



Insulating Systems for Wind Turbine Generators

We Enable Energy

As one of the oldest industrial companies in Switzerland, founded in 1803, we focus on products for power generation, rotating machines and mechanical engineering. Von Roll is the global market leader and the only company to offer the complete range of insulation products, equipment, composites and services for electrical machines such as wind turbine generators.

For more than 100 years, we have been making outstanding contributions to this market, developing a number of highly innovative products that have enabled both steady increases in power output and more compact machines.

Customers enjoy the following advantages:

- » One single source for all insulating materials
- » Proven compatibility for system components
- » Testing at Von Roll of both materials and systems
- » Manufacturing technology and equipment
- » Consulting in application engineering
- » Training in insulation materials and systems

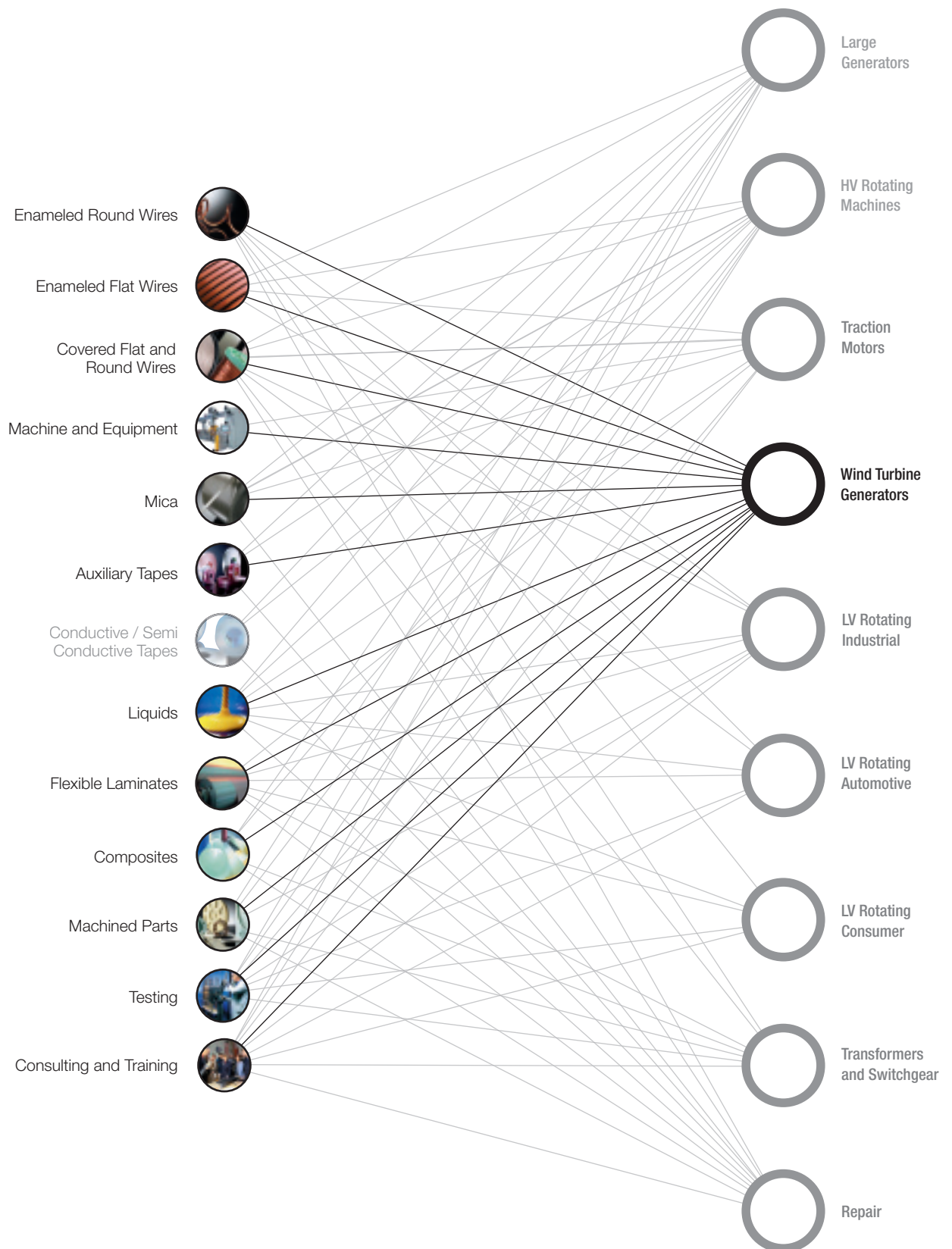
The insulation system of a wind turbine generator is a critical component for reliable and long-lasting operation. The insulating system and materials used for these machines are basically the same as for conventional generators and must be carefully selected in order to meet very high specific requirements.

