



ABB Switzerland Ltd

Micafil Laminate Technologies Generator Insulation Fastenings and Machined Parts

Power and productivity
for a better world™



High performance laminates for highly efficient generators

Micafil laminates are used for demanding applications in generators to achieve highly efficient electric power generation. This way, we contribute to saving natural energy resources by providing compound materials with high electrical, mechanical and thermal properties.

Our mold parts, fastenings and washers made of the composites Resolam®, Vetresit® or Vetrelam® have been used in a large number of applications by all leading manufacturers of generators worldwide.

All rotor slot insulators made at Micafil are subject to high voltage insulation and optionally inductive metal detecting tests.

We support our clients with specific developments covering your needs.

Standard dielectric test

The test voltage at 50 Hz, 1 minute, is applied in a perpendicular direction. The voltage level takes into consideration the shape and the surface of the slot insulation as well as the necessary flash-over distances.

Test voltage 50 Hz, 1 min	Thickness s in mm			
	= 0,5- <1.0	= 1.0- <1.2	= 1.2- <1.5	= 1.5- <2.0
Sheets/Strips	9 x s kV	9 kV	10 kV	12 kV
L sections	10 x s kV	10 kV	12 kV	15 kV
U sections	9 x s kV	9 kV	10 kV	12 kV

Resolam® products are electrically tested according to customer specifications

Micafil rotor insulation



Generator rotor insulation

Slot liners made of Resolam[®], Vetresit[®] and Vetrelam[®]



Resolam 02[®] or Resolam 03[®]

These are made of one or several layers of polyamide (Nomex[®]) and laminated at high pressure and temperature to provide high mechanical flexibility and toughness as well as very good thermal material properties. For mechanical reinforcement, Resolam[®] can be laminated with Vetresit[®]. Due to precise molding, slot insulation made of highly flexible Resolam[®] can be easily fitted in position.



Vetresit[®]

Vetresit[®] consists of several layers of heat-resistant epoxy resin reinforced with glass fabric laminated at high temperature and pressure. High mechanical strength, good resistance to heat and moisture, low dielectric losses and high electric strength are major features of Vetresit[®].

Vetresit[®] is used to produce rigid slot liners.



Vetrelam[®]

Vetrelam[®] is a laminate consisting of epoxy resin reinforced with glass fabric and aromatic polyamide fiber paper (PA), optionally with track-resistant top layers. Vetrelam[®] is also available with interleaved polyamide film for superior electrical performance and reliability. Fiberglass reinforced outer layers are responsible for the mechanical strength of the material. Layers of tough PA substantially reduce the compressive and shear stresses caused by deformation. Vetrelam[®] is a practically deformation-free insulating material with superior electrical, dielectric, tracking-resistant and thermal properties. It is odorless and highly resistant to solvents.

High performance laminates

Solutions for various applications

Standard dimensions and tolerances for Resolam®

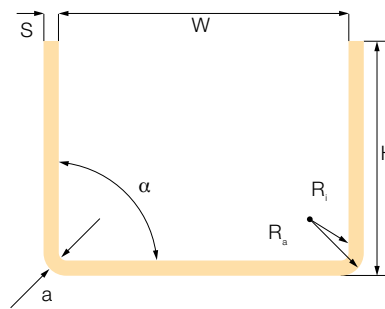
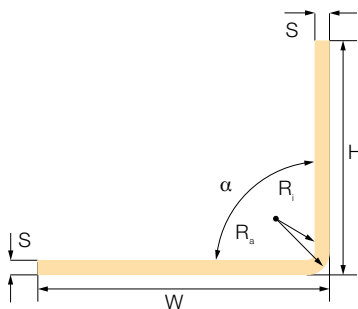
			U sections	
			Standard dimensions	Tolerance
Length	L	mm	= 10 000 max.	± 3
Width	W	mm	15–50	± 0.15
Height	H	mm	5–190	± 0.3
Wall thickness	s	mm	0.5–2.5	± 0.1
Wall thickness (curved part)	a	mm	a = s	+ 0.1 / -0.2
Inside radius	R _i	mm	1	± 0.2
Outside radius	R _a	mm	R _a = R _i + s	+ 0.4 / -0
Angle	α	°	90	± 3

Dimensions and tolerances can also be made customer specific.

