Halal® ECTFE
Fluoropolymer Coatings for Cleanroom Exhaust Duct Systems

The choice for performance and safety
To protect your critical ductwork, specify Halar® ECTFE.

This guide is intended to clarify the advantages of Halar ECTFE over ETFE for fluoropolymer coated duct applications. The information contained here summarizes the critical performance criteria required for exhaust duct applications, as outlined in the table below.

Detailed information is available upon request.

<table>
<thead>
<tr>
<th>Critical Performance</th>
<th>Halar ECTFE</th>
<th>ETFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Safety</td>
<td>SUPERIOR</td>
<td>Average</td>
</tr>
<tr>
<td>Surface Smoothness</td>
<td>SUPERIOR</td>
<td>Average</td>
</tr>
<tr>
<td>Permeation Resistance</td>
<td>Equal</td>
<td>Equal</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>Equal</td>
<td>Equal</td>
</tr>
<tr>
<td>Hardness</td>
<td>SUPERIOR</td>
<td>Average</td>
</tr>
<tr>
<td>Adhesion</td>
<td>SUPERIOR</td>
<td>Average</td>
</tr>
</tbody>
</table>
Halar ECTFE - A History of Success.

A leading choice in semiconductor fabs.

Since 1990, Halar ECTFE powder coatings have been used successfully for corrosion protection of exhaust duct systems that must meet the FM 4922 fire safety standard. In fact, Halar ECTFE was the first fluoropolymer coating to gain approval and listing under FM 4922 for Fume/Smoke Exhaust Duct Systems. Today, Halar is part of hundreds of duct system installations at more than 70 fabs worldwide.

In addition, Halar plastic sheet is used to meet FM 4910 and UL 2360 standards for fabrication of fire-safe cleanroom tools. And, seamless Halar powder coatings have replaced PVDF sheet linings in ultrapure water (UPW) systems (i.e., filter housing, ion exchange beds, storage tanks).

Success in chemical processing applications.

For over 20 years, Halar has also achieved exceptional results in chemical processing applications. It is used extensively as a coating and/or lining material for exhaust duct, vessels, and process equipment.
Superior fire safety properties of Halar ECTFE.

In response to industry-wide concerns about the fire resistance of all materials and components used in cleanroom process tools, the more stringent standards of FM 4910, UL 2360, and FM 4922 were established. These standards govern materials of construction for cleanroom equipment and exhaust duct systems.

Halar ECTFE can help you meet these standards, with performance properties for exhaust duct that include:

- FM 4922 Listing
- FM 4910 Listing
- Superior Limiting Oxygen Index (LOI)\(^a\) – 60 for Halar vs. 32 for ETFE
- UL rated to 94 V0

\(^a\) LOI is used to define the level of oxygen needed to support combustion, according to ASTM Method D2863.

In addition, Halar plastic sheet is FM 4910 listed and meets the UL 2360 Standard for Cleanroom Wet Bench and Tool construction. ETFE plastic sheet does not meet these standards.

High ignition resistance.

As the table shows, Halar ECTFE is much more difficult to ignite in the presence of an external heat source than ETFE.

<table>
<thead>
<tr>
<th>Polymer</th>
<th>Halar ECTFE</th>
<th>ETFE</th>
</tr>
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<tbody>
<tr>
<td>Auto-Ignition Temperature(^b)</td>
<td>655(^\circ)C (1211(^\circ)F)</td>
<td>500(^\circ)C (932(^\circ)F)</td>
</tr>
<tr>
<td>Critical Heat Flux(^c) (kW/ m(^2))</td>
<td>74</td>
<td>16</td>
</tr>
</tbody>
</table>

\(^b\) The lowest temperature for a combustible material to ignite in air without spark or flame. (ASTM D1929)

\(^c\) Critical heat flux is a measure of the energy needed to start ignition. The higher the value, the more flame retardant the material. (ASTM E1354)
Outstanding resistance to fire spread.

Halar ECTFE resists fire spread better than ETFE. Halar ECTFE forms a char to inhibit the flow of molten polymer. By contrast, ETFE breaks down into low molecular weight fragments that induce flow and cause fire dripping.

Within the Uniform Building Code (UBC), the ASTM E-84 test is used to measure surface burning characteristics of building materials. Halar ECTFE coated steel panels are rated to a value of 5d which places it within Class I of the safest materials in the UBC. ETFE coated steel panels were rated 10. Halar consistently measures one-half the value of ETFE in flame spread testing.

$^d$ Reference: concrete = 0; red oak = 100

**Halar ECTFE**

Demonstrating Halar’s superior resistance to fire spread. Testing done on powder coating grades compression molded.
Coating thickness: Fire safety unaffected.

