Architecture of ETFE

The Next Generation of ARCHITECTURE
ETFE – Ethylene-Tetra-Flouro-Ethylene
• The new generation material which goes beyond glass
• ETFE film is an extruded section made from flouro-polymer resin
• ETFE is commonly used as an electrical conduit cover
• Today is used as a single skin, double, or triple foil pillow
**Characteristics**

1. **Super Lightweight** ...350g/m²  
   More Quakeproof (light and flexible)  
   More Economical (Large span, Installation characteristic)

2. **Super Durability** ...Over 20 years  
   Maintains transparency (will not cloud)  
   Maintains strength (Little deterioration)

3. **Safety**  
   Fire retardant (self extinguishing)  
   Shatterproof (no sharp shards.)

**Performance**
ETFE Film Variations

- Diffused
- Transparent
- UV Cut (ultraviolet)
- IR absorption (infrared)

- White
- Silver Polka-dotted
- Silver Checkered
- Blue Polka-dotted
Light transparency of ETFE films

1. Light Transmittance chart by wave length
(Comparison with other materials)
Light transparency of ETFE films

2. Light Transmittance chart by wave length (by each grade)

![Graph showing light transmittance by wave length for different grades of ETFE films. The graph includes curves for 200NJ, 200UVC, 200IRC, and 200WT.]
<table>
<thead>
<tr>
<th>Material</th>
<th>Transmittance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparent</td>
<td>92%</td>
</tr>
<tr>
<td>White</td>
<td>50%</td>
</tr>
<tr>
<td>Checkered</td>
<td>45%</td>
</tr>
<tr>
<td>Polka-dotted</td>
<td>66%</td>
</tr>
</tbody>
</table>
# Thermal Insulation Performance

<table>
<thead>
<tr>
<th></th>
<th>Thermal transmittance $U$ (W/㎡K)</th>
<th>Solar shading coefficients</th>
<th>Thermal transmittance $U$ (W/㎡K)</th>
<th>Solar shading coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparent</td>
<td>5.8 (glass 5.9)</td>
<td>1.06 (glass 0.95)</td>
<td>5.2</td>
<td>0.56</td>
</tr>
<tr>
<td>Solar shading coefficients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transparent</td>
<td>2.6 (glass 3.3)</td>
<td>0.98 (glass 0.83)</td>
<td>2.3</td>
<td>0.52</td>
</tr>
<tr>
<td>Solar shading coefficients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transparent</td>
<td>1.7</td>
<td>0.92</td>
<td>1.5</td>
<td>0.33</td>
</tr>
</tbody>
</table>
A Comparison of ETFE Film and Glass
## Characteristics

<table>
<thead>
<tr>
<th></th>
<th>ETFE FILM</th>
<th>Float glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>100 ~ 250 micron</td>
<td>3 ~ 19 mm</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.75</td>
<td>2.5</td>
</tr>
<tr>
<td>Weight</td>
<td>0.175 ~ 0.438 kg/m²</td>
<td>7.5 ~ 47.5 kg/m²</td>
</tr>
<tr>
<td>Transmittance</td>
<td>~ 93%</td>
<td>~ 88%</td>
</tr>
<tr>
<td>Tensile strength,</td>
<td>Tensile strength (23°C): ≥ 45Mpa</td>
<td></td>
</tr>
<tr>
<td>Tensile elongation</td>
<td>Tensile elongation (23°C): ≥ 400%</td>
<td></td>
</tr>
<tr>
<td>Temperature range</td>
<td>-80～150°C (Melting point: 270°C)</td>
<td>(Melting point: 720°C)</td>
</tr>
<tr>
<td>Flame proof</td>
<td>Class B-1 [DIN 4102] V-0 (250NJ) [UL94] 1st grade [JIS A 1322]</td>
<td>Flame retardant material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-combustible material</td>
</tr>
</tbody>
</table>
Some multifunctional products made of ETFE film have become ready-made articles.
## Weight

