



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 and systems for power generation, transmission and distribution, rotating machines and mechanical engineering. Von Roll is the global market leader for insulation products and the only company to offer the complete range of insulation products, composites, consulting, tests and services for electrical machines such as turbo and hydro 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.

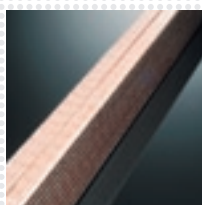
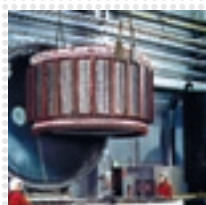
Customers enjoy the following benefits:

- » One single source for all insulating materials
- » Thorough expertise from power generation and transmission to its efficient utilization
- » Proven compatibility for system components
- » Testing at Von Roll of both materials and systems
- » Consulting for applications and technologies
- » Training in insulation materials and systems

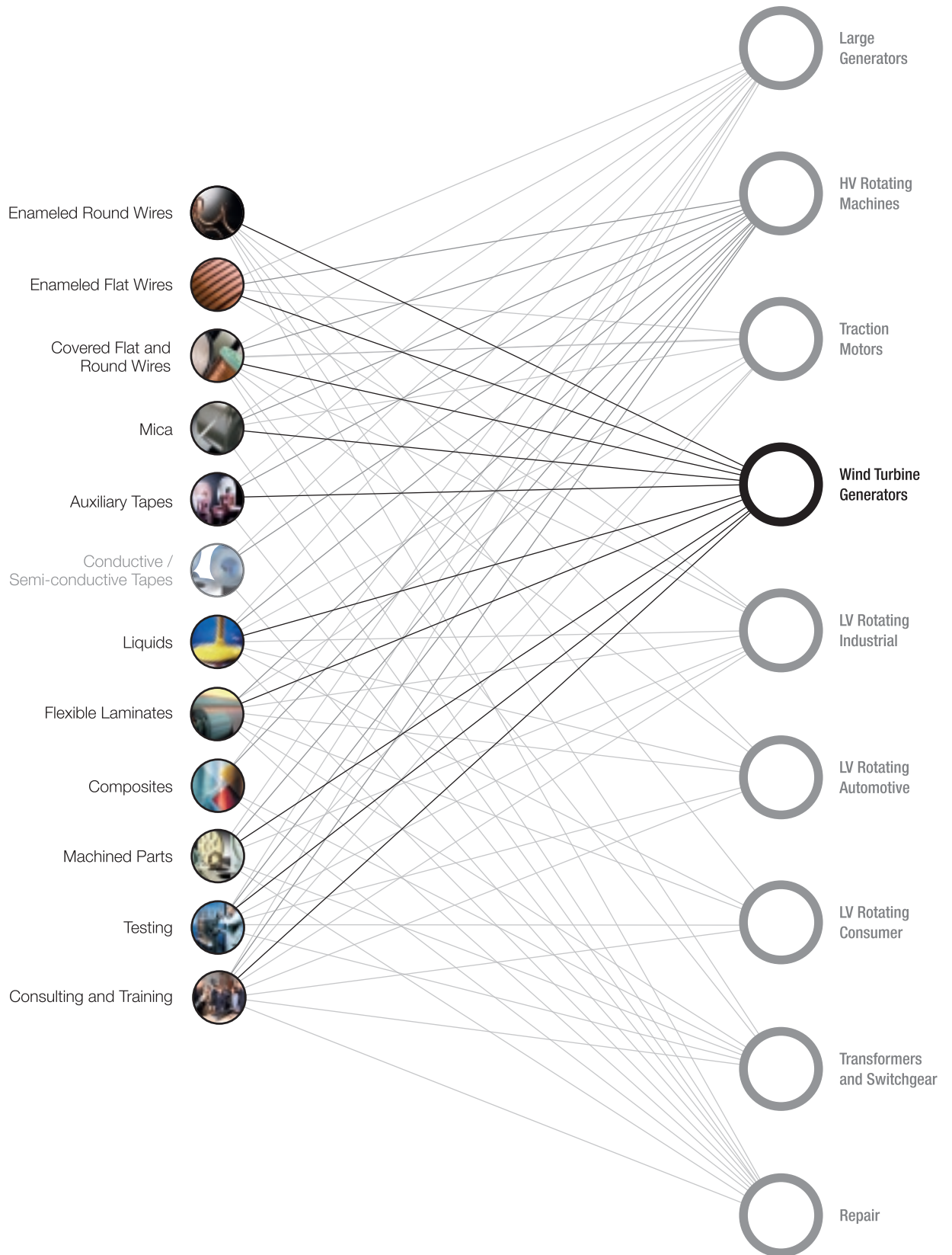
The insulation system of a wind turbine generator is a critical component for reliable and long-lasting operation. The insulating system and materials used for these machines are basically the same as for conventional generators and must be carefully selected in order to meet very high specific requirements.

