



TECHNICAL DATA SHEET (TDS)

G11/FR5 EPOXY GLASS LAMINATE

PRODUCT IDENTIFICATION

- **Product Name:** G11 / FR5 Epoxy Glass Sheet.
- **Material Type:** Epoxy Resin Bonded Glass Cloth Composite.
- **Details:**
 - **Company:** MISCO Australia
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- **TDS Number:** MISCO – TDS - 0015
- **TDS Date:** 01/12/2024
- TDS Version: 1

PRODUCT DESCRIPTION

G11 / FR5 Epoxy Glass is a glass cloth–reinforced epoxy thermoset composite designed for high mechanical, electrical, and thermal performance in demanding industrial and electrical insulation environments. This material offers superior heat resistance, maintaining structural integrity and dielectric strength at elevated temperatures where standard grades such as G10 or FR4 may degrade.

G11 is the high-temperature mechanical grade, while FR5 is the flame-retardant variant that meets UL 94 V-0 classification for use in electrical assemblies requiring certified fire resistance. Both grades exhibit exceptional dimensional stability, low moisture absorption, and excellent machinability, making them ideal for precision components in electrical, thermal, and structural insulation systems.

Produced under controlled resin-glass ratios and cured at elevated temperatures, the material provides uniform resin distribution, tight thickness control, and consistent electrical reliability across all sections. It is particularly suited for CNC-machined parts, switchboard

and transformer insulation, busbar supports, slot wedges, fixtures, and high-temperature electrical structures operating in continuous service temperatures up to 180 °C.

NEMA GRADE

NEMA Designation:

- **G11** — High Temperature Epoxy-Glass
- **FR5** — High Temperature, Flame-Retardant Epoxy-Glass

NEMA Reference:

- NEMA LI-1 G11
- Equivalent IEC Grade: EPGC204
- Typical MIL Spec: MIL-I-24768/3 (non-FR)

NEMA FR5

Description:

FR5 is the flame-retardant counterpart to G11, manufactured with a brominated epoxy resin system that achieves UL 94 V-0 flammability classification while maintaining similar mechanical and electrical performance. FR5 offers enhanced safety in enclosed or heat-intensive environments requiring certified flame resistance.

NEMA Reference:

- NEMA LI-1 FR5
- Equivalent IEC Grade: EPGC204 (flame-retardant variant)
- Typical MIL Spec: MIL-I-24768/28 (FR5)

CLASS

- **G11:** Class H (180°C) Electrical Insulation
- **FR5:** Class H (180°C) Electrical Insulation with Flame Resistance
- **Equivalent IEC Class:** EPGC204 (Class H – 180 °C)
- **Typical RTI:** 155–180 °C

MILITARY SPECIFICATIONS AND TYPE

- **MIL-I-24768/3 (G11) - GEB (G11)** - High-performance epoxy glass materials for electrical insulation used in demanding conditions.

- **MIL-I-24768/28 (FR5) - GEB-F (FR5)** - Flame-retardant epoxy glass materials suitable for high-temperature environments requiring UL 94 V-0 ratings.

These specifications ensure compliance with military standards for high-performance insulation materials, particularly in applications such as military electronics, transformers, and aerospace.

KEY PROPERTIES

- **High mechanical strength** retained at elevated temperatures.
- **Excellent dielectric strength** and electrical insulation stability.
- **Thermal Class H (180 °C)** continuous operating temperature.
- **Flame-retardant (FR5):** UL 94 V-0 compliant.
- **Low moisture absorption** and dimensional stability.
- **Good chemical and solvent resistance.**
- **Easily machinable** with clean finish and tight tolerances.
- **Complies with:** NEMA G11 / FR5, IEC 60893 EPGC204, MIL-I-24768 /3 & /28.

APPLICATIONS

- Switchboards and Control Panels: Busbar barriers, phase separators, terminal supports, mounting panels, and arc shields.
- Transformers: Coil spacers, wedges, packers, insulating rings, and compression blocks for high-temperature operation.
- Electric Motors and Generators: Slot wedges, end laminations, keyways, and thermal insulation parts.
- Power Distribution & Transmission: Insulating components in switchgear, substations, and high-voltage enclosures.
- Aerospace & Defence Equipment: Structural and dielectric components exposed to heat, vibration, and electrical load.
- Rail, Mining, and Industrial Machinery: Mechanically strong, flame-safe insulation parts for harsh service environments.
- Renewable Energy Systems: Used in wind turbine generators, inverters, and high-temperature busbar assemblies.
- CNC-Machined Components: Precision parts requiring close tolerance, electrical isolation, and thermal endurance.
- Fixtures & Tooling: High-temperature jigs, spacers, and non-conductive fixtures for electrical assembly or test setups.

