb</td>
<td>Below absorbance of standard solution</td>
<td>○ +</td>
<td>○ +</td>
</tr>
<tr>
<td></td>
<td>Cd</td>
<td>Below absorbance of standard solution</td>
<td>○ +</td>
<td>○ +</td>
</tr>
<tr>
<td>Dissolution Test (JP compliant)</td>
<td>Foaming test</td>
<td>Disappears within 3 min.</td>
<td>○ +</td>
<td>○ +</td>
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<tr>
<td></td>
<td>pH</td>
<td>Difference of 1.5 or less to blank solution</td>
<td>○ +</td>
<td>○ +</td>
</tr>
<tr>
<td></td>
<td>NMDA reducing substance</td>
<td>Difference of 1.5 or less to blank solution</td>
<td>○ +</td>
<td>○ +</td>
</tr>
<tr>
<td></td>
<td>UV absorption spectrum</td>
<td>220~261nm:0.03 or less</td>
<td>○ +</td>
<td>○ +</td>
</tr>
<tr>
<td></td>
<td></td>
<td>241~350nm:0.03 or less</td>
<td>○ +</td>
<td>○ +</td>
</tr>
<tr>
<td></td>
<td>Residue on evaporation</td>
<td>1.0mg or less</td>
<td>○ +</td>
<td>○ +</td>
</tr>
</tbody>
</table>

○ = Compliant or negative results obtained in the performed tests.

1 Standard: polyethylene or polypropylene containers for aqueous reactions (Japan Pharmacopia 13th edition)

High Moisture Resistance

Transparent Resin with Lowest Transparency Coefficient. Prevents Transmittance of Moisture.

The lowest moisture permeability of APEL™ among transparent resins is perfectly fit for moisture-proof containers and PTP blister, and provides better barrier performance than PE, PP.
APEL™ Molding technical information for optical grades

1. Injection molding machine

1-1 Selection criteria for molding machines
- The molding machine size should be adequate to the product volume. A larger machine tends to lengthen the retention time of molten resin, often resulting in carbonation and/or yellow discoloration of the resin.

1-2 Screw design
- A lower compression ratio around 2 is preferable, but molding is possible with about 3.3.
- A full flight screw is recommended to use. It is preferable that the screw head incorporates a baffles prevention mechanism (a check valve).
- High shear stress at plastification may cause discoloration and/or black spots on APEL™.

1-3 Material of screw and cylinder
- Coating of non-attachment properties to resinated resin is recommended to use.
- Effective coating include Cr plating as well as TiN, TCN, TiC or W2C.

1-4 Nozzle
- Open type or slit of slot type is available.

2. Mold Design

2-1 Basic Structure
- Mold should be designed with APEL™ mold shrinkage of 0.6%, followed by a fine adjustment. A 0.2% shrinkage or greater should be avoided, taking the mold shrinkage into consideration.
- APEL™ is a resin that has high rigidity and is low in extensibility, this is not suitable for for undercut shape which may cause cracks on mold goods.

2-2 Material of mold
- A material that is suitable for thorough mirror polishing and on the mold surface of which gases resulting from molding processes are unlikely to produce tarnish.

2-3 Gates, Runners and Sprues
- Shapes similar to those used for conventional resins are applicable.
- A stagnant gate is effective for reducing internal stress in the gate of mold goods and for eliminating the need of finishing process on the gate of mold goods.
- A cold runner is more recommended than a hot runner as a hot runner may cause black spots, yellowing and/or discoloration due to retention of resins.
- Round type is the most suitable for runner.

2-4 Degassing
- Engaging can be done through the parting lines, but when tarnish is likely on account of gases is generated it will be necessary to make an approximately 0.02 mm deep ditch for degassing.

2-5 Stringiness prevention
- A high nozzle temperature can cause stringiness. A sprue having a stringiness preventing function will be effective.