Standard dimensions and tolerances for Vetresit® and Vetrelam®

			L sections		U sections	
			Standard dimensions	Tolerance	Standard dimensions	Tolerance
Length	L	mm	= 10 000 max.	± 1	= 10 000	± 3
Width	W	mm	20–250	± 0.25	15–50	± 0.25
Height	H	mm	5–50	± 0.25	5–150	± 0.25
Wall thickness	s	mm	0.5–2.5	± 0.1	0.5–2.5	± 0.1
Wall thickness (curved part)	a	mm	a = s	+ 0.1 / -0.2	a = s	+ 0.1 / -0.2
Inside radius	R _i	mm	3	± 0.2	1	± 0.2
Outside radius applicable for all other products	R _a	mm	R _a = R _i + s	+ 0.4 / -0	R _a = R _i + s	+ 0.4 / -0
Outside radius Vetrelam 410®				+ 0.3 / -0.2		+ 0.3 / -0.2
Angle applicable for all other products	α	°	90	± 2	90	± 2
Angle Vetrelam 410®				+ 5 / -2		

Dimensions and tolerances can also be made customer specific.



Customized composition of materials

Comprehensive product portfolio

Generator insulation kits

Micafil is in a position to offer a complete set of generator insulation including tailor-made solutions.

- slot liner
- interturn insulation
- cover channel
- corner insulation
- stator cap
- stator wedges
- fastenings



Corner insulation

Corner insulation is one of Micafil's accurate high-quality generator insulation products.



Specialties

Micafil also supplies specialties such as insulations designed for specific applications with customized composition of layers. Most of the Resolam®, Vetresit® and Vetrelam® slot liners can be optionally coated with PTFE (Teflon) film or track-resistant layers. Special finishes such as a rough surface as well as cutouts for ventilation are possible.

High performance laminates

Fastenings for demanding applications

Features

These structural elements operate under heavy electrical and mechanical stress even at high temperatures. Laminates made by Micafil are temperature class F with high tracking resistance. The elements are made of Vetresit 300®, Vetresit 305® or Vetresit 312®. Fastenings made of Vetresit® have comparable or even superior mechanical properties as those of metal.

What we offer

Vetresit 312 components

Round threaded rods

M8 to M12
M14 to M42

Standard length
1650 mm
1900 mm

Treaded rods with flats

M10 to M12
M14 to M42
Round bars 6 to 80 mm dia.

Standard length
1650 mm
1900 mm
1900 mm

On request, any length can be supplied as well as blanks, studs and structural components.

Vetresit 300 components

Nuts

M8 to M42

Bolts and nuts made of Vetresit®



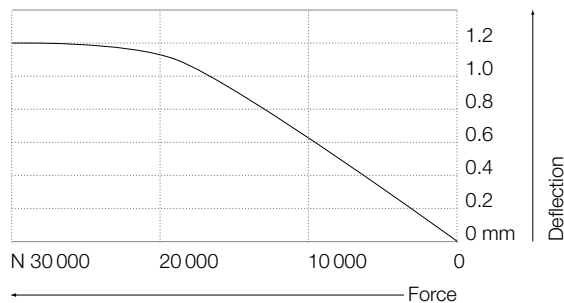
Vetresit 305[®] – the optimized material for elastic resilience at high temperature

Vetresit 305[®] components – spring cup washers

For spring cup washers made of Vetresit 305[®], a specially developed high-grade glass mat and duroplastic polymer laminate, the characteristic properties are:

- excellent behavior under permanent vibration
- modulus of elasticity approximately 18000 N/mm² at room temperature
- temperature class F (155 °C)

As supplied



The remarkable feature of these spring cup washers is their linear spring characteristic up to the limit of proportionality

Standard design

Sizes		M8	M10	M12	M16	M20	M24	M30
Ø De	mm	35.0	39.5	43.5	53.0	58.0	64.0	68.0
Ø Di	mm	8.5	10.5	12.5	16.5	20.5	24.5	30.5
Ø D	mm	12.5	14.5	17.5	21.5	26.5	30.5	36.5
h _o	mm	1.0	1.0	1.0	1.2	1.2	1.2	1.2
l _o	mm	3.4	4.3	4.6	7.3	7.3	7.8	8.6
t	mm	2.4	3.3	3.6	6.1	6.1	6.6	7.4
r	mm	1.0	1.0	2.0	2.0	2.0	2.0	2.0