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

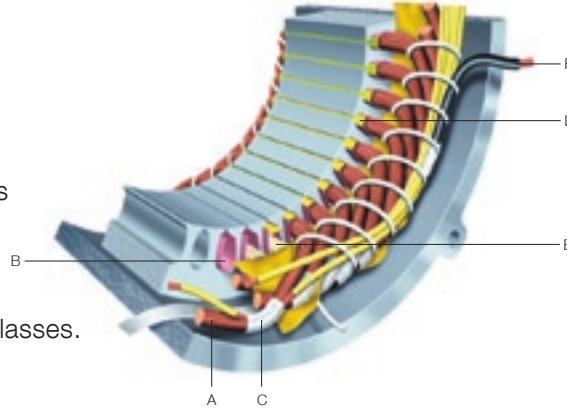


Von Roll offers full system solutions for every market shown in this application tree. Please contact us or visit our website www.vonroll.com for further information.

Low-Voltage Insulating Systems

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

- » Winding wires (A)
- » Slot insulation (B)
- » End-winding tape (C)
- » Slot wedges (D) and closures (E)
- » Cable (F)
- » Impregnation resin / finishing varnishes
- » UL testing



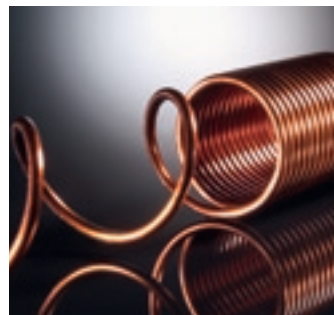
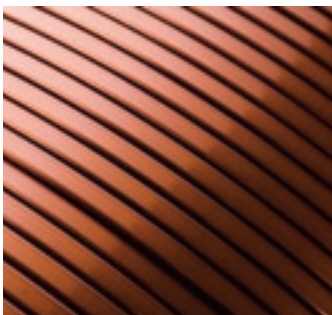
Most of these low-voltage products are listed in UL under different thermal classes.



Conductors for Low-Voltage Generators

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:

	Thermal class	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® 220	220 (C)	Enameled with polyamide-imide	<ul style="list-style-type: none"> – Outstanding mechanical, chemical and thermal properties – Suitable for windings which are subjected to constantly high temperatures and mechanical stress
Thermex® CR 201	200 (C)	Enameled with modified polyester-imide	<ul style="list-style-type: none"> – Excellent thermal and mechanical properties – Higher resistance to partial discharges compared to standard grades
Samicashield®	180 (H)	Enameled with polyester-imide base coat with a polyamide-imide overcoat and covered with a thin pore-free mica tape insulation	<ul style="list-style-type: none"> – Improved corona resistance compared to standard enamel or filled enamel insulations – Considerable longer life time in low voltage motors





End-Winding Tapes

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

	Thermal class	Backing	Thickness mm	Adhesive type	Tensile strength N/cm	Adhesion to steel N/cm
Intertape® 4616	130 (B)	Glass cloth	0.18	Thermosetting natural rubber	310	5.5
Intertape® 4617	155 (F)	Glass cloth	0.18	Thermosetting acrylic	310	4.4
Intertape® 4618	200 (C)	Glass cloth	0.18	Thermosetting silicone	310	4.4



Slot Insulation

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:

	Thermal class	Composition	Special properties
Myoflex® PVS Acuflex® DMD	155 (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	200 (C)	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"> – Same as PVS with a higher thermal class
Myoflex® 2N50 and 80 Acuflex® NMN	155 (F)	Three-ply flexible laminate made of a Nomex® paper, polyester film and a 75 µm 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®	155 (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 Vetronite® 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:

