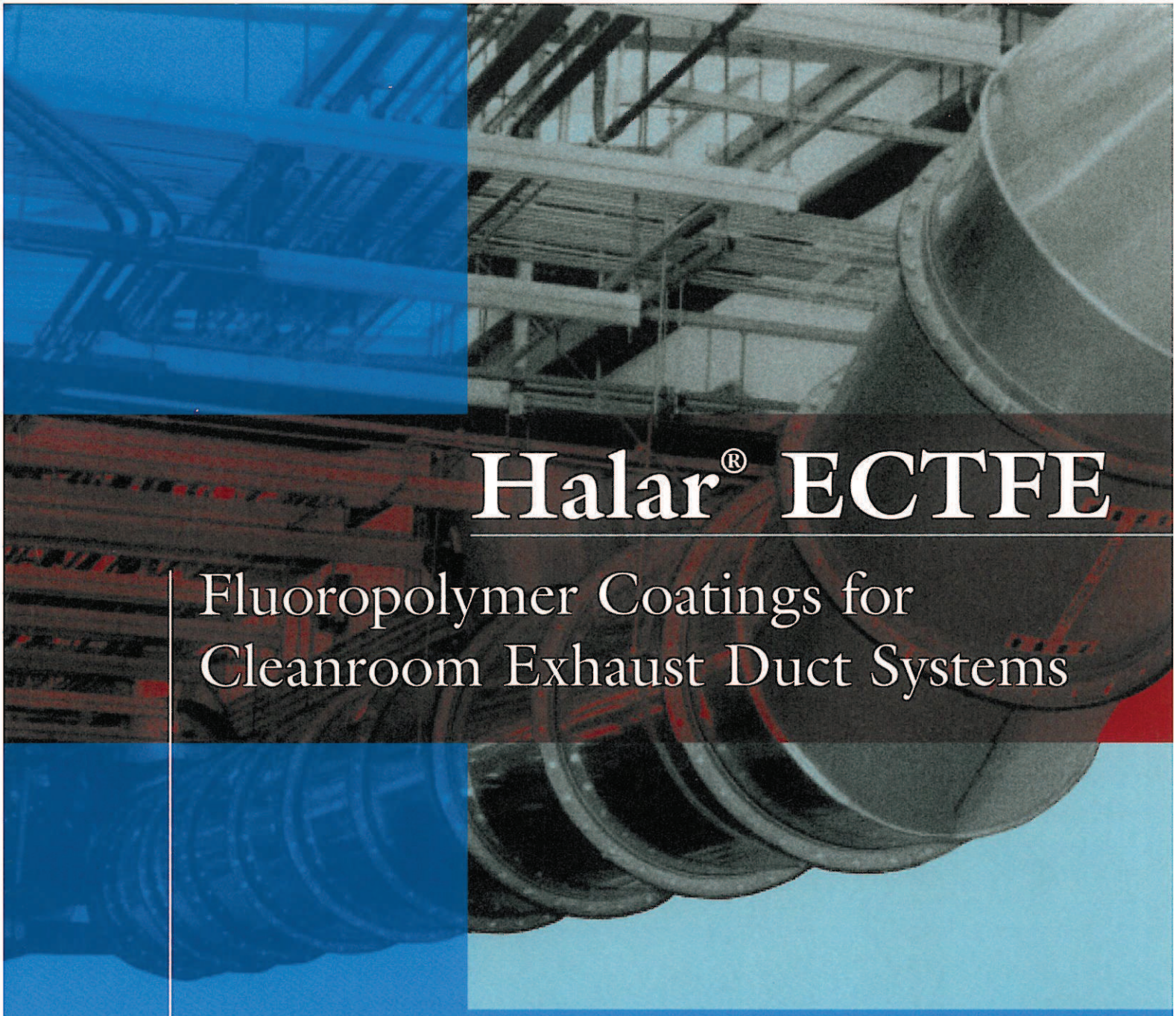


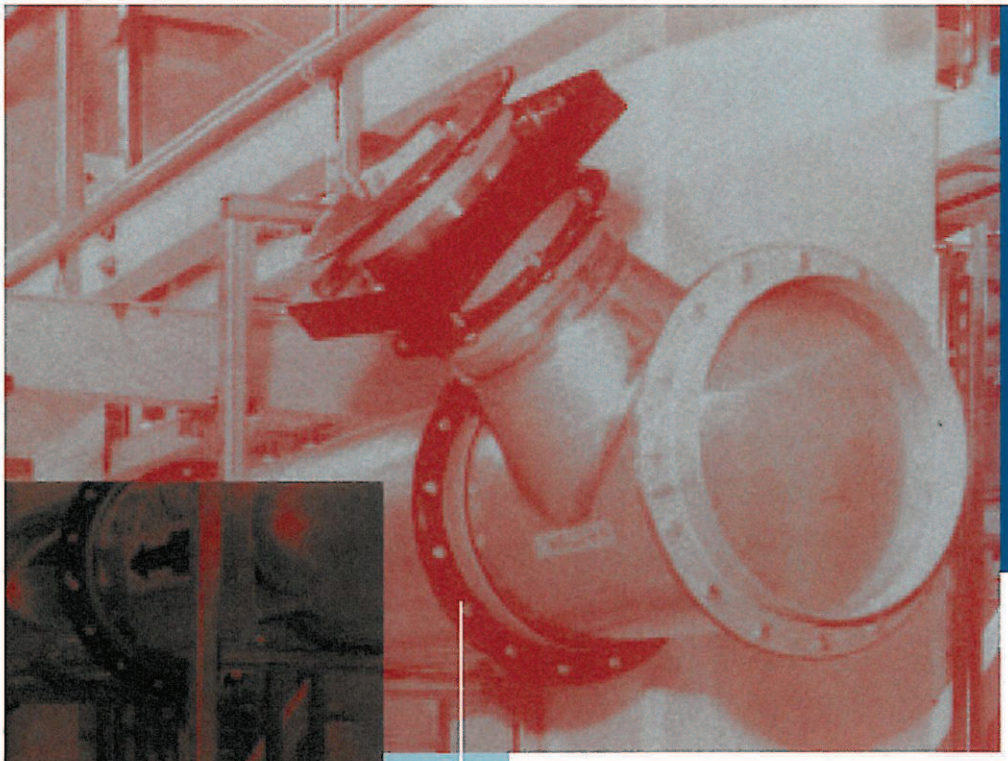
Halar® ECTFE

Fluoropolymer Coatings for Cleanroom Exhaust Duct Systems

The choice for performance and safety

Solvay
Solexis

SOLVAY



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.

Critical Performance

Criteria	Halar ECTFE	ETFE