The voltage output of generators in wind turbines ranges from 440 V to 6 kV. A variety of insulation systems are available and can be classified according to two different types:

- » Low Voltage insulation – typically up to a voltage output of 900 V, these systems are based on a random wound or form wound coil design
- » High Voltage insulation – for voltage output up to 6 kV, these systems are based on a form wound coil design both in vacuum pressure impregnation (VPI) and resin-rich (RR) technology



Our Products for Wind Turbine Generators

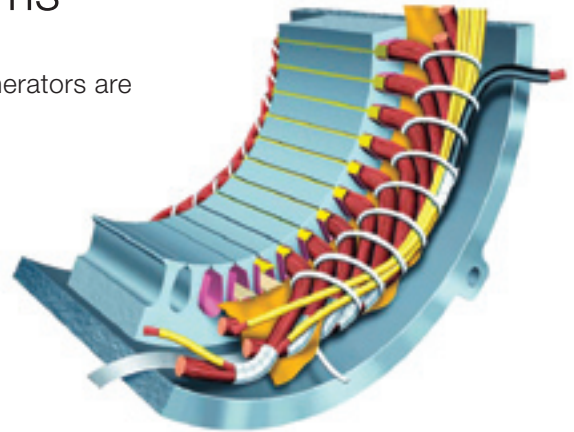


Von Roll offers full system solutions for every market shown in this application tree. Please contact us or visit our website www.vonroll.com for further information.

Low Voltage Insulating Systems

The insulation systems for low-voltage wind turbine generators are composed of the following materials and services:

- » Winding wires
- » Slot insulation
- » Impregnation resin
- » End-winding tape
- » Wedges and closures
- » Finishing varnishes
- » UL testing



Most of these low-voltage products are listed in UL under different thermal classes.



Winding Wires

Von Roll's winding wires are at the leading edge of technology.

We offer a wide range of high-quality winding wires for wind turbine generators both in round and rectangular forms. The following are the products we recommend for this application:

	Temperature index	Composition	Special properties
Thermex® 200	200°C	Enameled with modified polyesterimide base coat with a polyamide-imide overcoat	<ul style="list-style-type: none"> – Excellent thermal and chemical properties – Suitable for windings that are subjected to constantly high temperatures and mechanical stress – Suitable for use with high-speed automatic winders
Thermex® 200 CR	200°C	Enameled with modified polyesterimide coat	<ul style="list-style-type: none"> – Excellent thermal and chemical properties – Higher resistance to partial discharges compared to standard grades
Samicashield®	Class H	Enameled with polyesterimide base coat with a polyamide-imide overcoat and thin pore-free taped mica insulation	<ul style="list-style-type: none"> – Outstanding corona resistance compared to standard enamel or filled enamel insulations – Considerable longer lifetime in low-voltage motors
Thermibond® M for pole windings	200°C	Enameled with a modified polyamide-imide base coat with a thermosetting adhesive form	<ul style="list-style-type: none"> – The wires are self-bonding by means of a current surge or by curing in an oven – The bond coat solidifies the windings without impregnation



End Winding Tapes

Von Roll offers a wide range of high-quality adhesive tapes for a variety of applications. As an end-winding tape for low-voltage wind turbine generators we recommend:

	Temperature index	Backing	Thickness mm	Adhesive type	Tensile strength N/cm	Adhesion to steel N/cm
Intertape® 4616	Class B	Glass cloth	0.18	Thermosetting natural rubber	310	5.5
Intertape® 4617	Class F	Glass cloth	0.18	Thermosetting acrylic	310	4.4
Intertape® 4618	220°C	Glass cloth	0.18	Thermosetting silicone	310	4.4



Slot Insulation, Wedges and Closures

Von Roll is a world leader in laminated flexible insulations and coated materials.