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Density (Approx.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Float Glass (3mm ~ 19mm)</td>
<td>7.5~47.5 kg/㎡</td>
<td></td>
</tr>
<tr>
<td>ETFE Film (100~250 μm)</td>
<td>0.175~0.438 kg/㎡</td>
<td></td>
</tr>
</tbody>
</table>

Lightweight properties of ETFE Film is outstanding.
**Conformation Latitude**

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>Flat plate, and also having some constraints for Outline shape.</td>
</tr>
<tr>
<td>ETFE Film</td>
<td>Convex shape is available. (Convex curved surface, HP curved surface, etc.)</td>
</tr>
</tbody>
</table>

ETFE Film is excellent in design.
## Thermal Properties

<table>
<thead>
<tr>
<th>Glass</th>
<th>ETFE Film</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal Transmission</strong></td>
<td></td>
</tr>
<tr>
<td>Single plate 6mm</td>
<td></td>
</tr>
<tr>
<td>2 tiers (6mm+12mm+6mm)</td>
<td>5.9w/㎡k</td>
</tr>
<tr>
<td>2 tiers (Low-E6+12+Low-E6)</td>
<td>3.3w/㎡k</td>
</tr>
<tr>
<td>Single film 200 μm</td>
<td>1.8w/㎡k</td>
</tr>
<tr>
<td>2 tiers (200 μm+300+200)</td>
<td>5.8w/㎡k</td>
</tr>
<tr>
<td>3 tiers (200+300+200+300+200)</td>
<td>2.6w/㎡k</td>
</tr>
<tr>
<td><strong>Shading Co-Efficient</strong></td>
<td></td>
</tr>
<tr>
<td>Single plate 6mm</td>
<td></td>
</tr>
<tr>
<td>2 tiers (6mm+12mm+6mm)</td>
<td>0.95w/㎡k</td>
</tr>
<tr>
<td>3 tiers (Low-E6+12+Low-E6)</td>
<td>0.83w/㎡k</td>
</tr>
<tr>
<td>Single film 200 μm</td>
<td>0.65w/㎡k</td>
</tr>
<tr>
<td>Single W film 200 μm</td>
<td>1.06w/㎡k</td>
</tr>
<tr>
<td>Single printing film 200 μm</td>
<td>0.58w/㎡k</td>
</tr>
<tr>
<td>2 tiers (200 μm+300+200)</td>
<td>0.56w/㎡k</td>
</tr>
<tr>
<td>3 tiers (200+300+200+300+200)</td>
<td>0.98w/㎡k</td>
</tr>
<tr>
<td>2 tiers (200 IRC+300+200)</td>
<td>0.59w/㎡k</td>
</tr>
</tbody>
</table>

Heat transmission rate are homogeneous dimension for any ETFE materials.

Equivalent effectiveness can be achieved.
Focused on Sound Transmission Loss from the standpoint of NR Sound Insulation.
(large Sound Transmission loss = high Sound Insulation)

<table>
<thead>
<tr>
<th></th>
<th>Hz</th>
<th>10</th>
<th>20</th>
<th>50</th>
<th>80</th>
<th>100</th>
<th>160</th>
<th>200</th>
<th>400</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>single plate 6mm</td>
<td></td>
<td>17.7</td>
<td>23.2</td>
<td>30.9</td>
<td>33.7</td>
<td>34.3</td>
<td>32.2</td>
<td>26.8</td>
<td>34.8</td>
<td>37.3</td>
</tr>
<tr>
<td>2 tiers (6mm+A12mm+6mm)</td>
<td></td>
<td>20.0</td>
<td>16.8</td>
<td>32.3</td>
<td>37.4</td>
<td>39.2</td>
<td>37.2</td>
<td>31.8</td>
<td>39.1</td>
<td>41.0</td>
</tr>
<tr>
<td>ETFE Film</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>single film 200μm</td>
<td></td>
<td>3.0</td>
<td>3.0</td>
<td>6.9</td>
<td>10.4</td>
<td>12.0</td>
<td>15.5</td>
<td>17.1</td>
<td>22.2</td>
<td>23.9</td>
</tr>
<tr>
<td>2 tiers (200μm+A300mm+200)</td>
<td></td>
<td>4.6</td>
<td>3.5</td>
<td>8.3</td>
<td>11.8</td>
<td>12.4</td>
<td>17.2</td>
<td>20.2</td>
<td>29.4</td>
<td>33.0</td>
</tr>
</tbody>
</table>

Less Sound Insulation compared to glass.

