

# Insulating Systems for Large 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, composites, and mechanical engineering. Von Roll is the global market leader and the only company to offer the complete range of insulation products, equipment 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
- » 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

Demand for higher performance and reliability together with higher productivity in turbo and hydro generators is continuously increasing. Electricity producers are faced with new challenges, mostly imposed by the demand for energy efficiency in power distribution grids, that strongly influence the design and choice of insulation materials.

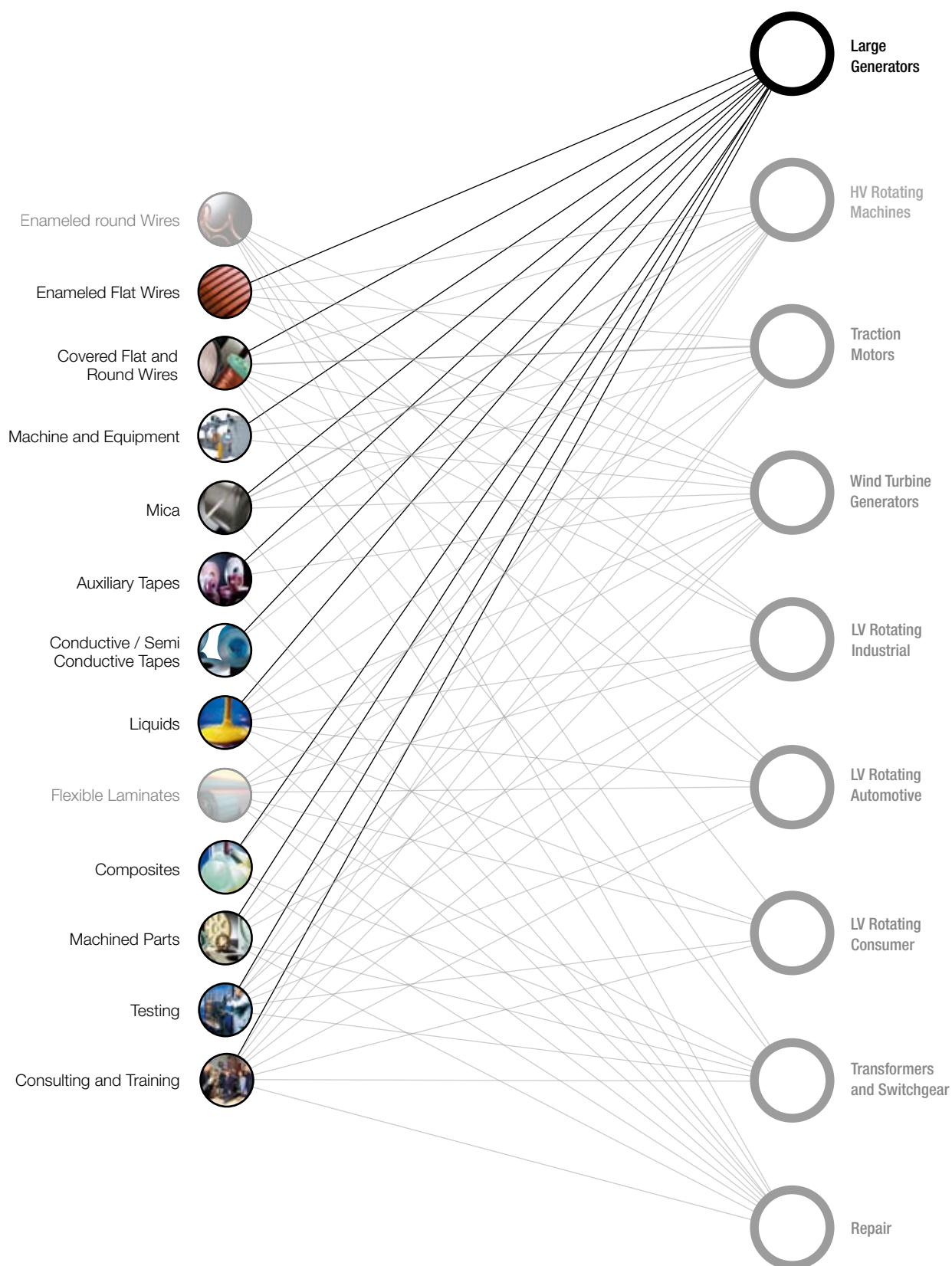
Von Roll has developed a full service solution for insulation systems and process technologies to accommodate these new challenges for turbo and hydro generators to meet our customers' global demand using both resin-rich (RR) and vacuum pressure impregnation (VPI) techniques.