Fire Safety	SUPERIOR	Average
Surface Smoothness	SUPERIOR	Average
Permeation Resistance	Equal	Equal
Chemical Resistance	Equal	Equal
Hardness	SUPERIOR	Average
Adhesion	SUPERIOR	Average

Halar ECTFE - A History of Success.

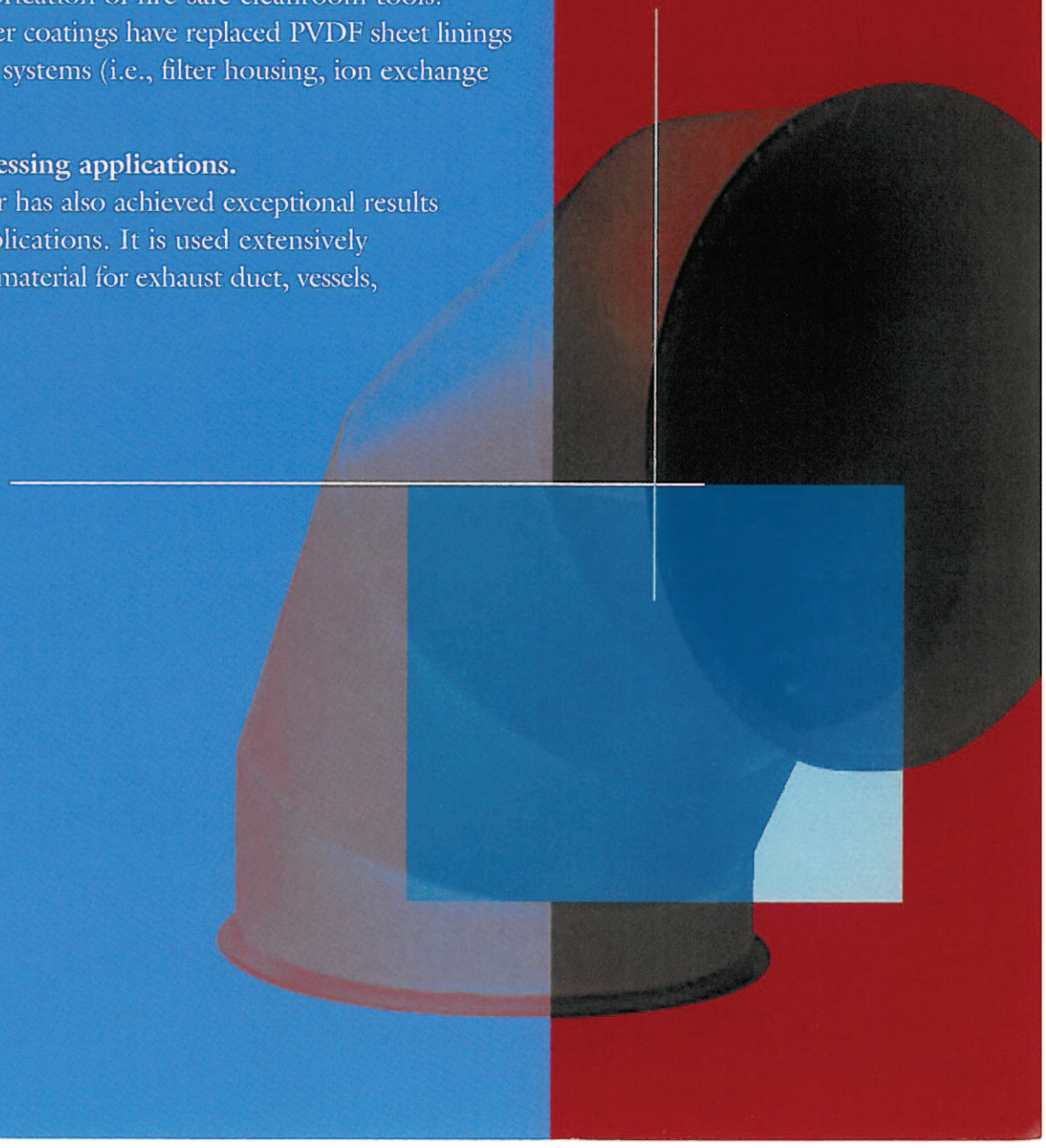
A leading choice in semiconductor fabs.