Our materials for slot liners, phase insulation, barrier applications and closures for low-voltage wind turbine generators are outstanding. We supply them in a wide variety of thicknesses to fit perfectly in your application. The following products represent the best choices in this category:

	Temperature index	Composition	Special properties
Myoflex® PVS Acuflex® DMD	Class F	Three-ply flexible laminate made of PET felt, PET film and a PET felt fully saturated with a synthetic resin.	<ul style="list-style-type: none"> – Designed for automatic insertion machine – Tough, affordable laminate – Excellent resistance to cut through and edge tear
Myoflex® PVS H	Class H	Three-ply flexible laminate made of PET felt, PET film and a PET felt fully saturated with a synthetic resin.	Same as PVS with a higher thermal class
Myoflex® 2N50 and 80 Acuflex® NMN	Class F	Three-ply flexible laminate made of a Nomex® paper, polyester film and a 75µm Nomex® paper bonded with a synthetic resin.	<ul style="list-style-type: none"> – Outstanding mechanical properties – Good resistance to thermal stress thanks to high-performance adhesive system – Designed for automatic insertion machine
Myosam®	Class F	Three-ply flexible laminate made of a polyester film, mica paper and polyester film or fleece bonded with a synthetic resin.	<ul style="list-style-type: none"> – Exceptional corona resistance properties – Very good mechanical properties

For wedges we recommend composite materials such as Vetronit® G-11 or Delmat® Epoxy 68660 that can be delivered either as sheets or machined parts. U and L profiles with bounded Nomex layers are also part of the slot insulation program on request.



Impregnation Resins for Low Voltage Machines

Impregnation resins are among the most important components in any low-voltage machine. We offer a wide range of impregnation resins for low-voltage wind turbo generators with particular importance for class H systems.

The most suitable materials are listed below:

	Temperature index	Composition	Flash Point °C	Curing process	Special properties
Damisol® 3340	Class H	Polyesterimide	53	2 h at 150 °C	Class H resin. Outstanding dielectric properties up to class H.
Damisol® 3032	Class H	Polyesterimide	32	2 h at 140 °C	Multipurpose class H resin. Outstanding dielectric properties up to class H.
Damisol® Blue line 3630	Class H	Polyesterimide	>100	30 min at 150 °C	Multipurpose class H solventless varnish. High stability. Outstanding thermal aging properties. No VOCs. Low organic emissions.

The Damisol® blue line includes materials that have no or very little VOC emission and were engineered to be environmentally friendly. Our resins are described in detail in a separate brochure titled «Impregnating Resins and Varnishes».

High Voltage Insulation Systems

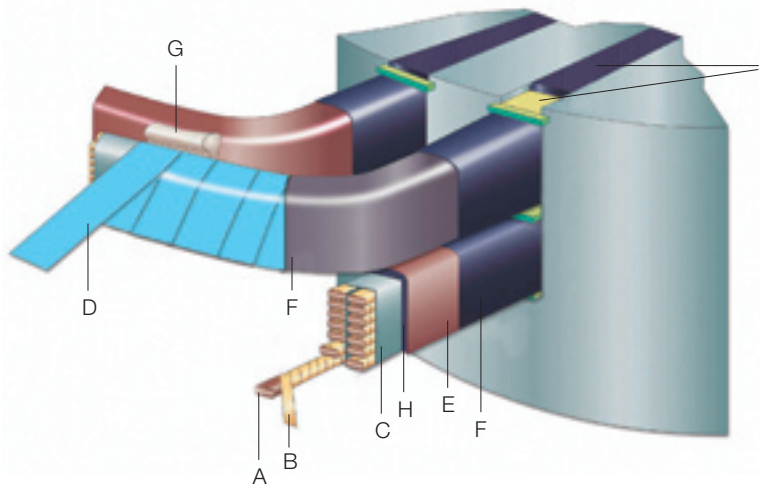
Many different materials are used in constructing high-voltage coils for wind turbo generators:

- » Winding wire (A)
- » Conductor insulation (B)
- » Stack consolidation (C)
- » Main wall insulation:
 - For VPI mica tape (D) + resin (H)
 - RR Mica tapes (D)
- » Conductive paint or tape (F) (typically for machines with voltages higher than 5 kV)
- » Finishing or sealing tapes (E)
- » Bracing materials (G)
- » Slot wedging materials (I)

Von Roll has developed a VPI insulation system under the name of Samicabond® with the following advantages:

- » Resins with high tank stability at room temperature
- » Impervious to moisture
- » Low viscosity
- » Fast curing with non-accelerated mica tapes
- » Excellent electrical properties
- » Class H
- » Very high price/quality ratio

In this document the main products associated with this system will be exposed.