## **Examples of such developments are:**

- » High thermal conductivity main wall tapes (HTC) that enable higher performance through better thermal conductivity of the insulation
- » Fast curing materials that substantially increase productivity
- » New generation of conductive tapes that are more stable against corona effects with time and considerably increase the life span of electrical machines



# Our Products for Large 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](http://www.vonroll.com) for further information.





# Conductors

Roebel bars in hydro and turbo generators need especially mechanically robust insulation at the crossover part of the bars. Von Roll has developed a glass yarn-covered enameled copper conductor with high bonding strength that can be used with automatic Roebeling machines. The high thermal resistance of this rectangular insulated conductors makes it suitable for class H high-temperature generators.



Conductors are offered in a wide variety of dimensions.

The table below shows the preferred materials for large generators:

Product name	Rated voltage			Dimensions	Description
	<6kV	6–13.8kV	>13.8kV		
Silix on bare wire	•			On request	Glass-lapped wire with or without B-stage overcoat.
Silix on enameled wire	•	•	•	On request	
Daglas on bare wire	•			On request	Daglas-lapped wire with or without B-stage overcoat.
Daglas on enameled wire	•	•	•	On request	



# Roebel Bar Manufacturing Machines

We offer complete systems and are involved in every aspect of high-voltage technology, including process equipment. Together with its partners, Von Roll has come up with an automated line for large generators that considerably increases productivity and quality.



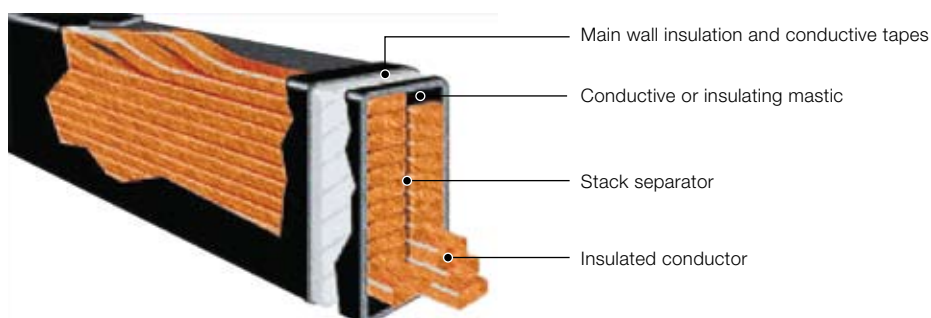
Machine producing Roebel bars for large generators.



## Stack Consolidation

Von Roll has developed state-of-the-art materials for stack consolidation:

Product name	Form	Rated voltage			Thickness mm	Description
		<6kV	6–13.8kV	>13.8kV		
Glasoflex® 261.10-03	Tape	•	•	•	0.5	Impregnated glass fleece with high resin content for overhangs.
Glasoflex® 371.62-02	Tape	•	•	•	1	Impregnated glass fleece/glass cloth/glass fleece.
Glasoflex® 371.27	Tape	•	•	•	0.85	Impregnated glass fleece/glass cloth/glass fleece.
Conductive mastic 8004	Mastic			•	On demand	Conductive mastic in extruded tape form.
Samica Kitt 326.01	Mastic			•	On demand	Nonconductive mastic in sheet form.



We have the right solutions you need to increase your productivity and efficiency. This is why we created a full range of fast-curing materials that enable our customers to halve processing time and reduce energy requirements.