Due to it’s light mass/volume ratio, the acoustic performance of an ETFE covering is a great advance against other type of covers. An ETFE roof with a mass of less than 1 kg/sqm is acoustically ‘transparent’; loud crowd noises are not reflected back. This means that the internal environment is considerable more comfortable with lower reverberation times than if the cladding had been constructed from an acoustically hard material. This is particularly evident on spherical domes or other structures where the focus effect of hard acoustic cladding can make speech almost unintelligible.
A Comparison of ETFE Film and Fabric
## CHARACTERISTICS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (μm)</td>
<td>250</td>
<td>800</td>
<td>730</td>
</tr>
<tr>
<td>Weight (kg/m²)</td>
<td>0.438</td>
<td>1.3</td>
<td>0.9</td>
</tr>
<tr>
<td>Tensile strength (N/3cm)</td>
<td>375</td>
<td>4500 × 3600</td>
<td>1962 × 1962</td>
</tr>
<tr>
<td>Tensile elongation (%)</td>
<td>400</td>
<td>10 × 15</td>
<td>28.5 × 33.9</td>
</tr>
<tr>
<td>Transmittance (%)</td>
<td>90</td>
<td>10.6</td>
<td>11.4</td>
</tr>
<tr>
<td>Temperature range (°C) (Maximum use)</td>
<td>150</td>
<td>260</td>
<td>60</td>
</tr>
<tr>
<td>Flame retardancy</td>
<td>Good</td>
<td>Excellent</td>
<td>Fair</td>
</tr>
</tbody>
</table>
Printing on ETFE Film
## Printing Process

<table>
<thead>
<tr>
<th>Type</th>
<th>Gravure Roll Printing</th>
<th>Screen Printing</th>
<th>Digital Printing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification</td>
<td>Corona discharge treating + fluorocarbon resin + Aluminum flake powder</td>
<td>Corona discharge treating + fluorocarbon resin + Aluminum flake powder</td>
<td>Corona discharge treating + UV hardening type ink (Radical type)</td>
</tr>
<tr>
<td>Thickness</td>
<td>Coating thickness 3~5 μm</td>
<td>Coating thickness 9 μm</td>
<td>—</td>
</tr>
<tr>
<td>Design</td>
<td>Design repeating</td>
<td>Simple design is available</td>
<td>Design, various colors</td>
</tr>
<tr>
<td>Process</td>
<td>Available to fabricate for long length</td>
<td>Cannot fabricate for long length (up to around 4m)</td>
<td>Up to around 50m</td>
</tr>
<tr>
<td>Durability</td>
<td>—</td>
<td>Unconfirmed the endurance yet</td>
<td>Unconfirmed the endurance yet</td>
</tr>
</tbody>
</table>
ETFE Extrusion and Applications
Installation process of the ETFE extrusion clamping detail

Divisional clamping of the fastener (cushion panel)
Internal Pressure Control System

- Wind sensor
- Snow sensor
- Cushion
- Solenoid valve
- Control panel
- Internal pressure
- Automatic valve
- Fan
- Dehumidifier
- Air Supply

*Control panel*
Internal Pressure Control System

- Wind sensor
- Snow sensor
- Cushion
- Solenoid valve
- Control panel
- Internal pressure
- Automatic valve
- Fan
- Dehumidifier
- Air Supply
- Closed
Internal Pressure Control System

- Wind sensor
- Snow sensor
- Solenoid valve
- Control panel
- Cushion
- Automatic valve
- Fan
- Dehumidifier
- Internal pressure
- OFF
- closed
- Air Supply
**Sunlight Control System**