Conductors

For conductors of high-voltage coils, we offer a complete range of high-quality products:

- » Covered wires with impregnated glass yarn (Silix®)
- » Covered wires with mixed glass/polyester yarn (Daglas®), with or without coating
- » Samicafilm® tape-covered wires
- » Flat rolled litz wires with bare or enameled single conductors, covered with Samicafilm® tape

Samicafilm® tape covering on bare or enameled wires is the preferred conductor insulation for stator and rotor coils due to its substantial advantages:

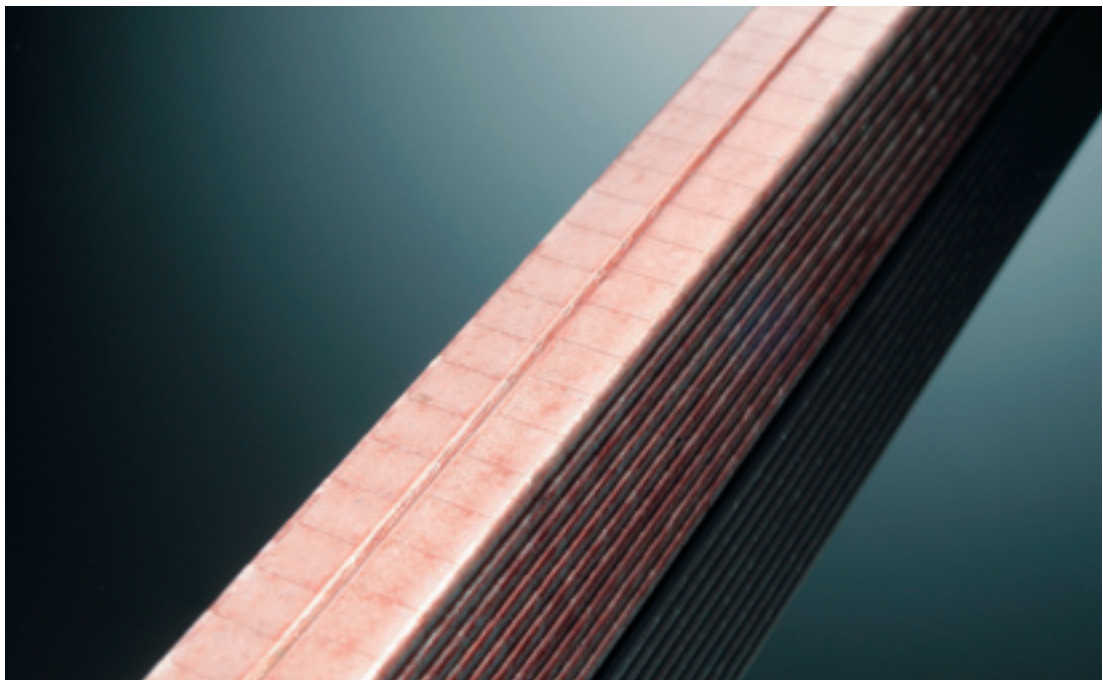
- » Better corona resistance
- » Reduced insulation thickness
- » Softer copper enabling easier workability
- » Greater manufacturing flexibility

Samicafilm® products are based on Von Roll Samica® mica paper impregnated with modified epoxy resin, reinforced with one or two polyester film backings and with or without adhesive coating.

Product name	Thickness mm	Weight g/m ²	Mica g/m ²	Composition	Adhesive
Samicafilm® F60+	0.06	76	30	Film/Mica	Yes
Samicafilm® F75	0.075	101	50	Film/Mica	No
Samicafilm® 315.14	0.09	131	75	Film/Mica	No
Samicafilm® 315.15-11	0.09	135	75	Film/Mica	Yes
Samicafilm® F2 90	0.09	124	65	Film/Mica/Film	No
Samicafilm® F2 90+	0.09	126	65	Film/Mica/Film	Yes

Samicafilm® tapes are applied butt-lapped or overlapped to the conductor. We supply both tape and taped conductors to our customers.

Product name	Insulation design	Thickness		Adhesive
		unpressed	pressed	
Samicafilm® 315.14 on bare wire	2 butt-lapped layers	0.36	0.3	No
Samicafilm® 315.15-11 on bare wire	2 butt-lapped layers	0.36	0.3	Yes
Samicafilm® F2 90 on bare wire	3 butt-lapped layers	0.54	0.43	No
Samicafilm® F2 90+ on bare wire	3 butt-lapped layers	0.54	0.43	Yes