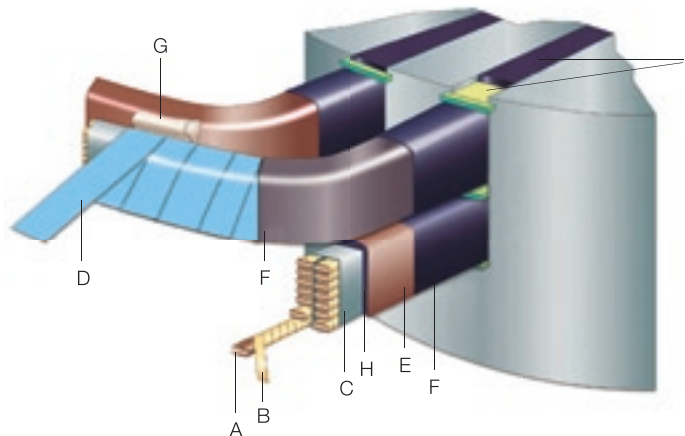
	Thermal class	Composition	Flash point °C	Curing process	Special properties
Damisol® 3340	180 (H)	Polyesterimide	53	2 h at 150 °C	– Class H resin – Outstanding dielectric properties
Damisol® 3032	180 (H)	Polyesterimide	32	2 h at 140 °C	– Multipurpose class H resin – Outstanding dielectric properties
Damisol® Green range 3630	180 (H)	Polyesterimide	>100	30 min at 150 °C	– Multipurpose class H varnish, solventless – High stability – Outstanding thermal aging properties – No VOCs, low organic emissions

The Damisol® green range 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

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

- » 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 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



Conductors for High Voltage

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
- » 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® tapes are thin but show outstanding corona resistance.

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.

Samicafilm® type	Thickness mm	Weight g/m ²					Breakdown voltage kV	Adhesive
		Total	Mica	PET foil 1	PET foil 2	Resin		
315.11-01	0.06	72	30	32		10	≥ 5	No
315.12-01	0.07	93	50	32		11	≥ 5	No
315.70-01	0.075	101	50	42		9	≥ 8	No
315.14	0.09	131	75	42		14	≥ 8	No
315.15-01	0.09	131	75	42		14	≥ 8	No
315.11-11	0.06	76	30	32		14	≥ 5	Yes
315.12-11	0.07	97	50	32		15	≥ 5	Yes
315.15-11	0.09	135	75	42		18	≥ 8	Yes
315.72-01	0.085	124	65	32	17	10	≥ 8	No
315.23-01	0.09	112	50	32	17	13	≥ 8	No
315.25-03	0.1	141	75	42	8	16	≥ 8	No
315.72-21	0.09	133	65	32	17	19	≥ 8	1 side
315.23-11	0.09	126	50	32	17	27	≥ 8	2 sides
315.25-11	0.11	151	75	32	17	27	≥ 8	2 sides

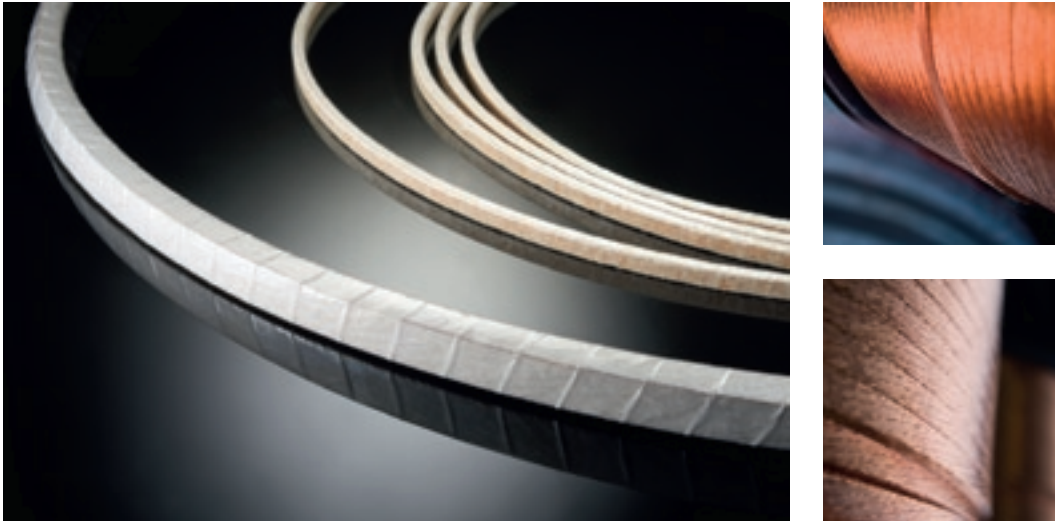


Pressed Rectangular Litz Wires

Litz wires with a rectangular profile as an alternative for common solid flat wires enable smaller overhang areas, higher copper filling factors and a higher efficiency on the same cross section due to less eddy-current losses (reduction of the skin- and proximity effects).