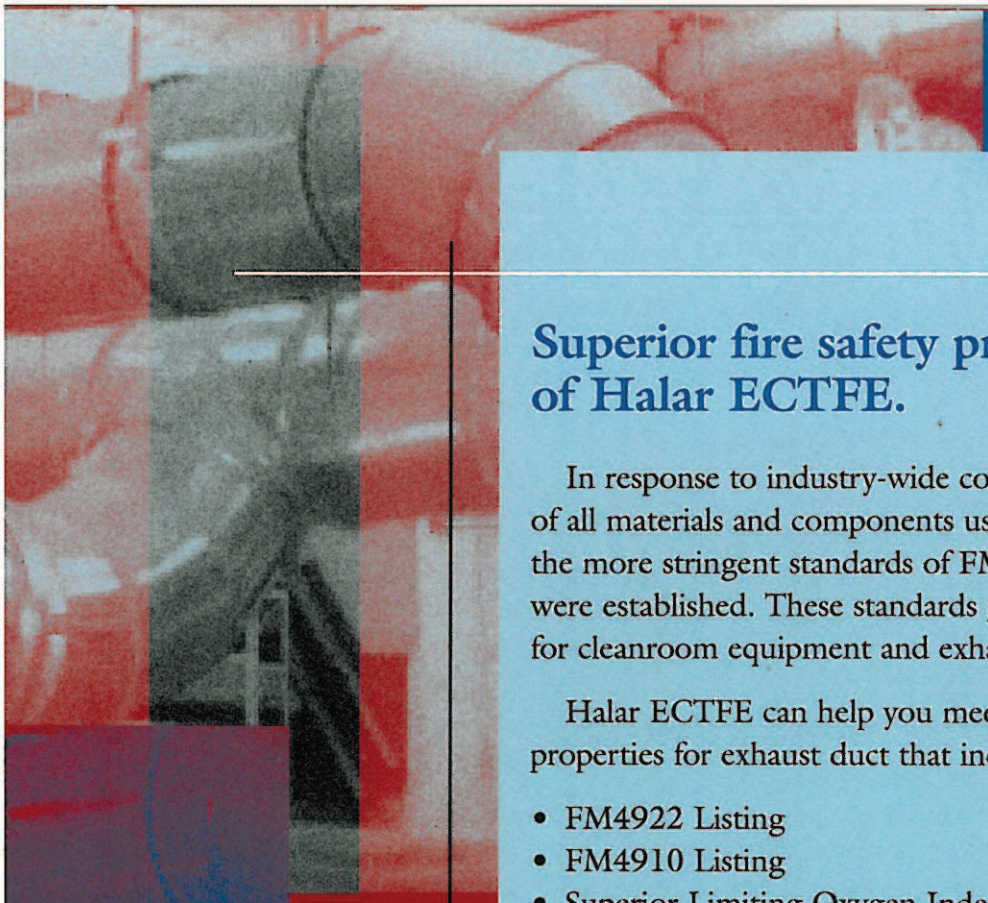
Since 1990, Halar ECTFE powder coatings have been used successfully for corrosion protection of exhaust duct systems that must meet the FM4922 fire safety standard. In fact, Halar ECTFE was the first fluoropolymer coating to gain approval and listing under FM4922 for Fume/Smoke Exhaust Duct Systems. 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 FM4910 and UL2360 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 FM4910, UL2360, and FM4922 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:

- FM4922 Listing
- FM4910 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 FM4910 listed and meets the UL2360 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.

Polymer	Halar ECTFE	ETFE
Auto-ignition Temperature[b]	655°C (1211°F)	500°C (932°F)
Critical Heat Flux[c] (kW/m²)	74	16
	SUPERIOR	Average