Spring force for 0.75 h deflection

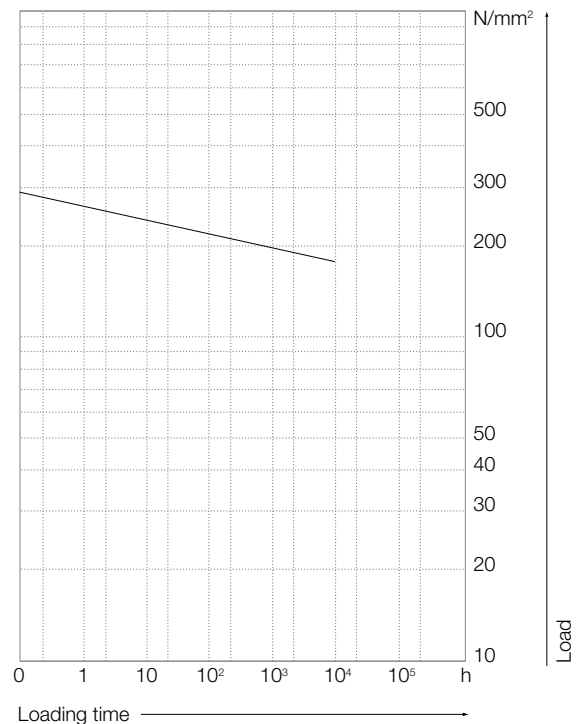
Standard design

Sizes		M8	M10	M12	M16	M20	M24	M30
F _{s1}	kN	1.5	2.5	3.5	7.0	10.5	11.5	14.0

Representative values

Extended tests at high temperature

M16 threaded rods were subjected to prolonged heat-stability tests in air at 120 °C.



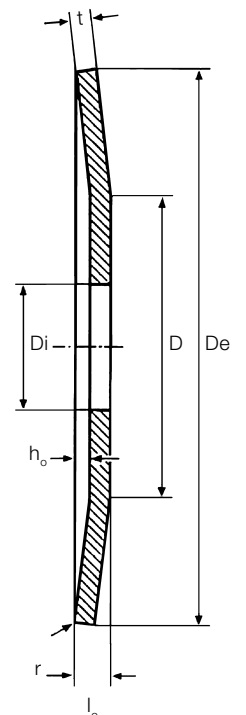
Tolerances according ISO 2768, DIN 7168

Degree of accuracy:

- φ, D, r = coarse
- h_o, t = medium
- l_o = ± 0.2 mm

Abbreviations:

- De = outside diameter
- Di = inside diameter
- D = upper bearing surface diameter
- F_{s1} = spring force for 0.75 · h_o deflection
- h_o = clear height of unstressed individual washer
- l_o = overall height of unstressed individual washer l_o = h_o + t
- t = thickness of individual washer
- r = radius



Micafil insulation engineering and manufacturing

As the world's leading company in power technologies and automation, ABB has significant expertise when it comes to laminates. Micafil has specialized in the engineering and manufacturing of high-quality, high voltage electrical insulating components made of laminates and fiber composites.



Our core expertise includes:

- manufacturing electrical insulation components of all shapes and sizes; e.g., for switchgear, transformers and high voltage circuit breakers
- laminate components for industrial applications in small and medium-size batches for which automated manufacturing using injection molding systems is not worthwhile
- re-fabrication of critical insulation components no longer available in the marketplace
- engineering and development consulting services

Leading global power, traction and space companies trust our technical expertise. Our proximity to the ABB Research Center guarantees that we are in tune with the latest plastics and technology trends.

Engineering

Engineering is our forte. Our insulators made of polyester, epoxy or phenolic resins are capable of withstanding voltages up to 40 kV and temperatures to 160°C. Furthermore, new composite materials with different and improved material properties can be produced by combining several materials having different characteristics.

We would be happy to share our expertise with you regarding the thermal behavior of laminates and composite materials, fiber reinforcements or manufacturing methods in any of the following areas:

- development
- design
- calculation
- re-engineering
- manufacturing technologies
- consulting

Project management

Our broad range of products and services in the fields of machining and chipless machining enable us to execute even projects with extensive logistics and coordination demands.