Von Roll offers a wide range of rectangular Litz wires in various dimensions and compositions:

- » Single wires, bare or enameled
- » Total cross section of copper: 1 to greater than 100 mm² (width to thickness ratio 1.25:1 to 3:1)
- » Additional insulations: one or more layers of mica tape Samicafilm®



Main Wall Insulation for the VPI System

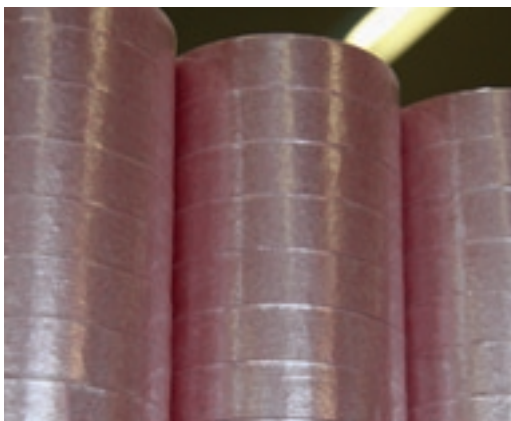
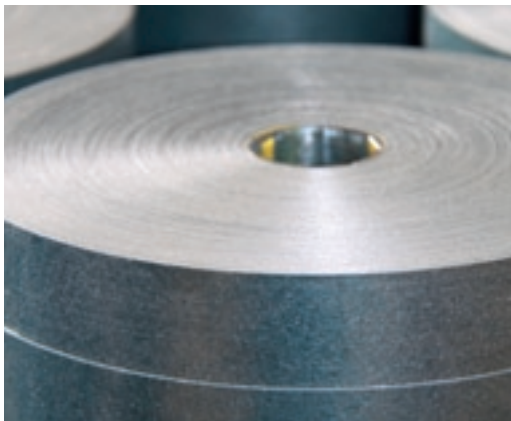
Von Roll is highly committed to mica. Our added value is evident throughout the entire manufacturing chain. It starts with mining, preparing the mica scrap and mica paper pulp, producing mica paper and finally manufacturing mica tapes to the highest standards for use in main wall insulations.

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	Rated voltage		Thickness mm	Weight g/m ²		Composition	Resin compatibility and thermal class		
	< 6 kV	> 6 kV		Total	Mica		Non-accelerated epoxy-anhydride	Accelerated epoxy VPI systems	Polyesterimide Samicabond® system
Samicapor® 366.55-10	•	•	0.15	200	160	Glass/Mica	155 (F)		
Samicapor® 366.55-12	•	•	0.14	198	160	Glass/Mica	155 (F)		
Samicapor® 366.58	•	•	0.15	195	160	Glass/Mica		155 (F)	155 (F)/180 (H)
Samicapor® 366.58-18	•	•	0.15	213	180	Glass/Mica		155 (F)	155 (F)/180 (H)
Samicapor® 366.58-20	•	•	0.17	224	180	Glass/Mica		155 (F)	155 (F)/180 (H)
Samicapor® 374.04	•		0.18	241	160	Glass/Mica/PET fleece		155 (F)	155 (F)
Samicapor® 374.15	•		0.18	241	160	Glass/Mica/PET fleece	155 (F)		
Samicapor® P 315.33	•		0.18	241	160	PET film/Mica	155 (F)		
Samicapor® P 315.45	•		0.18	241	160	PET film/Mica		155 (F)	155 (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 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 Samicatherm® that are used for wind turbine generators:

Main wall tapes for conventional hot pressing:

Product name	Rated voltage			Thickness mm	Weight g/m ²		Description
	< 6 kV	6–13.8 kV	> 13.8 kV		Total	Mica	
Samicatherm® 366.28/366.28-02	•	•		0.19	265	120	Mica/Glass with/without interleaving foil
Samicatherm® 366.28-04/366.28-03	•	•		0.19	265	120	Mica/Glass with/without interleaving foil, slightly dryer
Samicatherm® 366.28-05	•	•		0.19	265	120	Mica/Glass with embossed interleaving foil, slightly dryer
Samicatherm® 366.28-06	•	•		0.20	277	120	Mica/Glass without interleaving foil, slightly higher resin content
Samicatherm® 366.33-62	•	•	•	0.25	350	180	Mica/Glass without interleaving foil
Samicatherm® 366.32	•	•	•	0.26	458	240	Mica/Glass with interleaving foil
Samicatherm® P 315.20/315.20-02	•			0.16	252	150	Mica/PET film with/without interleaving foil
Samicatherm® P 315.20-10	•			0.17	270	150	Mica/PET film without interleaving foil
Samicatherm® PI 315.51	•			0.09	117	60	Mica/Polyimide foil, class H



