3M™ Flexible Insulations
Product Selection Guide

Effective, efficient, sustainable.
As the demands on electrical components increase, 3M offers insulating and protecting products that are performance engineered to meet the most rigorous applications. These state-of-the-art materials have been refined, tested and proven in a wide variety of applications.

Use 3M™ Flexible Insulation for:

- Ground, phase and interwinding insulation for dry-type transformers
- Slot, phase and wedge insulation for electric motors and generators
- Flame barrier insulation for appliances
- Collars for voice coils used in speakers
- Wire and cable wrap
- Layer insulation used in cast coil transformers

Inorganic paper technology offers:

Voltage endurance
3M Flexible Insulation retains a high percentage of dielectric strength even after extended exposure to high operating temperatures while its inorganic content helps reduce damage caused by partial discharge.

Thermal conductivity
The high thermal conductivity of flexible insulation helps achieve the heat dissipation required in today’s electrical apparatus, allowing more efficient operation or the design of smaller, more cost-effective equipment.

Varnish absorption
The good varnish absorption characteristics of flexible insulation can enhance its already high thermal conductivity, helping equipment to run cooler, quieter, and last longer.

Low moisture absorption
Manufactured with less than 1% moisture content, flexible insulation papers exhibit dimensional stability even in humid environments and do not require extended drying time prior to varnish saturation.
**3M™ ThermaVolt Calendered Inorganic Insulating Paper**

For high-temperature electrical insulation applications up to Class 220(R), the high thermal conductivity of 3M ThermaVolt Electrical Insulation Paper helps achieve the heat dissipation required in today's electrical apparatus, allowing more efficient operation or the design of smaller, more cost-effective equipment. 3M ThermaVolt AR (TVAR) paper combines the long-recognized advantages of 3M ThermaVolt paper with improved mechanical properties.

**Features and benefits**

- UL systems recognition through Class 220(R)
- Excellent thermal conductivity
- Good dielectric breakdown resistance
- Thicknesses: 3 mils (0.08 mm) to 30 mils (0.76 mm)

**Applications**

High temperature electrical insulation for:

- Dry-type transformers, coils and reactors
  - Ground insulation
  - Phase insulation
  - Layer insulation
  - Interwinding insulation
  - Electromagnet layer insulation

3M ThermaVolt AR paper after 2 weeks aging at 260°C

**3M ThermaVolt Calendered Inorganic Insulating Paper Average Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Basis Weight</th>
<th>Strength, MD</th>
<th>Break, MD</th>
<th>Tensile Strength, MD</th>
<th>Basis Weight</th>
<th>Tear, CD</th>
<th>Conductivity</th>
<th>Thermal Conductivity</th>
<th>Thickness</th>
<th>Nominal Basis Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal Conductivity</strong></td>
<td>0.05 lb/yd</td>
<td>1050 g/m²</td>
<td>8.6 N</td>
<td>16.8 kV</td>
<td>0.13 lb/yd</td>
<td>95 lb/in</td>
<td>870 N/cm</td>
<td>2740 N/cm</td>
<td>0.25 mm</td>
<td>1110 g/m²</td>
</tr>
</tbody>
</table>

**3M ThermaVolt Laminates**

3M ThermaVolt TvF Calendered Inorganic Insulating Paper

A two-ply composite of 3M ThermaVolt calendered inorganic paper bonded to both sides of a polyester film.

3M ThermaVolt TvFTv Calendered Inorganic Insulating Paper

A three-ply composite of 3M ThermaVolt paper bonded to both sides of 3M ThermaVolt paper.

**3M ThermaVolt Calendered Inorganic Insulating Laminates Average Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Basis Weight</th>
<th>Strength, MD</th>
<th>Break, MD</th>
<th>Tensile Strength, MD</th>
<th>Basis Weight</th>
<th>Tear, CD</th>
<th>Conductivity</th>
<th>Thermal Conductivity</th>
<th>Thickness</th>
<th>Nominal Basis Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal Conductivity</strong></td>
<td>0.13 lb/yd</td>
<td>1050 g/m²</td>
<td>8.6 N</td>
<td>16.8 kV</td>
<td>0.13 lb/yd</td>
<td>95 lb/in</td>
<td>870 N/cm</td>
<td>2740 N/cm</td>
<td>0.25 mm</td>
<td>1110 g/m²</td>
</tr>
</tbody>
</table>
3M™ CeQUIN
Inorganic Insulating Paper, Laminates and Boards

3M CeQUIN Inorganic Insulating Paper is for high-temperature electrical insulation applications up to Class 220(R).