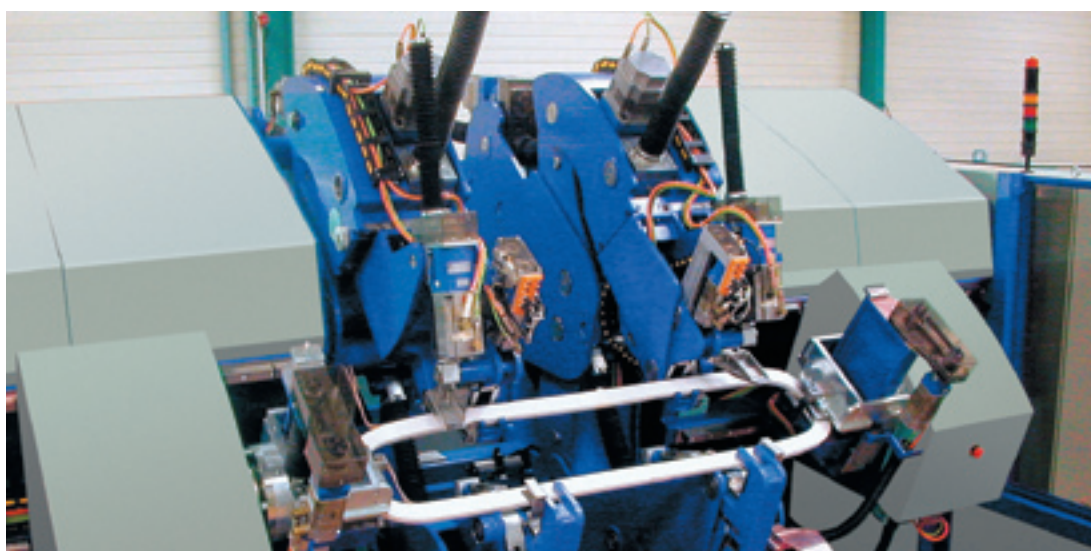
Samicafilm® tapes are thin but show outstanding corona resistance.



Coil Production

We offer complete systems and are involved in every aspect of high-voltage technology, including process equipment. For wind turbine generators Von Roll has come up with a line of coil-producing machines that use flat-coil technology. This line of equipment increases our customers' efficiency and includes the following units:

- » Wire dispensing and preparation
- » Loop winding
- » Taping
- » Coil forming



Coil-forming machine.



Stack Consolidation

Employing Samicafilm® with hot-melt adhesive or glass-lapped wires at B stage enables rapid consolidation of conductor stacks without the need for additional consolidation products.

When using Samicafilm® without hot-melt adhesive or non-B-stage wires, traditional hot-press consolidation is preferred. This system can be achieved by overlapping the stack with Thermopreg® 251.78.

Von Roll standard materials for stack consolidation:

Product name	Form	Thickness mm	Description
Thermopreg® 251.78	Tape	0.1	Impregnated glass cloth
Polyester fleece 101.74-07	Tape	0.56	Nonimpregnated polyester fleece
Glasoflex 261.10-03	Tape	0.5	Impregnated glass fleece with high resin content
Damival® 15182/9030	Resin		Solventless two-component epoxy resin



Main Wall Insulation for the VPI System

Von Roll is highly committed to mica. Our added value is evident throughout the entire manufacturing chain. It starts with mining, preparing the mica scrap and mica paper pulp, producing mica paper and finally manufacturing mica tapes to the highest standards for use in main wall insulations.

We have exactly the solutions you need to improve the quality and cost-effectiveness of high-voltage insulation in your applications.

With Samicapor®, Von Roll has designed a range of outstanding VPI mica tapes that fulfill the requirements of main wall and end-winding insulation, namely:

- » High dielectric strength
- » Corona discharge resistance
- » Fast and easy impregnation
- » Resin retention without draining
- » Smooth application without creasing
- » Both manual and fast-running machine application
- » Full compatibility with predefined resin systems

Product name	Thickness mm	Weight g/m ²	Mica g/m ²	Composition	Resin compatibility and thermal class		
					Non-accelerated epoxy-anhydride	Accelerated epoxy VPI systems	Polyesterimide Samicabond® system
Samicapor® 366.55-10	0.15	200	160	Glass/Mica	F		
Samicapor® 366.58	0.15	195	160	Glass/Mica		F	H
Samicapor® 366.58-18	0.15	213	180	Glass/Mica		F	H
Samicapor® 374.04	0.18	241	160	Glass/Mica/ Fleece		F	F
Samicapor® 374.15	0.18	241	160	Glass/Mica/ Fleece	F		
Samicapor® P 315.33	0.18	241	160	PET-film/Mica	F		
Samicapor® P 315.45	0.18	241	160	PET-film/Mica		F	F



Von Roll's commitment to mica starts with mining and ends with the production of mica-taped wires.