Suitable wherever strength, electrical insulation, and thermal stability must be maintained under continuous high-temperature service.

SPECIFICATIONS

- **Product Form:** Sheets, rods, tubes, and CNC-machined parts
- **Standard Colours:** Natural green or yellow - green.
- **Sheet Size:** 1220 × 2440 mm (custom sizes available)
- **Thickness Range:** 0.5 – 60 mm (others on request)
- **Rod Diameter Range:** 6 – 200 mm standard (larger on request)
- **Tube Dimensions:** ID / OD to order, precision cut lengths.
- **Flammability:** FR5 – UL 94 V-0 compliant
- **Thermal Class:** Class H (180 °C)
- **Compliance:** NEMA G11 / FR5, IEC 60893 EPGC204, MIL-I-24768/3 & /28
- **Environmental Compliance:** RoHS 3 and REACH compliant, halogen-free options available.

TOLERANCES ON SHEET THICKNESS

(as per NEMA LI-1)

Nominal Thickness (mm)	Tolerance (mm)
0.5 – 1.5 mm	±0.13 mm
1.6 – 3.2 mm	±0.18 mm
3.3 – 6.4 mm	±0.25 mm
6.5 – 12.7 mm	±0.38 mm
12.8 – 50 mm	±0.51 mm

Custom thicknesses and tighter tolerances available on request.

MECHANICAL PROPERTIES

Property	Test Method	Typical Value
Density	ASTM D792	1.80 – 2.00 g/cm ³
Tensile Strength	ASTM D638	300 – 420 MPa
Flexural Strength	ASTM D790	450 – 600 MPa
Compressive Strength (Flatwise)	ASTM D695	350 – 500 MPa
Elastic (Flexural) Modulus	ASTM D790	18 – 24 GPa
Shear Strength	ASTM D732	30 – 45 MPa
Impact Strength (Charpy, unnotched)	ISO 179	90 – 120 kJ/m ²
Hardness	Barcol 934-1	40 – 55 (Barcol)
Poisson's Ratio (ν)	ASTM E132	0.12 – 0.20
Water Absorption (24 h @ 23 °C)	ASTM D570	≤ 0.20 %
Machinability	—	Excellent

Notes:

- Values represent typical averages; actual performance varies with thickness and orientation.
- Strength and modulus are retained at elevated temperatures up to 180 °C (Class H).
- FR5 exhibits equivalent mechanical strength to G11 with added flame-retardant performance.

ELECTRICAL PROPERTIES

Property	Test Method	Typical Value
Dielectric Strength (perpendicular to lamination, 2–3 mm)	ASTM D149	10 – 20 kV/mm
Dielectric Strength (parallel to lamination)	ASTM D149	35 – 45 kV
Insulation Resistance (dry/wet)	ASTM D257	$\geq 1 \times 10^{12} \Omega \cdot \text{cm}$
Volume Resistivity	ASTM D257	$\geq 1 \times 10^{12} \Omega \cdot \text{cm}$
Surface Resistivity	ASTM D257	$\geq 1 \times 10^{12} \Omega / \text{sq}$
Dielectric Constant (1 MHz)	ASTM D150	4.5 – 5.4
Dissipation Factor (1 MHz)	ASTM D150	≤ 0.03
Arc Resistance	ASTM D495	120 – 180 sec
Comparative Tracking Index (CTI)	IEC 60112	250 – 400 (grade dependent)
Electric Strength Retention at 180 °C	IEC 60243	$\geq 70 \%$ of room temperature value

Notes:

- Electrical insulation remains stable across a wide temperature and humidity range.
- FR5 maintains equivalent dielectric performance to G11 while providing UL 94 V-0 flame retardancy.
- For critical HV insulation or creepage/clearance design, use batch-certified dielectric data.

THERMAL PROPERTIES

Property	Test Method	Typical Value
Thermal Class	IEC 60085	Class H (180 °C)
Glass Transition Temperature (T_g)	ASTM D3418 (DSC)	160 – 180 °C
Continuous Operating Temperature	—	155 – 180 °C
Short-Term Peak Temperature	—	up to 200 °C
Thermal Conductivity	ASTM E1530	0.25 – 0.35 W/m·K
Coefficient of Thermal Expansion (in-plane)	ASTM E831	12 – 18 × 10 ⁻⁶ /K
Coefficient of Thermal Expansion (through-thickness)	ASTM E831	35 – 50 × 10 ⁻⁶ /K
Flammability Rating (FR5)	UL 94	V-0
Heat Deflection Temperature (1.8 MPa)	ASTM D648	210 – 230 °C
Thermal Index (RTI, electrical/mechanical)	UL 746B	155 – 180 °C

Notes:

- Both G11 and FR5 maintain high mechanical and dielectric integrity under sustained thermal load.
- FR5 provides certified flame resistance without significant loss of thermal stability.
- Ideal for long-term use in high-temperature electrical insulation and structural applications requiring dimensional accuracy.