3M CeQUIN 3000 Inorganic Insulating Paper
3M Inorganic Insulating Paper CeQUIN 3000 is a modified version of 3M CeQUIN I paper designed with higher mechanical strength. Available in 3-mil thickness.

**Features and benefits**
- UL systems recognition through Class 220(R)
- CSA Component Acceptance: Temperature Class 220
- Very good thermal conductivity

**Applications**
- High temperature electrical insulation for:
  - Dry-type transformers, coils and reactors
  - Ground insulation
  - Phase insulation
  - Layer insulation
  - Interspacing insulation
  - Barrier insulation
  - Core wrap
  - End Fill
  - Electromagnet layer insulation
  - Switchgear insulation
  - Spiral and convolute tubing

### 3M CeQUIN Inorganic Insulating Paper Average Properties

<table>
<thead>
<tr>
<th>ASTM Test Method</th>
<th>3M CeQUIN I paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Thickness</td>
<td>0.13 mm (5 mil)</td>
</tr>
<tr>
<td>Basis Weight</td>
<td>2.0 oz/ft²</td>
</tr>
<tr>
<td>Tensile Strength, MD</td>
<td>6,400 lb/100 in</td>
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<tr>
<td>Elongation to Break, MD</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>Electric Breakdown Strength</td>
<td>6 kV</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>0.11 W/m°C</td>
</tr>
</tbody>
</table>

**Voltage Endurance Comparison**

Calendered Aramid Paper (10 mils) tested to ASTM D2275-89:
- Voltage: 60 Hz, 20°C, 50% RH
- Tested under ASTM D2275: average of 5 data points

![Voltage Endurance Comparison Chart](chart)

Calendered Aramid Paper (10 mils) tested to ASTM D2275-89:
- Voltage: 60 Hz, 20°C, 50% RH
- Tested under ASTM D2275: average of 5 data points

![Voltage Endurance Comparison Chart](chart)

**Varnish Absorption**

3M test method reflects percent weight absorption. (10-min dip in polyester resin (250 cps). Excess varnish removed with steel rod.)

![Varnish Absorption Chart](chart)

**3M CeQUIN 3000 Inorganic Insulating Paper Average Properties**

<table>
<thead>
<tr>
<th>ASTM Test Method</th>
<th>3M CeQUIN 3000 paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Thickness</td>
<td>0.08 mm (3 mil)</td>
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<tr>
<td>Basis Weight</td>
<td>1.0 oz/ft²</td>
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<tr>
<td>Tensile Strength, MD</td>
<td>12 lb/100 in</td>
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<tr>
<td>Elongation to Break, MD</td>
<td>&lt;2%</td>
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<tr>
<td>Electric Breakdown Strength</td>
<td>0.8 kV</td>
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<tr>
<td>Thermal Conductivity</td>
<td>0.09 W/m°C</td>
</tr>
</tbody>
</table>

* DS = Data Sheet, SDS = Safety Data Sheet
** Data not available at this time
Inorganic-Based Insulating Papers

3M™ CeQUIN Inorganic Insulating Laminates

Features and benefits
- UL Systems Recognition from Class 120(8) through Class 220(R)
- CSA Component Acceptance: Temperature Class 220
- High temperature capabilities
- Long-term dielectric strength
- Good thermal conductivity
- Low moisture absorption
- Cost effective
- Combined with the added benefits of polyester film
- Improved cut-through resistance
- Good Softness and snap back
- Higher mechanical strength
- Improved resistance to tear
- High initial dielectric strength

3M CeQUIN Inorganic Insulating Laminates Average Properties

<table>
<thead>
<tr>
<th>ASTM Text Method</th>
<th>3M CeQUIN paper 30F</th>
<th>3M CeQUIN paper 30IF</th>
<th>3M CeQUIN paper 30F</th>
<th>3M CeQUIN paper 30IF</th>
<th>3M CeQUIN paper 30F</th>
<th>3M CeQUIN paper 30IF</th>
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</thead>
<tbody>
<tr>
<td>Nominal Thickness</td>
<td>D-645</td>
<td>0.23 mm</td>
<td>0.33 mm</td>
<td>0.25 mm</td>
<td>0.33 mm</td>
<td>0.25 mm</td>
</tr>
<tr>
<td></td>
<td>5 mil</td>
<td>5 mil</td>
<td>7 mil</td>
<td>6 mil</td>
<td>7 mil</td>
<td></td>
</tr>
<tr>
<td>Basis Weight</td>
<td>D-202</td>
<td>0.36 kg/m²</td>
<td>0.39 kg/m²</td>
<td>0.36 kg/m²</td>
<td>0.39 kg/m²</td>
<td>0.36 kg/m²</td>
</tr>
<tr>
<td></td>
<td>59 lb/inch</td>
<td>62 lb/inch</td>
<td>62 lb/inch</td>
<td>62 lb/inch</td>
<td></td>
<td></td>
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<tr>
<td>Tensile Strength, MD</td>
<td>D-828</td>
<td>44 lb/inch</td>
<td>40 lb/inch</td>
<td>42 lb/inch</td>
<td>40 lb/inch</td>
<td>42 lb/inch</td>
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<tr>
<td></td>
<td>77 N/cm</td>
<td>60 N/cm</td>
<td>70 N/cm</td>
<td>60 N/cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dielectric Breakdown Strength</td>
<td>D-149</td>
<td>9 kV</td>
<td>9 kV</td>
<td>9 kV</td>
<td>9 kV</td>
<td>9 kV</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>E-1530</td>
<td>0.38 W/(mK)</td>
<td>0.38 W/(mK)</td>
<td>0.38 W/(mK)</td>
<td>0.38 W/(mK)</td>
<td>0.38 W/(mK)</td>
</tr>
</tbody>
</table>