Main Wall Tapes for the RR System

Assuring optimum quality of main wall insulation requires careful selection of the micaceous tape and detailed attention to the way the tape is applied and processed. With these demands in mind, we have created a complete range of RR main wall insulation tapes under the name of Samicatherm® that are used for wind turbine generators:

Product name	Thickness mm	Weight g/m ²	Mica g/m ²	Description
Samicatherm® 366.28	0.19	303	120	Glass/Mica with interleaving foil.
Samicatherm® 366.28-02	0.19	265	120	Glass/Mica without interleaving foil.
Samicatherm® 366.32	0.26	458	240	Glass/Mica tape.
Samicatherm® 366.33-62	0.25	350	180	Glass/Mica tape.
Samicatherm® P315.20-02	0.16	252	150	PET film/Mica tape.
Samicatherm® P 315.51	0.09	117	60	Polyimide film/Mica tape class H.

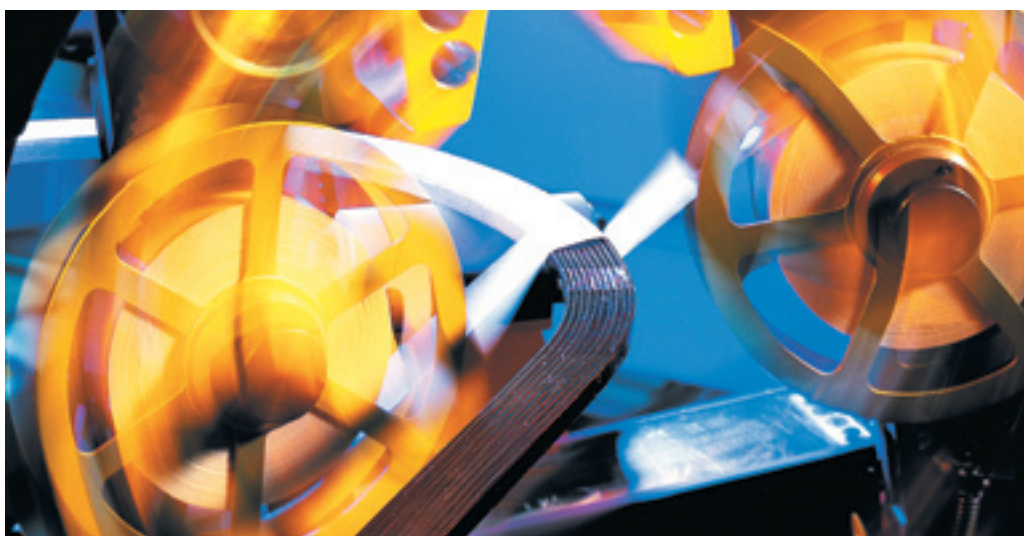
Overhang tapes for conventional hot pressing:

Product name	Thickness mm	Weight g/m ²	Mica g/m ²	Description
Filosam® 326.57-20	0.15	206	109	PET film/Mica/Glass threads; highly flexible.
Filosam® 326.57-50	0.13	177	75	PET film/Mica/Glass threads; highly flexible.
Samicaflex® 366.18	0.12	150	75	Glass/Mica tape, Class H flexible for higher voltages.
Samicaflex® 366.19	0.18	215	120	Glass/Mica tape, Class H flexible for higher voltages.



Taping Machines

Optimal quality application of Samicapor® and Samicatherm® tapes can be achieved with high-speed taping machines.





Pressing in the RR Process

RR processed coils need to be heated and pressed in order to achieve the proper final dimensions, while allowing flow of the resin, filling of possible voids and finally curing of the total insulation. State-of-the-art presses are the ideal solution.



Mica tapes for VPI applications.



Finishing Tapes

The mica tapes used in main wall and overhang insulation contain materials that can easily be damaged and need to be protected against:

- » Moisture
- » Mechanical load
- » Damage
- » Atmospheric pollutants

With Epoflex® Von Roll found the appropriate solution that fulfills these requirements:

Product name	Form	Thickness mm	Description
Epoflex® 324.03	Tape	0.09	Polyester glass fabric with a polyester film and reduced binder quantity.



Machine Winding and Bracing

The simplicity of the winding process for machines with «dry» coils is a recognized benefit of VPI technology. Substantial advantages obtain during the end-winding bracing and support process. Von Roll has developed a range of ropes, cords and sleeves for «surge ring» intercoil lacing and tying applications.

The main advantages of these products are:

- » Class C (glass) and F (polyester) applications
- » Compressibility and resilience
- » Glass or polyester yarn on the outside
- » Wide range of dimensions
- » Nonimpregnated for use with VPI; no further processing
- » Impregnated polyester shrink cord for use with RR technologies

Product name	Form	Thickness mm	Description
Isocord® 151.10	Cord	From 1.8 to 50	Braided silane E-glass yarn outside with staple glass filler.
Isocord® 151.12	Cord	From 1.5 to 60	Braided polyester yarn outside with staple glass filler.