CHEMICAL RESISTANCE

Chemical / Medium	Resistance	Notes
Water / Humidity	Excellent	Low moisture absorption (<0.2%); minimal effect on dielectric strength.
Transformer Oil / Mineral Oils	Excellent	No degradation under normal service conditions.

Hydraulic & Lubricating Oils	Excellent	Stable; does not swell or soften.
Alcohols (Methanol, Ethanol, IPA)	Good	Slight surface dulling possible with prolonged exposure.
Aliphatic Hydrocarbons (e.g. Hexane)	Excellent	No noticeable effect.
Aromatic Hydrocarbons (e.g. Toluene, Xylene)	Moderate	Slight softening or discoloration possible over time.
Acids (Dilute)	Fair	Short-term exposure acceptable; avoid long-term contact.
Acids (Concentrated)	Poor	Surface attack and loss of gloss likely.
Alkalis (Dilute)	Fair	Limited resistance; rinse and dry after contact.
Alkalis (Strong / Hot)	Poor	Gradual degradation; avoid continuous exposure.
Ketones (e.g. Acetone, MEK)	Poor	Causes surface softening and loss of properties.
Esters / Chlorinated Solvents	Poor	Not recommended for immersion or prolonged contact.

G11 and FR5 offer excellent resistance to oils, fuels, moisture, and most industrial solvents. Avoid prolonged contact with strong acids, alkalis, or aggressive organic solvents. For critical applications, conduct compatibility testing under actual service conditions.

PROCESSING AND MACHINING CONSIDERATIONS

General Handling

- Allow material to stabilise to workshop temperature (24–48 h) before machining.
- Store sheets flat to prevent warping; avoid leaning thin panels.
- Identify and maintain batch traceability for all parts.

Dust & Safety

- Machining generates fine glass and epoxy dust — harmful if inhaled.
- Use local exhaust ventilation (LEV) or wet suppression.
- Operators must wear P2/P3 respirators, safety glasses, and protective clothing.
- Clean machines with vacuum extraction; do not use compressed air.

Cooling & Temperature Control

- Prefer dry machining with strong extraction.
- Avoid excessive heat buildup — resin can soften locally if overheated.
- Light mist coolant or cold air guns may be used where temperature control is critical.

Finishing

- Deburr using fine abrasive wheels, nylon brushes, or sandpaper (P240–P400).
- Seal exposed edges if parts operate in high-humidity or HV environments.
- Inspect surfaces for delamination, edge chips, and fibre pull-out.

WATERJET CUTTING

No Heat-Affected Zone – Cutting is cold, preserving resin strength and dielectric properties.

High Precision – Produces accurate, clean edges suitable for tight-tolerance insulation parts.

No Tool Wear – Abrasive cutting eliminates tool loading or edge chipping common with conventional machining.

Higher Cost – Slower cutting speeds and abrasive consumption increase processing cost.

Edge Fibre Exposure – May require light deburring or sealing for high-voltage applications.

Moisture Uptake Risk – Parts should be dried before electrical use to remove surface moisture.

SHEET HANDLING BEFORE MACHINING

Proper handling of G11 / FR5 sheets before machining is essential to maintain dimensional accuracy, prevent warping, and preserve electrical insulation quality.

- **Storage Position:** Store sheets flat on a level surface, fully supported to prevent bowing or edge stress. Do not lean sheets vertically or stack unevenly.
- **Environmental Conditioning:** Allow material to stabilise for 24–48 hours in the workshop environment before machining to equalise temperature and humidity.

- **Cleanliness:** Keep surfaces free from dust, oil, or moisture. Contaminants can affect tool performance and edge finish.
- **Handling:** Lift sheets with two or more people or mechanical aids to avoid flexing or cracking. Do not drag across hard surfaces.
- **Identification:** Ensure batch and grade labels remain intact for traceability. Handle by edges to avoid fingerprints or resin smudging.
- **Inspection:** Before cutting, check for surface defects, delamination, or damage from storage or transit.

ENVIRONMENTAL COMPLIANCE

- **RoHS 3 Compliant:** Free from lead, mercury, cadmium, hexavalent chromium, and other restricted substances.
- **REACH Compliant:** Contains no SVHC (Substances of Very High Concern) under current REACH listings.
- **Asbestos-Free:** Manufactured without asbestos, mineral fibres, or other hazardous fillers.
- **Halogen-Free Grades:** Available on request for low smoke and toxicity applications.
- **Recyclability:** Material is non-toxic but not recyclable through standard plastic streams.
- **Disposal:** Dispose of through licensed industrial waste facilities in accordance with local regulations.
- **Environmental Stability:** Chemically stable and non-leaching under normal service and storage conditions.