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

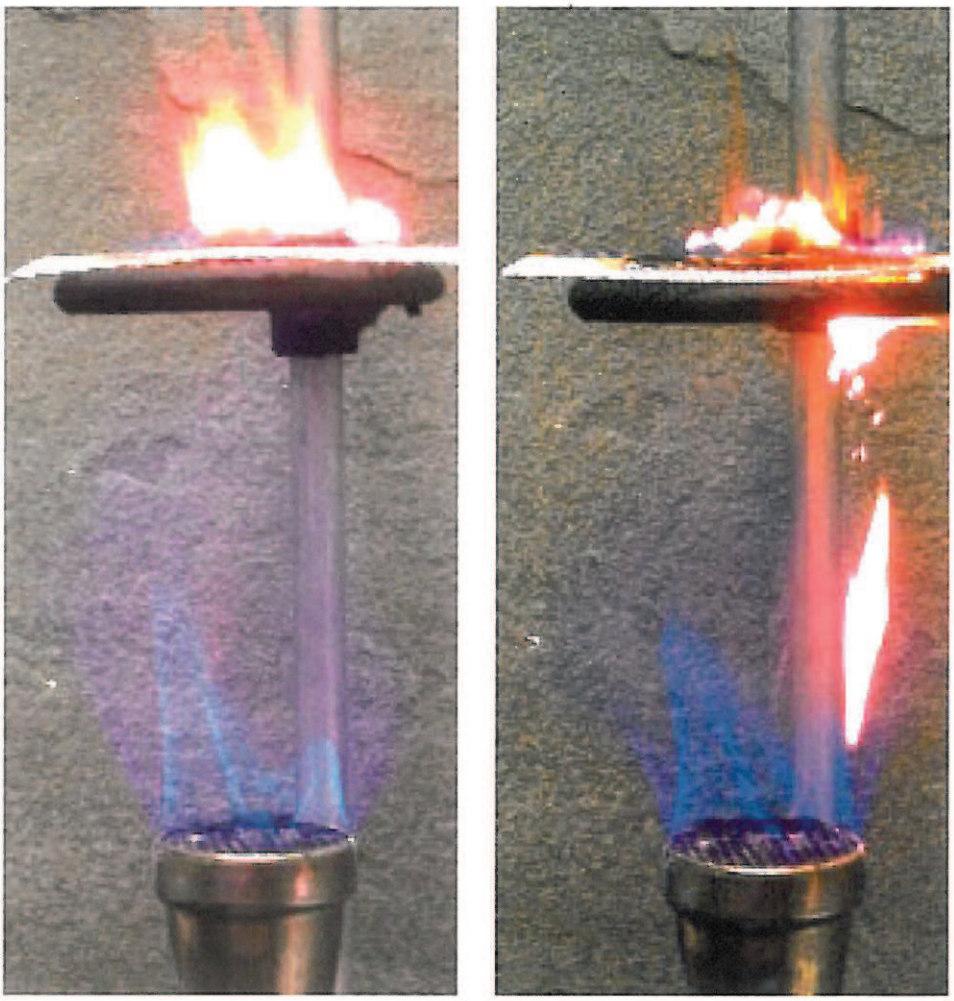
[c] Critical heat flux is a measure of the energy needed to start ignition. The higher the value, the more flame retardant the material. (ASTM E1354)

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 5[d] 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 **ETFE**

Demonstrating Halar's superior resistance to fire spread. Testing done on powder coating grades compression molded.

Coating thickness: Fire safety unaffected.

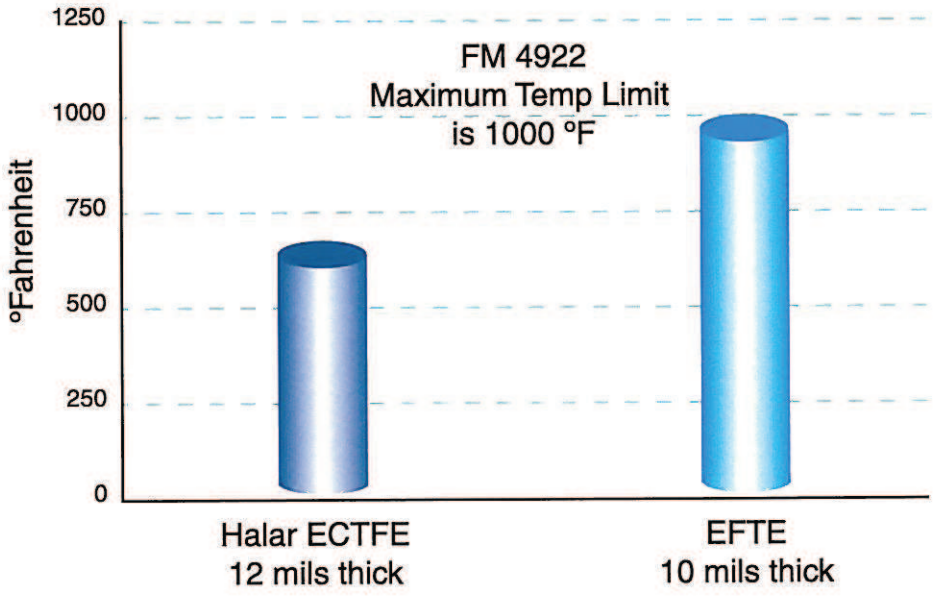
Compared with ETFE, the flammability of Halar is relatively unaffected by coating thickness, giving fabricators more flexibility in adding extra protection against corrosion and pinholes.