Glass or glass polyester cords.

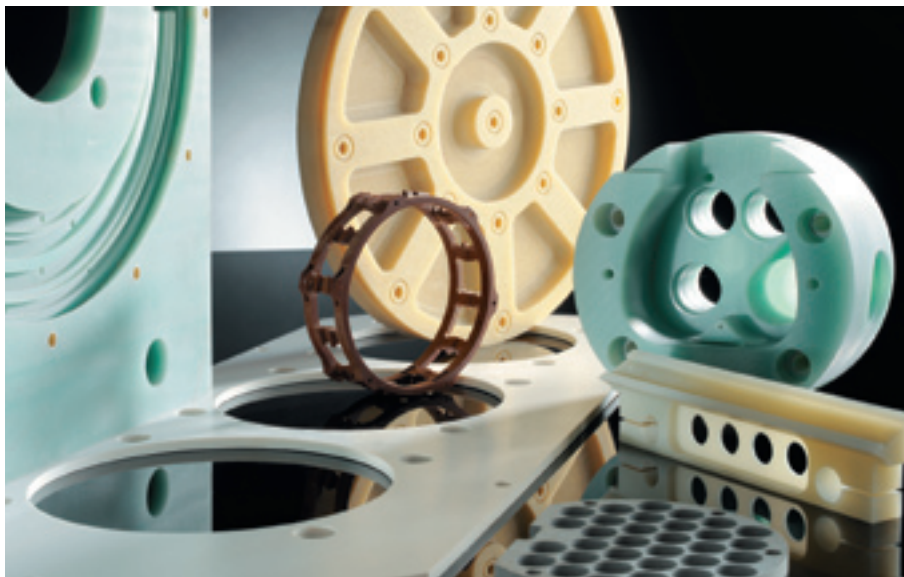


Composite Materials for Wind Turbine Generators

Von Roll offers a variety of high-quality composite materials that can be delivered as wedges, sheets, machined parts or special components for use in different sections of a high-voltage rotating machine. The following are just a selection. Please ask our specialists about additional products.

Different materials used for rotor and stator components and their application:

Reference	Form	Application	Stator	Rotor
Delbond® product range	Rolls, strips	Interturn insulation		•
Vetronite® G-11	Sheets, machined parts	Slot wedges, blocking parts	•	•
Delmat® Epoxy 68660	Sheets, machined parts	Slot wedges, blocking parts	•	•
Vetronite® 64170, Polyfibril	Long strips	Bottom and top insulation	•	•
Conductive Vetronite® 432.10-01	Long strips	Bottom and packers conductive layers	•	
Nomex® channels	Nomex® formed	Rotor slot insulation		•
U and L channels	Composite profiles	Rotor slot insulation	•	
Vetroferrite®	Machined parts	Magnetic slot wedges		



Machined parts tailored to customer specifications.



VPI Resins

Several families of resins have excellent electrical characteristics when cured. The factors that influence the final choice of resin used are much more complex. Important considerations relate to features of the design of the machines and the choice of insulating system, taping and VPI processes.

Von Roll offers a variety of high-performance resins that are compatible with all the other insulation materials within the system. For wind turbine generators we propose:

	Type	Thermal class	Curing process	
Damisol® 3340	Polyesterimide Samicabond® system	H	8h at 150 °C	Highly reactive, yet highly stable room-temperature impregnating resin. Good results on static curing.
Damisol® 3032	Polyesterimide Samicabond® system	H	8h at 140 °C	Highly reactive, yet highly stable room-temperature impregnating resin. Good results on static curing.
Damisol® 3407	Epoxy/anhydride 2K	F	10h at 170 °C	Accelerated tape needed.