### Conventional

### Fast Curing

» Curing conditions	» 30 min/160 C	» 15 min/120 C
» Shelf Life (RT)	» 6 months	» 4 months
» Thermal class	» F	» F

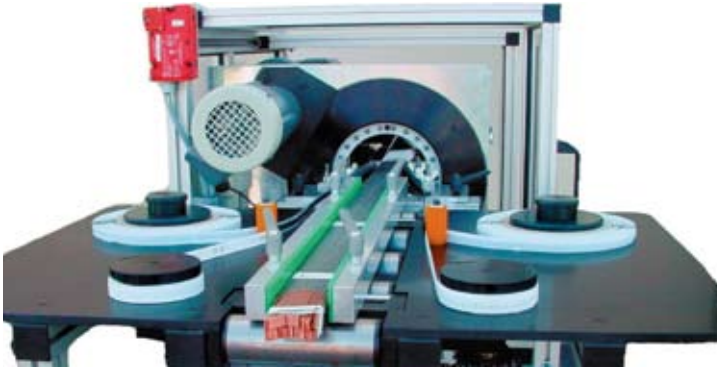
Recommended fast curing materials are:

Product name	Form	Rated voltage			Thickness mm	Description
		<6kV	6–13.8kV	>13.8kV		
Fast-curing conductive mastic 8019	Mastic			•	On demand	Conductive mastic in extruded tape form.
Fast-curing mastic 4363	Mastic	•	•		On demand	Nonconductive mastic in extruded tape form.
Glasoflex® 371.30	Tape	•	•	•	0.85	Rigid separator material for slot portion.
Glasoflex® 261.10-06	Tape	•	•	•	0.4	Impregnated glass fleece for overhangs.



## Mastic Processing Equipment

Von Roll has developed both materials and process equipment to achieve productivity increases with a fully automated way of applying mastic that replaces the manual process.



Perfect matching of machine and material assures top performance.



## Main Wall Tapes for the VPI System

We are continually developing and advancing the quality and cost-effectiveness of high-voltage insulation for you. Effective solutions include insulation systems based on VPI (Vacuum Pressure Impregnation) as well as for RR (resin-rich) processing systems. With Samicapor®, Von Roll has designed a range of VPI mica tapes that fulfill the requirements of main wall and end-winding insulation. The resins associated with these tapes are listed under «VPI impregnation resins» and are described in detail in a separate brochure.

Our Samicapor® VPI mica tapes are the perfect choice, because they:

- » Have high dielectric strength
- » Resist corona discharge
- » Impregnate fast and easily
- » Retain resin without draining
- » Can be applied smoothly without creasing
- » Can be applied by fast-running machines or manually
- » Are fully compatible with a predefined resin system



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

The table below shows the preferred mica tapes for VPI applications:

Product name	Rated voltage			Thickness mm	Total weight g/m <sup>2</sup>	Mica g/m <sup>2</sup>	Composition	Non- accelerated epoxy/ anhydride	Accelerated epoxy VPI systems
	<6kV	6–13.8kV	>13.8kV						
Samicapor® 366.55-20	•	•	•	0.15	200	160	Glass/Mica	Yes	No
Samicapor® 366.55-30		•	•	0.15	200	160	Glass/Mica	Yes	No
Samicapor® 366.55-60			•	0.15	215	180	Glass/Mica	Yes	No
Samicapor® 366.58	•	•	•	0.15	195	160	Glass/Mica	No	Yes
Samicapor® 366.58-18	•	•	•	0.15	213	180	Glass/Mica	No	Yes
Samicapor® 366.58-20	•	•	•	0.17	224	180	Glass/Mica	No	Yes
Samicapor® HTC 381.55-20	•	•	•	0.2	259	160	Glass/Mica	Yes	No

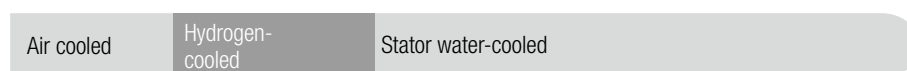
In addition, we have developed a special tape, mainly for indirectly cooled turbo generators, to expand the limits of power output. The Samicapor® HTC tapes can be applied like conventional mica tapes and have the following supplementary advantages to conventional tapes:

- » Increased thermal conductivity of the main wall insulation by a factor  $\cong 2$  voltage
- » Increased endurance
- » Increased thermal and mechanical properties

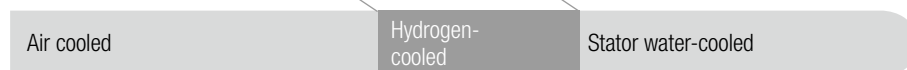


Mica tapes for VPI applications.