Turned and milled parts

We use primarily glass-reinforced laminates as the raw materials. Our high-precision machines enable us to fabricate turned and milled parts of any size, complex shapes or combinations of various processes and materials.

Assembly manufacturing

If desired, we handle the entire manufacturing sequence for assemblies, from procurement of raw materials to construction of jigs and fixtures, fabrication, assembly and logistics.

Micafil machined composite products



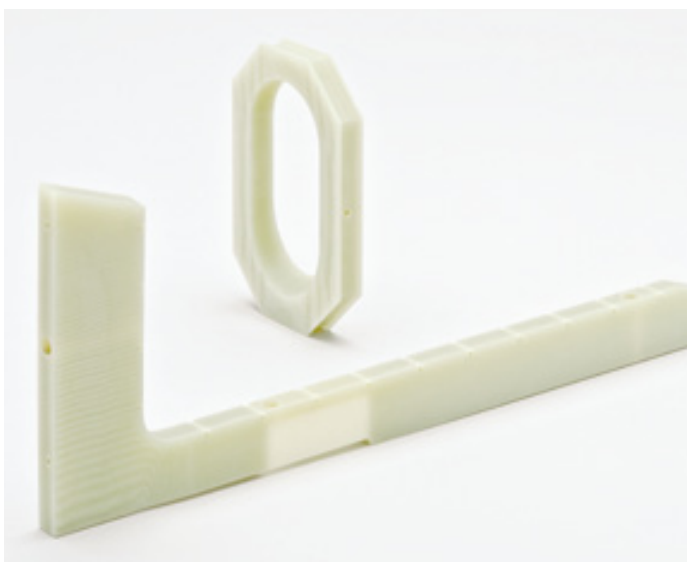
Best in class solutions for Generator Circuit Breakers

A torsion shaft manufactured with the resin transfer molding process. The high mechanical and electrical load on the insulation material offers compact structures. Its specific geometric shape acts in a secondary role as a failsafe design.



Tailor-made high-precision composite solutions

Based on customer drawings, our highly skilled employees manufacture with high precision using CNC-controlled 3- to 5-axis-machining centers. Availability, flexibility, service and short lead times are key words throughout our factory. The machining of high-precision fiber reinforced thermoset components for the electrical industry requires unique know-how. Our large range of equipment allows us to meet any requirements with regards to tolerances and surface roughness.



Micafil-machined composites fly into space

We also manufacture edge reinforcement and foam cores used in sandwich panels for the space industry with extremely high quality to tight tolerances.

Resolam® Vetresit® Vetrelam®

Technical data



		Fastening								
		Vetresit®				Vetresit®				
		300	305	304	312	14	17			
		laminates consisting of heat-resistant cycloaliphatic epoxy resin reinforced with glass mat	laminates consisting of heat-resistant modified epoxy resin reinforced with glass mat	laminates consisting of heat-resistant modified epoxy resin reinforced with one-directional roving glass fabric (UD) and with glass mat	laminates consisting of heat-resistant cycloaliphatic epoxy resin reinforced with one-directional roving glass fabric (UD) and with glass mat	laminates consisting of heat-resistant epoxy resin reinforced with glass fabric	thin laminates consisting of heat-resistant epoxy resin reinforced with glass fabric			
Support: glass fabric (GC) ¹⁾		ISO 1172	mass %	60	65	60	60	60	50	
Electrical properties	Electric strength 50 Hz 1 min h = 3 mm	I 23 °C	IEC 60243	kV/mm	13.5–20	10–15	10–15	13.5–20	13.5–20	20–35
		90 °C			13.5–20	13.5–20	10–15	13.5–20	13.5–20	20–35
	Dissipation factor tan δ 50 Hz	23 °C	IEC 60250		≤0.05	≤0.05	≤0.05	≤0.05	≤0.04	≤0.05
90 °C				≤0.10	≤0.10	≤0.10	≤0.10	≤0.10	≤0.10	
Mechanical properties	Comparative tracking index		IEC 60112	CTI	600	150	150	600	200	200
		Fiber side		CTI						
Mechanical properties	Tensile strength	MR	ISO 527	MPa	220	220	450	350	220–350	300
		QR		MPa			140	100	220–300	
		MR 150 °C		MPa			340	270		
	Flexural strength	MR	ISO 178	MPa	320	350	600	450–650	350–450	400
		QR		MPa			250	200–350	350–450	
		MR 150 °C		MPa	160	210	490	225–325	175–225	250
	Flexural strength after ageing 28d/180 °C	MR	ISO 178	MPa	250	250	600	350	250	300
		MR 150 °C		MPa			490	150		
	Flexural modulus of elasticity	MR	ISO 178	GPa	13–18	15–18	23–30	18–25	18–23	15–20
	Splitting load	II	DIN 53463	N	2,500	2,500	4,000	3,000–5,000	3,000–4,000	
Thermal properties	Temperature class		IEC 60085		F	H	H	F	F	F–H
	Linear thermal expansion (20–100 °C)	I	ISO 11359-2	10 ⁻⁶ /K	12–15	10–14	12–16	13–18	13–20	14–16
		II			40–60	35–50	8–12	8–13	40–60	35–50
Thermal conductivity (20–100 °C)	I	ISO 22007-4	W/m K	≥0.40	≥0.30	≥0.35	≥0.35	≥0.25	≥0.25	