SUSTAINABILITY AND ENVIRONMENTAL IMPACT

G11 / FR5 epoxy glass is a durable, long-life insulation material designed for extended service in electrical and industrial environments. Its sustainability performance is driven by longevity, stability, and low maintenance requirements, reducing the need for frequent replacement.

- **Long Service Life:** Exceptional thermal and mechanical endurance minimises material waste and replacement frequency.
- **Chemical Stability:** Non-leaching and inert under normal operating conditions; does not release harmful substances.

- **Resource Efficiency:** High material yield from CNC and waterjet processing with minimal offcut waste when properly nested.
- **Non-Toxic Composition:** Contains no asbestos or restricted heavy metals; compliant with RoHS 3 and REACH.
- **End-of-Life:** Material is non-recyclable but can be disposed of safely through licensed industrial waste management facilities.
- **Energy Use:** Production involves thermoset curing; however, extended lifespan offsets the embodied energy compared to lower-grade materials.

While not recyclable, G11 / FR5 offers long-term sustainability through performance and durability, reducing environmental impact across its operational lifespan.

SAFETY INFORMATION

G11 / FR5 epoxy glass is a stable, cured thermoset composite and is not classified as hazardous under normal handling or service conditions. However, machining or cutting operations can release fine dust and fibres that require proper control measures.

- **Physical State:** Solid, inert composite; non-toxic in finished form.
- **Fire Behaviour:**
 - G11 – non-flame-retardant, may char under direct flame.
 - FR5 – flame-retardant (UL 94 V-0), self-extinguishing.
- **Decomposition:** At extreme heat (>250 °C), decomposition may produce carbon monoxide, carbon dioxide, and phenolic/epoxy vapours — ensure adequate ventilation.
- **Dust Hazard:** Machining produces fine fibreglass and resin dust that can irritate the skin, eyes, and respiratory system.
- **Protective Equipment:**
 - Wear P2/P3 respirator, safety glasses, and gloves when machining or sanding.
 - Use dust extraction or wet suppression to control airborne particulates.
 - Avoid eating or drinking in machining areas.
- **First Aid:**
 - **Inhalation:** Move to fresh air; seek medical attention if irritation persists.

- **Skin Contact:** Wash with soap and water; do not rub.
- **Eye Contact:** Rinse thoroughly with clean water for at least 15 minutes.
- **Storage:** Store in a dry, well-ventilated area, away from direct sunlight and heat sources.

Refer to Safety Data Sheet (SDS) for full details before handling.

WARRANTY

MISCO Australia warrants that all G11 / FR5 epoxy glass materials supplied are free from defects in workmanship and materials at the time of dispatch.

Products conform to applicable manufacturing standards (NEMA G11 / FR5, IEC 60893 EPGC204, and MIL-I-24768/3 & /28) and are inspected for compliance before delivery.

This warranty is limited to the replacement or credit of defective material proven to be non-conforming under normal use and within the original supplied condition. It does not cover:

- Damage caused by improper storage, handling, or machining.
- Misapplication or use outside the specified temperature, electrical, or chemical limits.
- Normal wear, modification, or secondary processing by third parties.

MISCO Australia's liability is strictly limited to the value of the material supplied. No warranty is expressed or implied regarding suitability for a specific purpose, unless confirmed in writing prior to order acceptance.

All materials are supplied in accordance with MISCO Australia's Standard Terms and Conditions of Sale, ensuring quality, traceability, and compliance at the time of delivery.

Important Note:

It is the customer's responsibility to evaluate the suitability of the material for their specific application. No warranty is expressed or implied for performance in conditions not stated in this document.

DISCLAIMER

*The information provided in this data sheet is intended as a general guide for the use and handling of material. It is based on current knowledge and believed to be accurate and reliable as of the date of publication. However, **MISCO Australia** makes no warranties, express or implied, regarding the material's performance, suitability, or fitness for any specific application.*

Users are responsible for determining the material's suitability for their intended purpose, including conducting independent tests and evaluations as necessary. MISCO Australia does not accept any liability for any loss, damage, or injury resulting from the use of this information, the products described, or reliance on the provided recommendations.

Specifications are subject to change without notice as part of MISCO Australia's ongoing product improvement initiatives.

Always refer to the latest version of this data sheet before proceeding with critical applications.

All sales are subject to MISCO Australia's standard terms and conditions of sale.

End of Technical Data Sheet.