3. Method of molding

3-1 Pre-drying
- Pre-drying of the pellets is recommended.
- APEL™, being a low hygroscopic resin, can be molded without pre-drying.
- However, a slight amount of water on the surface of a pellet may affect the appearance of molded goods. Moreover, dissolved air in such a pellet may cause yellow discoloration and/or gas-inclusion if gasified it can cause poor transparency.
- Accordingly, pre-drying is effective whenever a high standard appearance is required.
- Pre-drying a pellet is also effective in making smooth plasticization at molding.

3-2 Material Purging
- When another material has been used, it is necessary to perform a purge with a commercially available cleaning pellet that is suitable for the existing temperature at plastification (hot-end-type) for 2 to 5 kg or as long as replacing to APEL™ for 2 to 5 kg. Check for moisture or tested surface on the molded goods.
- If purging is still insufficient, it will be effective to use glass-fiber reinforced polycarbonate as a purging material or to perform a cleaning with the screw removed.

3-3 Molding Conditions
- Cylinder Temperature
- The heat resistance of APEL™ offers according to grade, as a cylinder temperature should be set in line with the following formula:
- Cylinder temp. = APEL™ softening temp. + 100 to 130°C.

- Except for the space under the hopper, the temperature of each cylinder block should be practically flat.

- When temperature setting is too low and noice is found in the cylinder, increase the cylinder temperature. Decreasing the temperature in the hopper (from melting temperature to some compression section) will be especially effective.

- Mold Temperature
- Mold transfer performance of APEL™ tends to be affected by mold temperature. The lower the mold temperature (measured value) is to the glass transition temperature (Tg) of the resin, the better the mold transfer is. Adjunct to the “Tg” of the resin. (Recommended Temperature: Tg Tuesday - Tg+5°C (Measured value)

- [Back Pressure]
- 0.3-0.5MPa(50-80kgf/cm2) maximum 10MPa(150kgf/cm2)
- Too much backpressure may lead to yellowing, discoloration and/or gel generation.

- [Injection Pressure]
- Holding pressure (secondary pressure) should be set as low as possible in the range of 50 to 150 MPa.
- Because of high solidification speed of amorphous materials such as APEL™, too high holding pressure will cause cracks and/or leave deformation around the gate.

- [Injection Speed]
- Increasing injection speed is effective in improving mold transition, thus improving the appearance of goods.

- [Suck Back]
- Suck-back should be avoided as much as possible.
- Although suck-back is effective in preventing stringiness, by dragging air in from the nozzle it may cause bubbles and/or yellowing. If suck-back is unavoidable, make the suck-back volume minimal.

- [Screen Speed]
- If the screw speed is too high, it may drop air in and cause bubbles.

3-4 Pausing or termination of molding
- Stop the molding machine to interrupt the operation for a short time.
- If an interruption extends over 1 hour, lower the cylinder temperature to 100°C to avoid leaving the resin inside the cylinder.
- To terminate the operation, switch off the heater after the cylinder internal area is replaced with polycarbonate.
### Optical Grade Line-Up