1) Glass content is determined with standard samples; glass content of laminates with other thickness on demand.
2) Aromatic polyamide fiber paper = Nomex® type 410 (Du Pont).

MR: machine direction along support
QR: cross direction to support

Rotor slot insulation

	Vetrelam®						Resolam®		
	402	403	404	410	417		423	02	03
thin laminate consisting of heat-resistant tracking-proof epoxy resin reinforced with glass fabric	laminate reinforced with glass fabric, epoxy resin and aromatic polyamide fiber paper ²⁾	laminate reinforced with glass fabric, epoxy resin and aromatic polyamide fiber paper ²⁾ with tracking-proof top layers	laminate consisting of heat-resistant epoxy resin reinforced with glass fabric, inside covered with aromatic polyamide fiber paper ²⁾ , outside tracking-proof covering layers	laminate consisting of glass fabric, heat-resistant epoxy resin and aromatic polyamide fiber paper ²⁾ , additionally an electrically insulating film as reinforcing dielectric and tracking-resistant top layers	A laminate of heat-resistant epoxy resin reinforced with glass fabric and coated with one layer aromatic polyamide fiber paper ²⁾ 0.13 mm coated on one side	B coated on both sides	laminate reinforced with glass fabric, epoxy resin and aromatic polyamide fiber paper ²⁾ with tracking-proof top layers	aromatic polyamide fiber paper ²⁾ standard thickness 0.76 mm	thin laminate consisting of heat-resistant epoxy resin reinforced with several layers of aromatic polyamide fiber paper ²⁾
50	50	40	45	35-40	48	45	35		
20-35	20-35	20-35	23-35	35-50	20-35	20-35	35-50	13.4	20
20-35	20-35	20-35	23-35	35-50	20-35	20-35	35-50		
≤0.05	≤0.08	≤0.08	≤0.08	≤0.08			≤0.08		
≤0.10	≤0.10	≤0.10	≤0.10	≤0.10			≤0.10		
500	200	500	500	500	200		600 M		
			125		125	125			
300	200	200	300	200	310	300	200	650	100
								420	
400	250	250	400	250	450	400	200		110
300	150	150	300	150	300	250	100		55
				300					
				260					
15-20	12-20	12-20	12-20	12-20			12-20		
F-H	F-H	F-H	F-H	F-H	F-H	F-H	F-H	F-H	F-H
14-16	15-20	15-20	14-16	15-25	14-20	14-20	15-25	20	
14-16								80	
≥0.25	≥0.25	≥0.25	≥0.25	≥0.25	≥0.25	≥0.25	≥0.25		

Contact us

Your benefits with Micafil laminate technologies:

- large number of references for all types of generator insulation solutions
- your «one stop shopping» partner for rotor kits
- extensive knowledge of polymers and composites
- machining of laminates with the highest precision
- short lead times for customized products
- a highly skilled partner to achieve your product targets for laminate applications

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