**Conventional design:**



**New design with HTC insulation:**



0                      200                      400                      600                      800                      1000

Capacity P (MVA)



## Main Wall Tapes for the RR System

For optimum quality of the main wall insulation, careful selection of the micaceous tape and detailed attention to the way the tape is applied and processed are necessary. Von Roll has created a complete range of RR main wall insulation tapes and systems under the name of Samicatherm® for both conventional and hydrostatic pressing, and under the names of Filosam® and Samicaflex® for the overhang areas.

The advantages of these tapes are that they:

- » Have high dielectric strength
- » Resist corona discharge
- » Can be applied smoothly without creasing
- » Can be applied by fast-running machines or manually
- » Have short cutting times

Main wall tapes for conventional hot pressing:

Product name	Rated voltage			Thickness mm	Weight g/m <sup>2</sup>	Mica g/m <sup>2</sup>	Description
	<6kV	6–13.8kV	>13.8kV				
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 <sup>2</sup>	Mica g/m <sup>2</sup>	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.

Generator main wall tapes for hydrostatic pressing:

Product name	Thickness mm	Weight g/m <sup>2</sup>	Mica g/m <sup>2</sup>	Description
Samicatherm® V 374.29	0.22	368	150	Glass/Mica/Polyester fleece tape.
Samicatherm® V 374.30	0.21	173	60	Glass/Mica/Polyester fleece tape.





## Taping machines

Careful and optimum application of Samicapor® and Samicatherm® tapes can be achieved using Von Roll high-speed taping machines.



High-speed taping machine.



## 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.



Resin-rich press for Roebel bars.



## 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 impregnated and in paper form
- » Semi-conductive tapes
- » Conductive mastics
- » Conductive varnishes

All these tapes can be applied as:

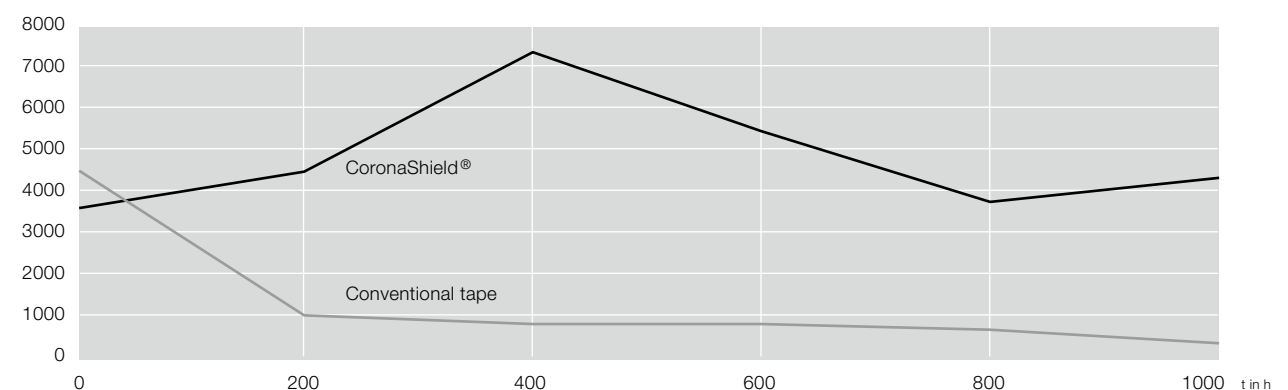
- » Internal corona protection (IGS) – in the conductor stack
- » External corona protection (AGS) – within the slot
- » End corona protection (EGS) – outside the slot