- Control panel
- Sunlight Control System
- Auto valve
- Solenoid valve
- Outer film (printed)
- Middle film (printed)
- Inner film
- Air Supply
Sunlight Control System

Control panel

Automatic valve

Solenoid valve

Outer film (printed)

Middle film (printed)

Inner film

Air Supply

Open

Closed

Sunlight Control System Sunlight Control System Sunlight Control System Sunlight Control System
Sunlight Control System

1. Sunlight Control System
   - Control panel
   - Automatic valve
   - Outer film (printed)
   - Middle film (printed)
   - Inner film
   - Solenoid valve
   - Air Supply
   - OFF

2. Solenoid valve
   - Closed

3. Automatic valve
   - Closed

4. Diagram

MakMax Australia
Sunlight Control System

- Control panel
- Automatic valve
- Air Supply
- Solenoid valve
- Outer film (printed)
- Inner film
- Middle film (printed)

- Sunlight Control System
- Sunlight Control System
- Sunlight Control System
- Sunlight Control System
- Sunlight Control System

- ON
- OFF
- Middle film (printed)
- Outer film (printed)
Sunlight Control System

Control panel

Automatic valve

Air Supply

Outer film (printed)

Inner film

Middle film (printed)

Solenoid valve

Solenoid valve

Open

Closed

Open

Closed

ON
Inspection of Sun Control System

- Sunlight control
- Transparent
- Printed
- Light penetration
- Light shading
Glossary of Items

1. Control box
2. Air blower
3. Dehumidifier
4. Chamber box
5. Duct
6. Air-supply valve (motor valve)
7. Flexible hose
8. Air exhaust valve (solenoid valve)
9. Control cable
10. Anemometer
11. Snow Gauge
12. Air inlet and outlet
13. Pressure detecting tube
**Control Unit and Blower**

① Control console
The console controls the on-off of the air blower and the opening and closing of the valve using PLC (Programmable Controller), on receipt of signals from disturbance detectors such as anemometers, snow detectors, and from pressure sensors.

② Air blower
A device for sending air into the cushion

③ Dry dehumidifier
A machine for dehumidifying the air sent into the cushion.
It is used to prevent the condensation from occurring inside the cushion in a high-humidity environment.
LED Lighting Additions

Indoor
Projection of Image on Inside Pillow
ETFE Project List
Sea Side Farm

TAIYOKOGYO CORPORATION
Location: Osaka, Japan
Surface area: Approx. 100 sqm
Form: Single layer
Completion: 2005.02
Sahara Star

TAIYOKOGYO CORPORATION
Location: Mumbai, India
Surface area: Approx. 1200 sq.m
Form: Air cushion 3 layers
Completion: 2005.10
Yuanda Factory Entry

TAIYOKOGYOCORPORATION
Location: Shenyang, China
Surface area: Approx. 700 sq.m
Form: Single layer (cable net)
Completion: 2007
GS Xi Model House

TAIYOKOGYO CORPORATION
Location: Busan, Korea
Surface area: Approx. 2500 sq.m
Form: Air cushion 2 layers
Completion: 2007.07
GS Xi Model House

TAIYOKOGYO CORPORATION
Location: Busan, Korea
Surface area: Approx. 2500 sq.m
Form: Air cushion 2 layers
Completion: 2007.07
Nan-Tong Exhibition

TAIYOKOGYO CORPORATION
Location: Nan Tong, China
Surface area: Approx. 1600 sq.m
Form: Air cushion 3 layers
Completion: 2007.09
ETFE Under Construction
Shenzhen Water Park

Location: Shenzhen, China
Surface area: Approx. 8000 sq.m
Form: Air cushion 3 layers
Completion: 2008.04
Waiten Number 18 Bar

TAIYOKOGYO CORPORATION
Location: Shanghai, China
Surface area: Approx. 400 sq.m
Form: Air cushion 2 layers
Completion: 2008