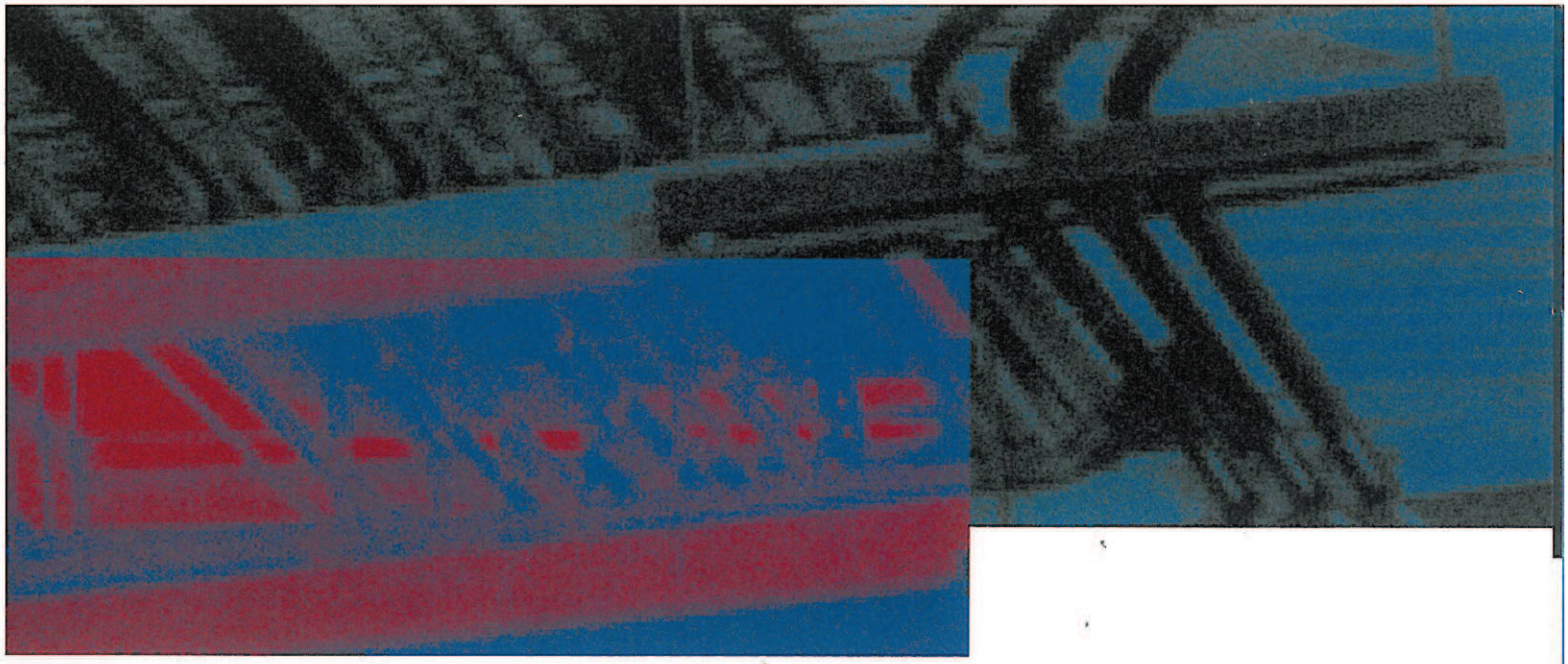
In FM4922 testing, ETFE coating with a thickness of 10 mil had a temperature of 950°F[c] at the exhaust duct end, marginally meeting the requirement of 1000°F. Halar ECTFE, with a thickness of 12 mil had a temperature of 625°F at the exhaust duct end. This result implies that ETFE coating with a thickness greater than 10 mil will not pass the FM4922 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.

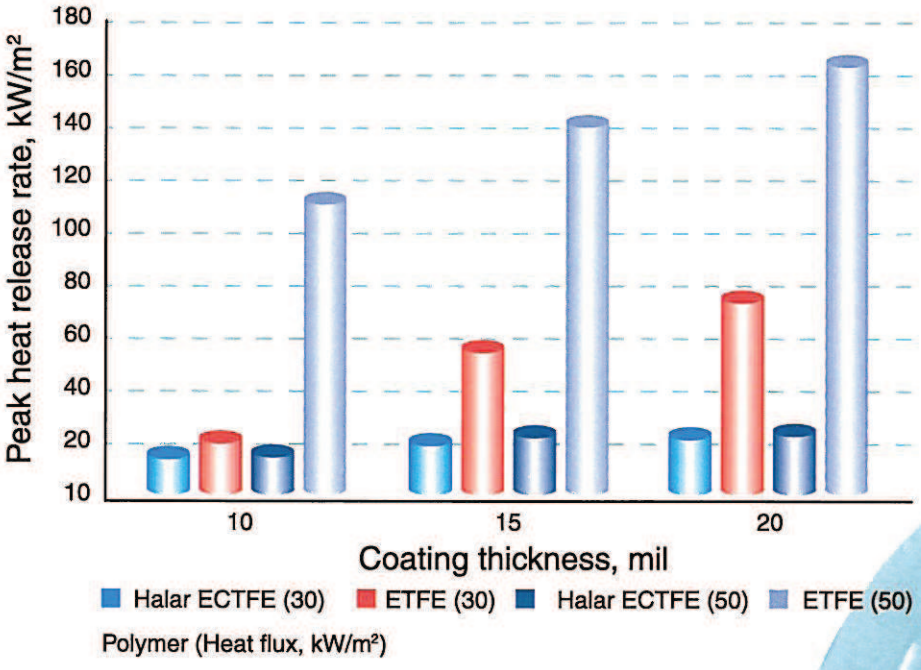
[c] As reported in competitor's published data.