Inorganic Insulating Boards

3M™ CeQUINBORD CGA Inorganic Insulating Board

Features and benefits
- UL systems recognition through Class 220(R)
- UL 94-V0 and 94-5VA Flame Rating for 1.6 mm 3M CeQUINBORD CGA Products

Applications
- High temperature electrical insulation for:
  - Dry-type transformers
  - Core Tubes
  - Motors (including traction) and generators
  - Flame barrier insulation for:
    - Home appliances (washers, dryers)
    - Electronic devices (TVs, computers, microwave ovens)
  - Heat sinks
  - Specialty gaskets
  - Switchgear
3M™ TufQUIN Hybrid Insulating Papers

For high-temperature insulation applications up to Class 200(N), 3M TufQUIN 110 Hybrid Insulating Paper is a tough, flexible and conformable paper with good dielectric characteristics and thermal conductivity. 3M TufQUIN 120 Hybrid Insulating Paper is similar to 3M TufQUIN 110 paper, but uses a modified manufacturing process that maintains conformability at high thickness.

### Applications

- Motors and generators
  - Slot liner
  - Wedge
  - Phase insulation
- Dry-Type Transformers, coils and reactors
  - Ground/interwinding insulation
  - Phase insulation
  - Layer insulation
  - Barrier insulation
  - Wire wrap
  - Spiral- and convolute-wound tubing
  - Switchgear insulation
  - Pressure-sensitive tapes

### Features and benefits

- UL systems recognition through Class 200(N)
- CSA Component Acceptance: Temperature Class 200
- Tough and conformable
- Good dielectric strength
- Excellent stiffness and tear resistance
- Very good thermal conductivity

### TufQUIN 120 Hybrid Insulating Papers

<table>
<thead>
<tr>
<th>Nominal Thickness</th>
<th>ASTM Test Method</th>
<th>3M TufQUIN 120 paper</th>
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</thead>
<tbody>
<tr>
<td>0.05 mm</td>
<td>D-645</td>
<td>0.05 mm</td>
</tr>
<tr>
<td>0.08 mm</td>
<td>D-645</td>
<td>0.08 mm</td>
</tr>
<tr>
<td>0.13 mm</td>
<td>D-645</td>
<td>0.13 mm</td>
</tr>
<tr>
<td>0.18 mm</td>
<td>D-645</td>
<td>0.18 mm</td>
</tr>
</tbody>
</table>

### TufQUIN 110 Hybrid Insulating Papers

<table>
<thead>
<tr>
<th>Nominal Thickness</th>
<th>ASTM Test Method</th>
<th>3M TufQUIN 110 paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 mm</td>
<td>D-645</td>
<td>0.05 mm</td>
</tr>
<tr>
<td>0.08 mm</td>
<td>D-645</td>
<td>0.08 mm</td>
</tr>
<tr>
<td>0.13 mm</td>
<td>D-645</td>
<td>0.13 mm</td>
</tr>
<tr>
<td>0.18 mm</td>
<td>D-645</td>
<td>0.18 mm</td>
</tr>
</tbody>
</table>

### Moisture Absorption

- **Data not available at this time**

### 3M TufQUIN Laminate Average Properties

#### 3M TufQUIN TF Hybrid Insulating Paper

A two-ply composite of 3M TufQUIN 110 Hybrid paper bonded to polyester film.

#### 3M TFT Hybrid Insulating Paper

A three-ply composite of 3M TufQUIN 110 paper bonded to both sides of a polyester film.