Compared with ETFE, the flammability of Halar is relatively unaffected by coating thickness, giving fabricators more flexibility in adding extra protection against corrosion and pinholes.

In FM 4922 testing, ETFE coating with a thickness of 10 mil had a temperature of 950°F at the exhaust duct end, marginally meeting the requirement of 1000°F. Halar ECTFE, with a thickness of 12 mil had a temperature of 625°F at the exhaust duct end. This result implies that ETFE coating with a thickness greater than 10 mil will not pass the FM 4922 requirement.

Heat release data shown in the chart to right demonstrates the superior resistance to ignition and fire spread of Halar ECTFE coatings versus ETFE coatings, regardless of thickness or energy source.

*e As reported in competitor’s published data.

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**FM 4922 Test Temperature Measurement**

![Temperature Chart](chart.png)

- **FM 4922 Maximum Temp Limit is 1000 °F**
- **Halar ECTFE 12 mils thick**
- **ETFE 10 mils thick**
Heat Release Comparison of Fluoropolymer Coatings

![Graph showing heat release rate comparison for different coating thickness and materials.](graph.png)
Properties of Halar Coated Ductwork.

Exceptional surface smoothness properties.

As shown in the AFM images and calculated surface roughness (Ra) values and AFM images, Halar ECTFE powder coated duct has a much smoother surface than ETFE coated duct.

Benefits of a smoother surface include:

- Reduces the risk of pinholes in the coating
- Inhibits buildup and accumulation of particles and metallic salts

These benefits result in better corrosion protection.

Surface smoothness parameters of fluoropolymer powder coatings.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Halar ECTFE</th>
<th>ETFE T1</th>
<th>ETFE T2</th>
<th>ETFE A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean roughness (Ra), nm</td>
<td>21.93</td>
<td>59.99</td>
<td>63.77</td>
<td>53.67</td>
</tr>
</tbody>
</table>

Note: Results on actual powder coated samples.
AFM Images of Powder Coatings

Halar® ECTFE

ETFE T1

ETFE T2

ETFE A

X 10,000 um/ div
Z 1000,000 nm/ div
**Wide-ranging chemical resistance.**

Halar coatings are resistant to solvents and acids/bases (pH 1–14). They have been used successfully for universal corrosion protection in the chemical processing industry since 1975.

In particular, Halar provides excellent resistance against these chemistries commonly encountered in exhaust duct:

- Hydrofluoric Acid (H F)
- Sulfuric Acid (H SO₄)
- Nitric Acid (H NO₃)
- Piranha
- Hydrogen Peroxide (H₂O₂)
- Ozone (O₃)
- Ammonium Hydroxide (NH₄OH)
- All Alkaline Chemistries
- All Etchants and Strippers
**Greater hardness.**

As illustrated in the table, Halar ECTFE produces harder coatings that are less prone to scratches and mechanical damage from sharp objects than ETFE coatings.

**Excellent coating adhesion.**

Halar ECTFE coatings provide excellent adhesion, as demonstrated by film rupture in a peel test. In fact, Halar ECTFE develops adhesion stronger and faster than ETFE.

Between 23 to 50°C, the thermal expansion coefficient of Halar coating (8~10 x 10⁻⁵ mm/mm/°C) is lower than that of ETFE (12~15 x 10⁻⁵ mm/mm/°C). A lower thermal expansion reduces the risk of stresses between the coating and the substrate that can accumulate during the coating process, leading to longer service life.

### Hardness of Fluoropolymer Coatings

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<tr>
<th>Polymer</th>
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<tbody>
<tr>
<td>Shore D (ASTM D2240)</td>
<td>D75</td>
<td>D67</td>
</tr>
<tr>
<td>Pencil Scratch Test f (ASTM D3363)</td>
<td>2B</td>
<td>6B</td>
</tr>
<tr>
<td>Cut through g (ASTM D3032)</td>
<td>54 (240)</td>
<td>46 (205)</td>
</tr>
</tbody>
</table>

f Determined by the lowest hardness of pencil to scratch the coating surface.

g Measures the force required to cut a 0.25 mm thick coating down to wire with a specified blade.

### Adhesion Development Comparison of Commercial Duct Coating Systems

Adhesion test conducted using coating conditions recommended by the resin manufacturer. Halar ECTFE is processed at 275°C; ETFE at 315°C. Primers are applied to develop maximum adhesion. The manufacturer of ETFE A recommends use of topcoat only.
Discover all the advantages.

For full details on how Halar ECTFE can help improve the safety and reliability of your critical processes, call (800) 323-2874 or visit www.solvaysolexis.com. Halar ECTFE ductwork systems are available worldwide.