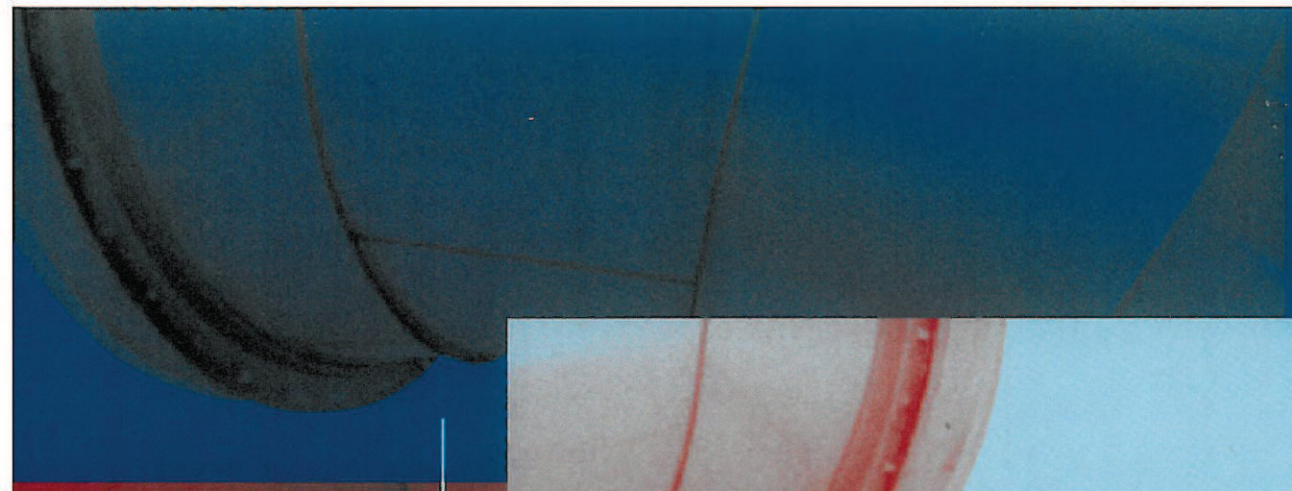
FM 4922 Test Temperature Measurement





Heat Release Comparison of Fluoropolymer Coatings





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

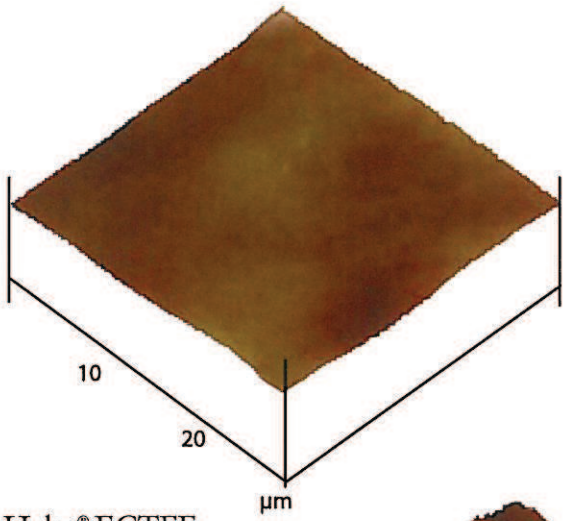
These benefits result in better corrosion protection.

Surface smoothness parameters of fluoropolymer powder coatings.

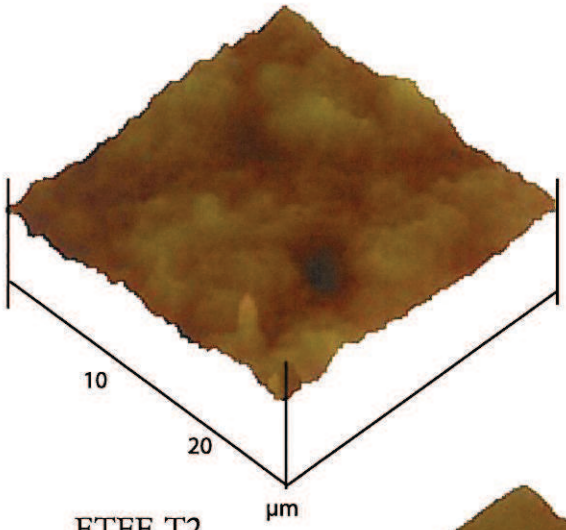
Sample	Halar ECTFE	ETFE T1	ETFE T2	ETFE A
Mean roughness (Ra), nm	21.93	59.99	63.77	53.67
	SUPERIOR	Average	Average	Average

Note: Results on actual powder coated samples.