#### Table of Product Properties

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Measurement method</th>
<th>Unit</th>
<th>Optical grade</th>
<th>Non-optical grade</th>
<th>Competitor's Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMA</td>
<td>Mitsui Chemicals method</td>
<td>°C</td>
<td>APL5016T</td>
<td>APL5014T</td>
<td>-</td>
</tr>
<tr>
<td>1g</td>
<td>Mitsui Chemicals method</td>
<td>°C</td>
<td>APL5016T</td>
<td>APL5014T</td>
<td>-</td>
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<tr>
<td>Specific gravity</td>
<td>ASTM D929</td>
<td>g/mm²</td>
<td>APL5016T</td>
<td>APL5014T</td>
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<tr>
<td>HDT (1.69MPa)</td>
<td>ASTM D648</td>
<td>°C</td>
<td>APL5016T</td>
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<tr>
<td>Tensile modulus of elasticity</td>
<td>ASTM D638</td>
<td>MPa</td>
<td>APL5016T</td>
<td>APL5014T</td>
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<tr>
<td>Tensile strength at yield</td>
<td>ASTM D638</td>
<td>MPa</td>
<td>APL5016T</td>
<td>APL5014T</td>
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<tr>
<td>Flexural modulus</td>
<td>ASTM D970</td>
<td>MPa</td>
<td>APL5016T</td>
<td>APL5014T</td>
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<tr>
<td>Flexural strength</td>
<td>ASTM D970</td>
<td>MPa</td>
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<td>Impact test</td>
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<td>J/360m²</td>
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<td>APL5014T</td>
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<td>Rockwell hardness</td>
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<td>k/20°C</td>
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<td>APL5014T</td>
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<td>Moisture permeability</td>
<td>ASTM F1249</td>
<td>g/mm²/m-50d</td>
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<tr>
<td>Total light transmission(20mm)</td>
<td>JS-073A1</td>
<td>%</td>
<td>APL5016T</td>
<td>APL5014T</td>
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<tr>
<td>haze</td>
<td>JS-071T3</td>
<td>%</td>
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<tr>
<td>Refractive index</td>
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<tr>
<td>Ash’s number</td>
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<td>-</td>
<td>APL5016T</td>
<td>APL5014T</td>
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<tr>
<td>Pachydispersion(dispjg)</td>
<td>-</td>
<td>-</td>
<td>APL5016T</td>
<td>APL5014T</td>
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<tr>
<td>Birefringence</td>
<td>Central part at 0-20 mm of a square plate 65x65x30 (mm)</td>
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<td>APL5016T</td>
<td>APL5014T</td>
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<tr>
<td>Mold shrinkage (MD/TFD)</td>
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<td>%</td>
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<td>APL5014T</td>
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<tr>
<td>Coefficient of linear expansion</td>
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<tr>
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<td>-</td>
<td>APL5016T</td>
<td>APL5014T</td>
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</tbody>
</table>

### Product Line-Up

#### Heat Resistance Improvement

#### Optical grade

<table>
<thead>
<tr>
<th>Application Sample</th>
<th>Optical</th>
<th>Automotive Camera</th>
<th>Medical packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphone</td>
<td>Smartphone, Automotive Camera</td>
<td>HMD, HUD</td>
<td>3D, Projector, DVD</td>
</tr>
<tr>
<td>Automotive</td>
<td>Smartphone, Automotive Camera</td>
<td>HMD, HUD</td>
<td>3D, Projector, DVD</td>
</tr>
<tr>
<td>Industrial parts</td>
<td>3D, Projector, DVD</td>
<td>3D, Projector, DVD</td>
<td>3D, Projector, DVD</td>
</tr>
<tr>
<td>Medical packages</td>
<td>3D, Projector, DVD</td>
<td>3D, Projector, DVD</td>
<td>3D, Projector, DVD</td>
</tr>
</tbody>
</table>

#### Non-optical grade

<table>
<thead>
<tr>
<th>Application Sample</th>
<th>Optical</th>
<th>Automotive Camera</th>
<th>Medical packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphone</td>
<td>Smartphone, Automotive Camera</td>
<td>HMD, HUD</td>
<td>3D, Projector, DVD</td>
</tr>
<tr>
<td>Automotive</td>
<td>Smartphone, Automotive Camera</td>
<td>HMD, HUD</td>
<td>3D, Projector, DVD</td>
</tr>
<tr>
<td>Industrial parts</td>
<td>3D, Projector, DVD</td>
<td>3D, Projector, DVD</td>
<td>3D, Projector, DVD</td>
</tr>
<tr>
<td>Medical packages</td>
<td>3D, Projector, DVD</td>
<td>3D, Projector, DVD</td>
<td>3D, Projector, DVD</td>
</tr>
</tbody>
</table>

### Data

The data indicated in this material are representative values obtained by our own testing methods. The contents in this material are based on currently available information and data etc. Please be mentioned that we do not provide any warranty about the listed data and evaluation.