Overhang tapes for conventional hot pressing:

Product name	Thickness mm	Weight g/m ²		Description
		Total	Mica	
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, Class H, flexible for higher voltages
Samicaflex® 366.19	0.18	109	120	Glass/Mica, Class H, flexible for higher voltages



Corona Protection

Electrical stress control measures are an essential component of any high-voltage machine. Von Roll has developed a number of products under the trade name CoronaShield®, namely:

- » Conductive tapes
- » Semi-conductive tapes
- » Conductive varnishes

All these tapes can be applied as:

- » External corona protection – within the slot
- » End corona protection – outside the slot

Product name	Thickness mm	Resistivity Ohm/m ²	Description
CoronaShield® 215.51	0.10	200–400	Conductive tape, impregnated PET fleece, not compatible with epoxy anhydride, cured
CoronaShield® 215.55	0.085	200–400	Conductive tape, impregnated PET fleece, cured
CoronaShield® 215.63	0.17	200–400	Conductive tape, impregnated PET fleece, cured
CoronaShield® 217.01/217.21	0.22	Variable	Semi-conductive tape, impregnated PET fabric, with specific characteristics, not cured (B-stage)
CoronaShield® 217.02/217.22	0.22	Variable	Semi-conductive tape, impregnated PET fabric, with specific characteristics, not cured (B-stage)
CoronaShield® 217.03	0.22	Variable	Semi-conductive tape, impregnated PET fabric, with specific characteristics, not cured (B-stage)
CoronaShield® 217.31	0.25	Variable	Semi-conductive tape, impregnated PET fabric, with specific characteristics, cured



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	Thickness mm	Description
Epoflex® 215.01	0.19	Polyester fleece with epoxy resin, not cured
Epoflex® 219.61-10	0.18	Polyester glass fabric with a polyester film with epoxy resin, not cured
Epoflex® 324.03	0.09	Polyester glass fabric with a polyester film and reduced binder quality, cured



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	Type	Diameter mm	Description
Isocord® 151.10	Cord	1.8–50	Braided silane E glass yarn outside with staple glass filler
Isocord® 151.12	Cord	1.5–60	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:

Product name	Type	Application	Stator	Rotor
Delbond® product range	Rolls, strips	Interturn insulation		•
Vetronit® 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	•	•
Vetronite® 432.10-01, conductive	Long strips	Bottom and packers conductive layers	•	
Nomex® channels	Nomex® formed	Rotor slot insulation		•
U and L channels	Composite profiles	Rotor slot insulation	•	



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:

Product name	Type	Thermal class	Curing process	Description
Damisol® 3340	Polyesterimide Samicabond® system	180 (H)	8 h at 150 °C	Highly reactive, yet highly stable room-temperature impregnating resin. Good results on static curing.
Damisol® 3032	Polyesterimide Samicabond® system	180 (H)	8 h at 140 °C	Highly reactive, yet highly stable room-temperature impregnating resin. Good results on static curing.
Damisol® 3407	Epoxy/Anhydride 2K	155 (F)	10 h at 170 °C	Accelerated tape needed.



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.

Product name	Color	Rated voltage			Drying time	Description
		< 6 kV	6–15 kV	< 15–22 kV		
Damicoat® 2404	N/RB/G	•	•		15 to 20 h	Highly chemically resistant overcoat varnish.
Damicoat® 2407	RB	•	•		1 to 2 h	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.



Ballistic Protection

High-quality systems for armored defense based on thermoset / thermoplastic products in single-use or tailored combinations.



Cables

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



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.



Flexibles

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



Liquids

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



Mica

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



Transformers

High-performance transformers for power transmission and distribution, tailored solutions to all applications of today's energy-supply companies.



Wires

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



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.

Please contact us or visit our website www.vonroll.com for further information

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About Von Roll

We Enable Energy – As one of Switzerland's longest established industrial companies, Von Roll focuses on products and systems for power generation, transmission and distribution. Von Roll's business portfolio is divided into five business segments: **Von Roll Insulation** is the global market leader in insulation products, systems and services. **Von Roll Composites** produces composite materials and parts for assorted industry appliances. **Von Roll Transformers** offers complete solutions for the fast expanding market of high performance transformers. **Von Roll Water** provides solutions for process engineering tasks in the field of water and waste water management. **Von Roll Solar** is developing a third-generation solar cell.