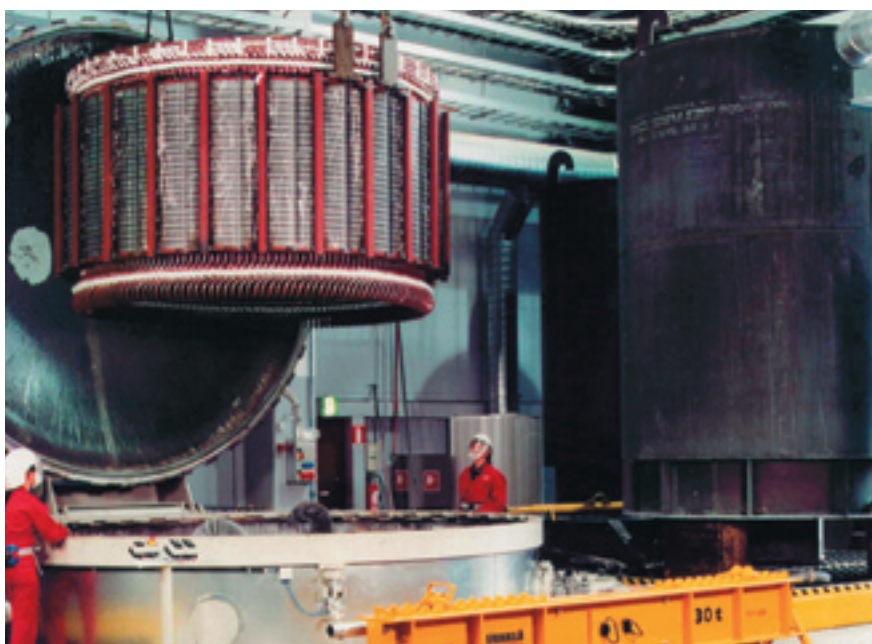
Drying and Impregnation

The principles of air drying, controlled rate impregnation, pressuring and curing of resin are well understood by VPI process users and potential users.

Von Roll offers VPI systems tailored to meet the needs of all sectors of the rotating machine industry.

For new equipment or upgrading existing plants, we ensure state-of-the-art VPI technology to increase our customers' efficiency.

Instrumentation for measuring capacitance, essential for in-line quality control of impregnation, is built into the systems.



Large Vacuum Pressure Impregnation (VPI) unit.



Finishing Coating

The Damicoat® range of finishing and overcoat varnishes includes air-drying and oven-curing solutions. All are single-component for easy processing by spray, brush and even dipping and dip rolling.

Selection table	Chemistry	Color	Thermal class	Drying time	Comments on products and use
Damicoat® 2404	Alkylphenol	N/RB/G	F	15–20h	Highly chemically resistant overcoat varnish.
Damicoat® 2407	Alkyd-modified	RB	F/H	1–2h	High-temperature-resistant overcoat varnish, used for up to class H high-voltage and traction machines.



Testing

Ensuring the requested specifications concerning mechanical, electrical and thermal characteristics means testing materials and systems.

Von Roll HV and LV laboratories can test their customers' materials and systems according to IEC, UL and other specifications. Our low- and medium-voltage laboratory in the US is certified by Underwriters Laboratories® Inc., performing system qualifications up to 6.9 kV.

- » Thermal, electrical and mechanical aging tests
- » Tan δ measurements at different temperatures
- » Partial discharge measurements with different voltage ranges



Testing in the Von Roll laboratory.



Training

For a number of years we have been offering a unique program of high-voltage insulation training within our Von Roll Corporate University. The objectives of this program are:

- » Better understanding of high-voltage insulation technology for rotating machines and up-to-date knowledge on insulating materials and systems
- » Practical experience in the application of electrical insulating materials



Our training courses are attended by customers and partners from around the globe.

We Enable Energy

Von Roll is the sole full range supplier of materials and systems for the insulation of electrical machines as well as high-performance products for various high-tech industries.



Mica

All materials related to high-voltage insulation. Von Roll's commitment to mica starts with mining and ends with finished tapes.



Wires

Insulated round, flat and Litz wires for high-voltage, low-voltage and electronic applications.



Cables

Mica tapes for fire-resistant cables. Von Roll provides a wide range of products that are ideally suited to all commonly used standards.



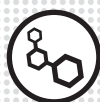
Liquids

Impregnation resins for high and low voltage, potting resins, casting resins, as well as encapsulating and conformal coatings.



Flexibles

Insulating flexible materials for low-voltage applications such as flexible laminates and adhesive tapes.



Composites

Engineered materials made from a resin and a support structure with distinct physical, thermal and electrical properties. They can be molded, machined or semi-finished.



Machines

Processing machines for high-voltage applications. Von Roll supplies a wide range of machinery from coil and bar taping up to VPI (Vacuum Pressure Impregnation) equipment.



Testing

Von Roll provides electrical, thermal and mechanical testing of individual materials as well as complete insulating systems. We are UL-certified.



Training

Von Roll Corporate University provides a training program in high- and low-voltage insulation to its customers.

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About Von Roll

As one of Switzerland's longest-established industrial companies, founded in 1803, Von Roll focuses on products and systems for power generation, motors in the high- and low-voltage sectors, composites and other specialty products for the mechanical engineering. Von Roll is the global market leader in insulation products, systems, process equipment and services and is represented in 18 countries with around 3,100 employees at 32 sites.