With 3M TufQUIN TF and TFT Hybrid Insulating Papers, the polyester film provides an excellent dielectric barrier and adds stiffness and snapback characteristics to the composite, uniquely suited for motor/generator slot liner, wedge and phase insulation applications.
**High-Performance Flexible Laminates**

**3M™ Flexible Laminates DMD**

3M Flexible Laminates DMD is a family of tough, formable insulation designed for high reliability for such common uses as slot liner, wedge and phase insulation. It has UL Systems recognition through Class 155 (F).

**Applications**
- Motors and Generators
  - Slot Liner
  - Wedge
  - Phase Insulation

**Laminates using polyester film**

**Why use a polyester film laminate?**

Polyester film can provide mechanical support for inorganic insulating paper. However, considering the thermal, mechanical, electrical, and UL factors together can be complex.

**What are the thermal capabilities of polyester film?**

Polyester film is a component rated as a 130°C material; it will shrink and embrittle when aged at high temperatures. The primary mode of this degradation is oxidation. However, Lamination will help slow this process as will properly applied varnish or impregnation. As the film slowly oxidizes, it breaks down into its constituent chemicals which do not attack other components nor carbonize the film. This “friendly” degradation is one of the reasons that polyethyleneterephthalate (PET) polyester film is so widely used in electrical insulation applications. Despite the concern of some that this 130°C material will melt, the actual melting point of PET polyester film is over 240°C. Although it will begin to lose mechanical strength at high temperatures, polyester film can withstand short-term thermal excursions if protected from oxidation.

**Won’t polyester film shrink and embrittle at high temperatures?**

Shrinkage and embrittlement due to thermal aging can be addressed through equipment design. For example, in a tightly wound unit a 3M™ CeQUIN Inorganic Insulating Laminates (paper/polyester) will be held in place, greatly reducing shrinkage. Likewise, a tightly wound, well-impregnated coil will significantly reduce mechanical stress and vibration that could affect the polyester film portion of the laminate as it ages.

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For more information about these products, including data sheets, go to www.3M.com/oem.

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**How long have polyester film laminates been used?**

From a historical perspective, inorganic papers laminated with polyester film have been used successfully for more than 40 years in Class 220(R) coil applications, ranging from small H.I.D. ballast transformers to medium size dry-type distribution transformers. For example, 3M CeQUIN IF inorganic insulating paper laminate is used as a wire wrap in the manufacture of a 250°C-rated appliance wiring material (UL Style 5298/CSA Class 1, Group A/B) for use in high-temperature, severe environments. The acceptance of inorganic insulating paper/polyester film laminates for use in these high performance applications speaks for itself.
UL recognition

3M™ Flexible Insulations have undergone extensive thermal aging evaluation per UL 1446, “Standard for Systems of Insulating Materials – General.” As a result they are UL Recognized for use as major insulation in electrical insulation systems as listed under 3M Innovative Paper Technologies File No. E65007 and may be found on UL’s Electrical Insulation Systems Database at http://data.ul.com/systems/. All systems listed on this database are available for use by any electrical apparatus manufacturer by contacting the nearest UL office. UL 1446 systems with 3M Flexible Insulations also comply with IEC Publication 85.

Recommended usage

Optimum performance of an electrical insulation system is dependent upon many factors including proper choice of materials, acceptable design criteria, and good manufacturing procedures. Varnishing is recommended for construction of equipment that may be exposed to the elements. For design purposes, it is recommended that operating electrical stresses in electrical apparatus not exceed 40 V/mil (1.6 kV/mm) in order to minimize the risk of partial discharge.

Other 3M insulating products

Insulating & Conductive Tapes

3M offers a wide variety of electrical and electronic insulating tapes for insulating, holding, protecting, bonding, resin impregnation, harnessing and electromagnetic compatibility. Most of these tapes feature industry component recognition, such as UL, as well as excellent mechanical, electrical and physical properties.

3M™ Insulating and Conductive Tapes are designed to provide a high level of protection for electrical and electronic components. All 3M tapes and related products feature exceptionally high quality backed by experienced technical support.

Liquid Insulating Resins

3M Scotchcast™ Electrical Liquid Resins are 100-percent solid, thermosetting, electrical-grade insulating resins. These two-part liquids are classified chemically as either epoxies or polyurethanes. These resins have electrical and physical properties that make them excellent for insulating and protecting electrical and electronic parts and assemblies.

Powder Resins

3M Scotchcast Powder Resins are a series of one-part, 100-percent solid electrical-grade systems offering fast curing, excellent thermal and mechanical shock resistance, significant cut-through resistance, high adhesion, excellent chemical and moisture resistance, high-to-low flow characteristics, and excellent electrostatic coating capability. Insulation systems established per UL 1446 and IEC 85 requirements are available in this family of resins up to Class H (180°C).
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