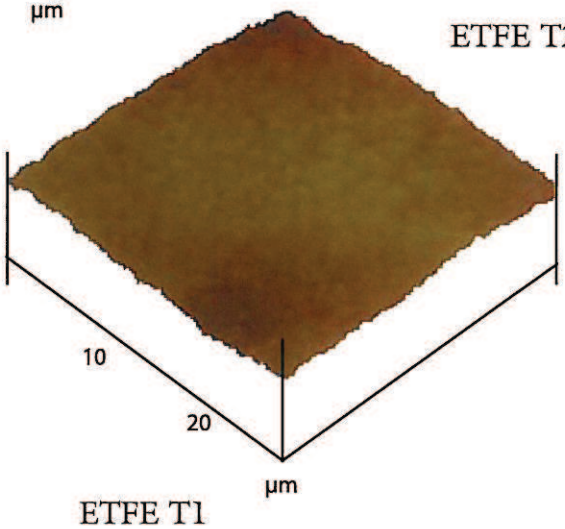
AFM Images of Powder Coatings



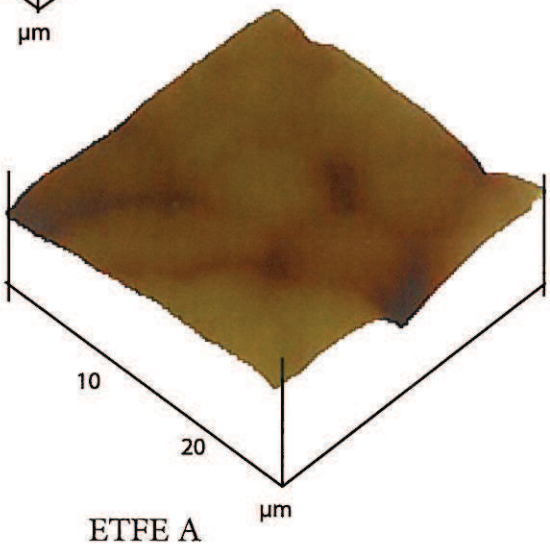
Halar® ECTFE



ETFE T2



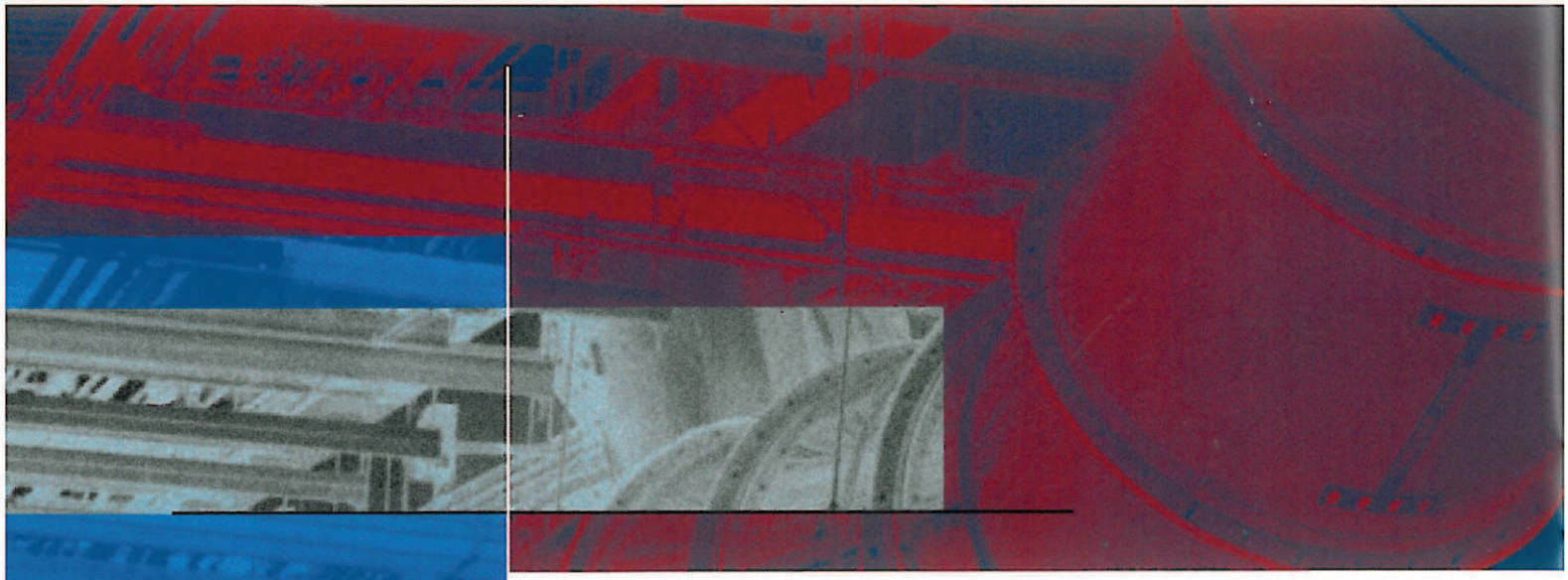
ETFE T1



ETFE A

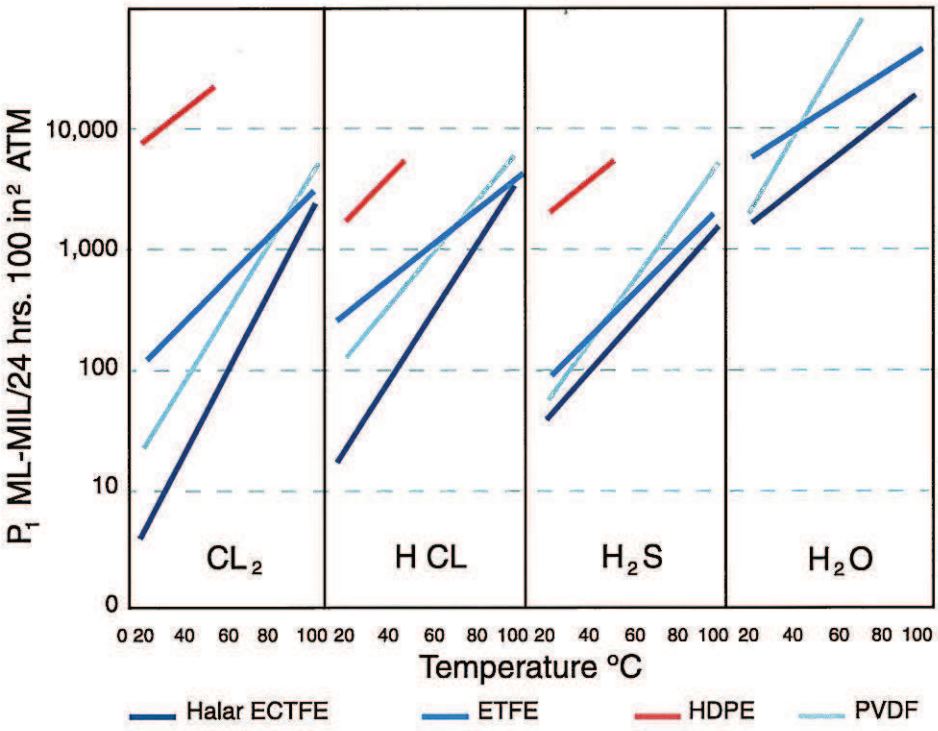
X 10.000 um/div

Z 1000.000 nm/div



Superior permeation resistance.

For chemistries encountered in semiconductor exhaust tools, Halar ECTFE provides excellent permeation resistance. Because the chlorine atom in Halar ECTFE is larger than the fluorine atom in ETFE, the segments of the molecule are more restricted in rotation. This reduced mobility, coupled with Halar's advantages in coating thickness, further enhance Halar's permeation resistance.