Product name	Form	Rated voltage			Thickness mm	Resistivity Ohm sq	Description
		<6kV	6–13.8kV	>13.8kV			
CoronaShield® conductive 215.51	Tape		•	•	0.1	200–400	Based on impregnated nonwoven polyester fleece. Not compatible with epoxy anhydride VPI resin.
CoronaShield® conductive 215.55	Tape		•	•	0.085	200–400	Based on impregnated nonwoven polyester fleece.
CoronaShield® 2500 NB 70	Tape		•	•	0.07	2500	Conductive tape made with Nomex® paper technology (not impregnated).
CoronaShield® semi-conductive 217.01/217.21	Tape		•	•	0.22	Variable	B-stage semi-conductive tape with different characteristics.
CoronaShield® semi-conductive 217.31	Tape		•	•	0.25	Variable	Fully cured silicone carbide-filled resin tape impregnated in a nonwoven fabric.

CoronaShield® NB is a newly developed tape based on a revolutionary paper technology that has the following advantages:

- » High resistivity
- » Considerably better aging compared to conventional tapes
- » High thermal resistance (class 220°C)
- » Free of binder resin
- » No washing out of carbon/graphite particles
- » No abrasion
- » Can be taped with the main wall taping machine

R in Ohm cm/cm Surface Resistivity at TEA 17 kV/175°C





## Finishing Tapes

To protect your equipment, the use of finishing tape is highly recommended. This material will protect the main wall insulation in the overhang area against:

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

With Epoflex® Von Roll found the right solution to meet these requirements:

Product name	Form	Rated voltage			Thickness mm	Description
		<6kV	6–13.8kV	>13.8kV		
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 arise during the end-winding bracing and support procedure. 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
- » Un-impregnated for use with VPI; no further processing
- » Impregnated polyester shrink cord for RR uses

Product name	Form	Rated voltage			Thickness mm	Description
		<6kV	6–13.8kV	>13.8kV		
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.





## Composite Materials for Large Generators

Von Roll offers a variety of composite materials that can be delivered as U & L profiles, strips and sheets, machined parts, or special components for use in different areas of large generators. The following are just a selection. Please ask our specialists about additional products.



High- and low-pressure laminates.



Long parts tailored to customer specifications.



## Rotor Components

The following materials represent excellent choices for rotor components and their applications:

Product name	Form	Rated voltage			Slot insulation	Pole face packing	End-winding packing	Slot bottom packers	Bottom packers	Slot top packers	Interturn insulation
		<6kV	6–13.8 kV	>13.8 kV							
Vetronite® 64170/G11	U or L profile, machined components, strips, rolls, or full-size sheet	•	•	•	•	•		•		•	•
Vetronite® 69020/64480	Machined parts, rolls, or strips	•	•	•					•	•	•
Delmat® 68660	Machined components	•	•	•		•	•				
Delbond® 54000	Machined parts, rolls, or strips	•	•	•							•
Polyfibre® 63020	Machined components and strips	•	•	•			•	•			





## Stator Components

The following materials represent excellent choices for stator components and their applications:

Product name	Form	Rated voltage			Top slot wedging	End caps	Slot wedges	Support brackets
		<6kV	6–13.8 kV	>13.8kV				
Vetronite® 64170/G11	Machined parts or full-size sheet	•	•	•			•	
Conductive Vetronite® 432.10	Machined parts or full size sheet	•	•	•			•	
Delmat® 68660	Machined parts or full-size sheet	•	•	•			•	•
Delmat® 68420	Machined parts or full-size sheet	•	•	•			•	
Conductive and nonconductive ripple springs	Strips or full size-sheets	•	•	•	•		•	
End caps	Molded parts	•	•	•		•		



## VPI Impregnation Resins

Von Roll has developed a variety of high-performance resins that meet the expected electrical and mechanical characteristics when cured for hydro and turbo generators. The factors that influence the final choice of resin used are complex. Important considerations relate to features of the design of the machines, and the choice of insulating system, taping, and VPI processes. Important criteria include:

- » Resin thermal class
- » Tank stability
- » Storage conditions (cooled or ambient temperature)
- » Moisture sensitivity
- » VOCs (volatile organic compounds)
- » Impregnating temperature
- » Necessity of rotating curing
- » Curing time
- » Total processing time
- » Compatibility with mica tapes and remaining materials
- » Rated voltage
- » Dielectrical properties
- » Mechanical properties
- » Thermal conductivity
- » Continuous and maximum peak operating temperature

