AFLAS® Fluoroelastomers for HEV/EV Cable Applications
What is AFLAS®?

- AFLAS 100 and 150 Series are unique fluoroelastomers
  - Classified by ASTM D1418 as FEPM
- Totally different from other FKM type fluoroelastomers
  - Viton
  - Daiel
  - Tecnoflon
  - Etc…
- AFLAS 100 and 150 Series are formulated as Tetrafluoroethylene/Propylene copolymer (TFE/P)
- AGC is the only manufacturer of this polymer in the world
Benefits of AFLAS

• Excellent heat resistance
  o 200°C continuous service temperature
• Superior base resistance
• Unmatched electrical resistivity compared to FKM grades
• Used today for various cable insulator applications
  o HEV / EV power cable
  o Transmission cable
  o ATF resistant
Positioning Map for Various Elastomers

Heat Resistance (℃)

Oil Resistance (ΔV% ASTM No. 3 Oil)

ACM
HNBR
CR
VMQ
EPDM
NR
FKM, FEPM
AFLAS

Fluoroelastomers

Fluoroelastomers

Acrylonitrile-Butadiene Rubber (NBR)
Chloroprene Rubber (CR)
Neoprene Rubber (NR)
Styrene-Butadiene Rubber (SBR)
Ethylene-Propylene-Diene Monomer Rubber (EPDM)
Vinyl Chloride-Vinyl Acetate Copolymer (VMQ)
Viton (FKM, FEPM)
AFLAS

Heat Resistance

Oil Resistance
Polymer Structure

FEPM = AFLAS TFE-P

\[-(\text{CF}_2-\text{CF}_2)_p-(\text{CH}_2-\text{CH})_q-\]

TFE  Pr

FKM = Viton, etc.

\[-(\text{CH}_2-\text{CF}_2)_l-(\text{CF}_2-\text{CF})_m-\]

VdF  HFP  \[-(\text{CF}_2-\text{CF}_2)_n-\]

TFE

Deterioration by Base
AFLAS Advantages Over FKM

Heat Resistance
Acid Resistance
Base Resistance
Steam Resistance
Electrical Resistivity
Volume Swell in Nonpolar Solvents
Flexibility at Low Temp
Brittle Point
## Resistance to Automotive Fluids

<table>
<thead>
<tr>
<th>Oil</th>
<th>Component</th>
<th>Application</th>
<th>Temperature (ºC)</th>
<th>AFLAS®</th>
<th>FKM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Oil</td>
<td>Crank Shaft Seal</td>
<td>160</td>
<td>⌀</td>
<td>△</td>
<td></td>
</tr>
<tr>
<td>AT Fluids</td>
<td>Transmission Seal</td>
<td>160</td>
<td>⌀</td>
<td>△</td>
<td></td>
</tr>
<tr>
<td>Gear Oil</td>
<td>Pinion Seal</td>
<td>135</td>
<td>⌀</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Brake Fluids Polyglycolether</td>
<td>135</td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coolants</td>
<td>Glycol-H₂O</td>
<td>Cylinder Liner Seal</td>
<td>135</td>
<td>○</td>
<td>△</td>
</tr>
<tr>
<td>Operating Oils</td>
<td>Glycol-H₂O</td>
<td>Shock Absorber Seal</td>
<td>110</td>
<td>○</td>
<td>△</td>
</tr>
<tr>
<td>Phosphate</td>
<td>-</td>
<td>-</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Silicone Oil</td>
<td>-</td>
<td>-</td>
<td>○</td>
<td>△</td>
<td></td>
</tr>
<tr>
<td>Fuels</td>
<td>Gasoline</td>
<td>110</td>
<td>x</td>
<td>⌀</td>
<td></td>
</tr>
<tr>
<td>Light Oil</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>⌀</td>
<td></td>
</tr>
<tr>
<td>Heavy Oil</td>
<td>-</td>
<td>-</td>
<td>⌀</td>
<td>△</td>
<td></td>
</tr>
<tr>
<td>100% Methanol</td>
<td>-</td>
<td>-</td>
<td>⌀</td>
<td>△</td>
<td></td>
</tr>
</tbody>
</table>

- **⌀**: Suitable
- **○**: Applicable
- **△**: Caution
- **X**: Not Applicable
AFLAS has excellent electrical resistivity and heat resistance.

<table>
<thead>
<tr>
<th></th>
<th>AFLAS 150</th>
<th>AFLAS 200</th>
<th>FKM</th>
<th>EPDM</th>
<th>Silicone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume Resistivity (Ω•cm)</td>
<td>$10^{16}$</td>
<td>$10^{15}$</td>
<td>$10^{13}$</td>
<td>$10^{16}$</td>
<td>$10^{16}$</td>
</tr>
<tr>
<td>Dielectric constant (1 kHz)</td>
<td>3</td>
<td>6</td>
<td>10</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Dielectric strength (kV/mm)</td>
<td>23</td>
<td>16</td>
<td>20</td>
<td>40</td>
<td>25</td>
</tr>
</tbody>
</table>
Weight Reduction Concept for HEV/EV Cable

Choice of High Voltage Cable

XL-PE: (150°C)
AFLAS: (200°C)
Weight Reduction Concept: Cable Comparison

- **XLPE / Aluminum**
  - Core wire size: 38mm²
  - Thickness of insulator: 1.4mm
  - Cable diameter: 11.0mm
  - Cable weight: 219g/m
  - Cable volume: 95cm³/m
  - 14wt% lighter, 52vol% reduced

- **XLPE / Cu**
  - Core wire size: 20mm²
  - Thickness of insulator: 1.1mm
  - Cable diameter: 8.7mm
  - Cable weight: 241g/m
  - Cable volume: 59cm³/m
  - 22wt% lighter, 24vol% reduced

- **Cu copper wire**
  - Core wire size: 15mm²
  - Thickness of insulator: 1.1mm
  - Cable diameter: 7.6mm
  - Cable weight: 189g/m
  - Cable volume: 45cm³/m
  - Same spec of maximum electric current 115A at 80°C

Same conductivity for XLPE / Aluminum and XLPE / Cu.
Advantages of AFLAS cable concept:

• Non-Flammable
• Weight Reduction
• Improved Flexibility
• Vibration Resistance
• Excellent Heat Resistance
• Superior Chemical resistance

Disadvantages of XL-PE material usage:

• Filler added (lots of Mg(OH)2)
• Stiff
• Limited Heat Resistance
• Intelligent Resins
• Custom Compounds
• Smart Chemistry Solutions

Learn more
www.agcchem.com
800-424-7833

Your Dreams, Our Challenge