The chart shows simple chemistries that are components of the more complex chemistries found in exhaust duct systems.

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 (HF)
- Sulfuric Acid (H_2SO_4)
- Nitric Acid (HNO_3)
- Piranha
- Hydrogen Peroxide (H_2O_2)
- Ozone (O_3)
- Ammonium Hydroxide (NH_4OH)
- 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.

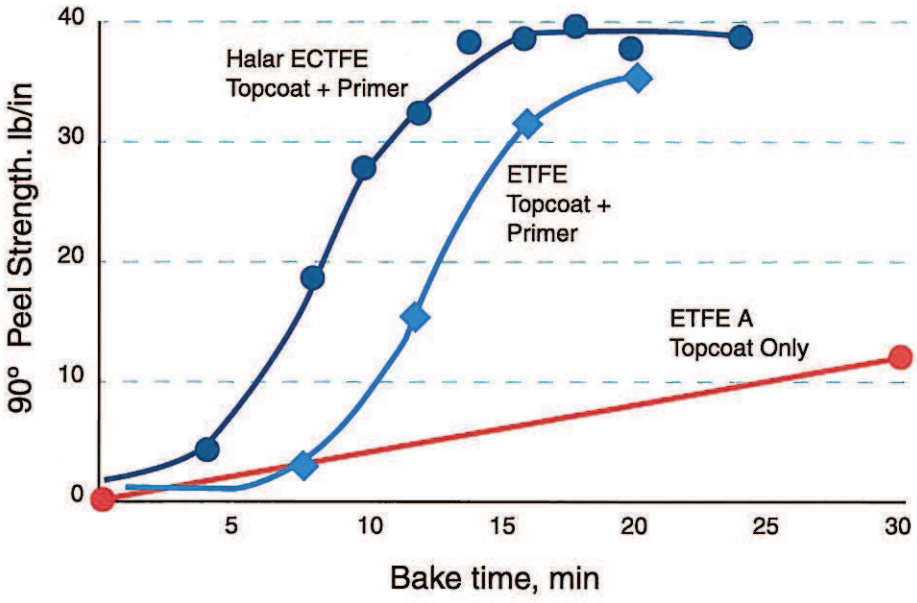
Hardness of Fluoropolymer Coatings

Polymer	Halar ECTFE	ETFE
Shore D (ASTM D2240)	D75	D67
Pencil Scratch Test[f] (ASTM D3363)	2B	6B
Cut through[g] (ASTM D3032) lbf (Newton)	54 (240)	46 (205)
	SUPERIOR	Average

[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.