Our high-performance resins are described in detail in a separate brochure. The following represent a selection:

	Type	Thermal class	Rated voltage			Impregnation temperature	Curing process	
			<6kV	6–15kV	15–22kV			
Damisol® 3413	Epoxy/anhydride 2K	F	•	•		23°C	10h at 150°C	Low-viscosity 2K accelerated epoxy resin with outstanding mechanical properties.
Permafil® 74038	Epoxy 1K	H	•	•		23–60°C	8h at 160°C	1K epoxy resin without diluent; very low organic emission (VOC<2%).
Damisol® 3407	Epoxy/anhydride 2K	F	•	•	•	40–70°C	10h at 170°C	Accelerated tapes needed.
Damisol® 3415	Epoxy/polyester	F	•	•	•	23°C	8h at 150°C	Highly reactive room-temperature impregnating epoxy-modified resin; storage below 5°C.



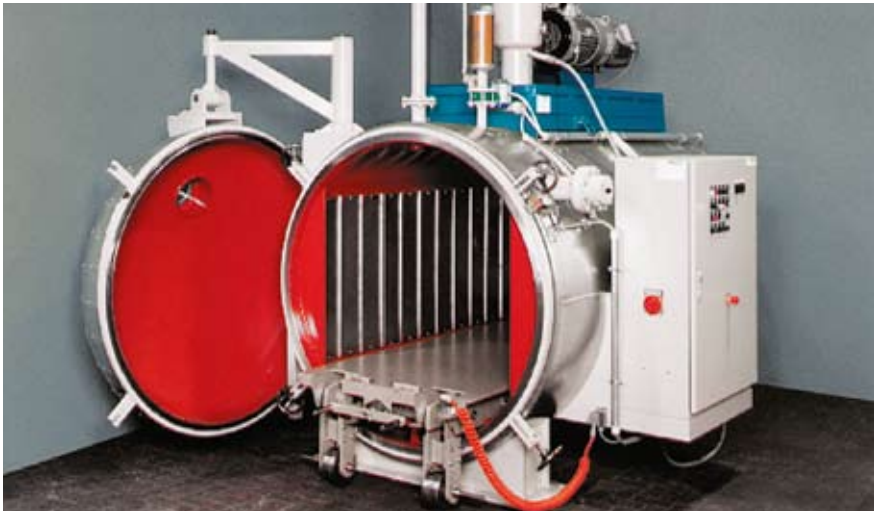
# Drying and Impregnation

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

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

For new equipment or upgrading existing plants, we ensure state-of-the-art VPI technology.

Instrumentation for measuring capacitance, temperature, pressure, and time are vital for in-line quality control of impregnation and can be built into the systems.



Machine in the VPI impregnation process.



# Finishing Coating

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

Selection table	Color	Rated voltage			Thermal class	Drying time	Comments on products and use
		<6kV	6–15 kV	15–22kV			
Damicoat® 2404	N/RB/G	•	•		F	15–20h	Highly chemically resistant overcoat varnish.
Damicoat® 2407	RB	•	•		F/H	1–2h	High-temperature-resistant overcoat varnish, used for up to class H high-voltage and traction machines.



## Testing

Materials and systems have to be tested in order to ensure the requested specifications concerning mechanical, electrical, and thermal characteristics.

Von Roll HV laboratories can test their customers' materials and systems according to IEC, UL, and other specifications:

- » Thermal, electrical, and mechanical aging tests
- » Tan  $\delta$  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.



## Flexibles

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



## Wires

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



## Transformers

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



## Cables

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



## Testing

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



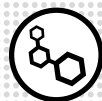
## Liquids

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



## Training

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



## 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.

Please contact us or visit our website **[www.vonroll.com](http://www.vonroll.com)** for further information:

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## About Von Roll

As one of the longest established 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 in insulation products, systems and services and is represented at more than 32 locations in 19 countries with around 3,400 employees.