Insulating Systems for Low-Voltage Motors and Generators

von Roll

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 the electrotechnical industry.

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 smaller and more compact machines.

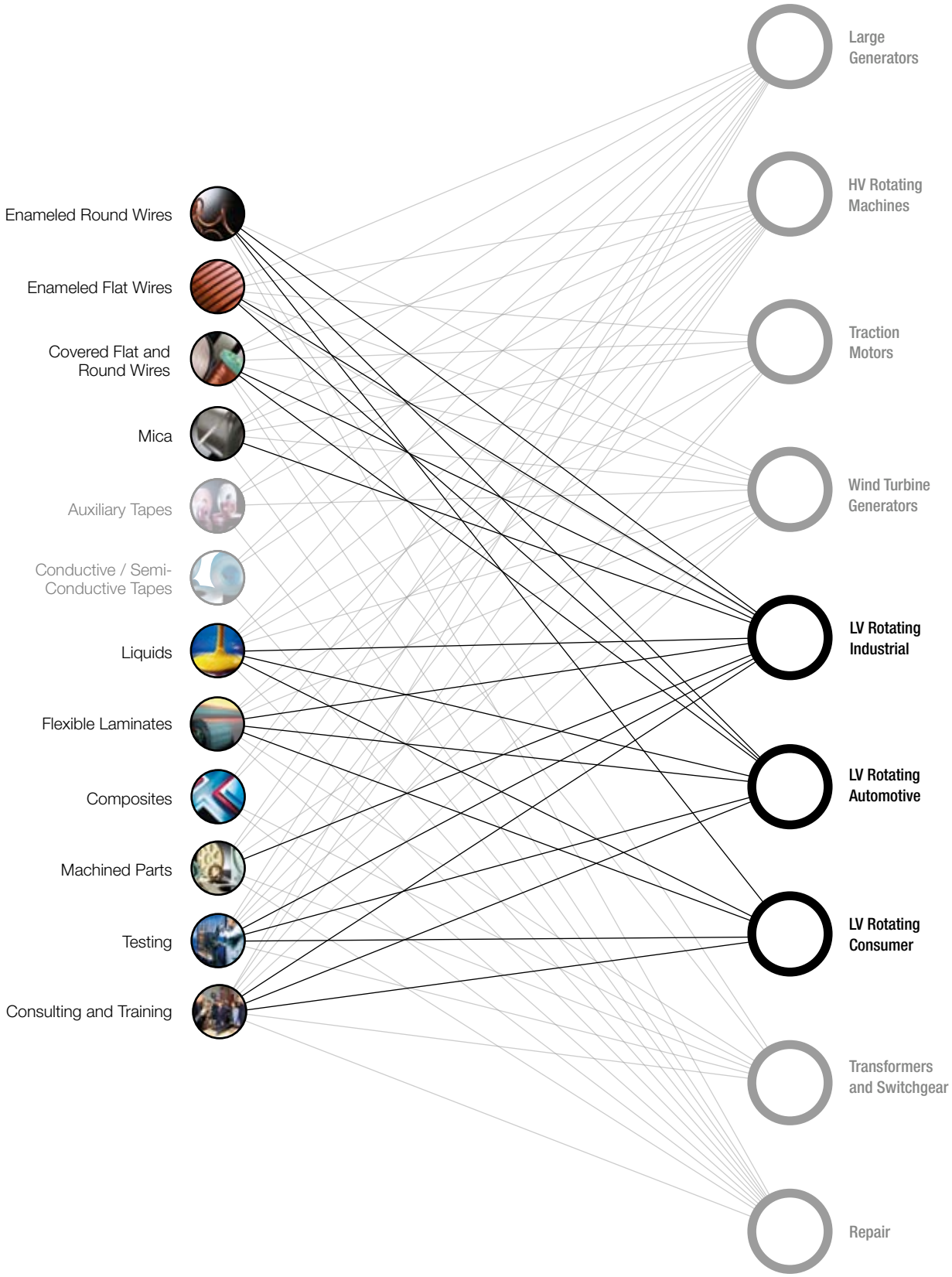
Customers enjoy the following benefits:

- 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 differences in application of low-voltage motors and generators are very extensive, and the requirements concerning electrical, mechanical, environmental and thermal specifications exceptionally varied. For all these requirements there are materials that are specially adapted. Von Roll offers a wide range of high-quality materials, systems and services that are ideal for all these motors and generators such as submersible pumps, tubular and micro motors, power tools, automotive, hermetic motors, inverter driven motors and others.



Our Products for Low-Voltage Applications



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.

A Variety of Insulation Systems

Von Roll offers a great variety of insulation materials for low-voltage motors and generators: conductors, flexible laminates, resins, tapes and other structural materials. All these have been developed to create the most reliable machines. For every application there is an ideal set of materials that form a fully compatible system. We also supply engineering application support and testing services to maximize production efficiency and optimize approval processes. Von Roll is a global company with multiple manufacturing sites in most continents, allowing optimized regional support.

The insulation systems for low-voltage motors and 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 products are listed in UL under different thermal classes. In the table on page 6 and 7 you can see some of Von Roll material types and their applications.

Conductors

Von Roll offers a large selection of high-quality conductors for low-voltage motors and generators that meet international standards for almost all applications.

	Temperature index	Composition	Special properties
Soldex 155 or 180	155°C or 180°C	enameled with modified polyurethane	» directly solderable without prior removal of the insulation » high thermal stability
Thermex® 200	200°C	enameled with modified polyesterimide base coat with a polyamide-imide overcoat	» 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	» outstanding mechanical, chemical and thermal properties » suitable for windings that are subjected to constantle high temperatures and mechanical stress
Thermex® 201 CR	200°C	enameled with modified polyesterimide	» 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	» outstanding corona resistance compared to standard enamel or filled enamel insulations » considerably longer lifetime in low-voltage motors
Thermibond® 158	200°C	enameled with a THEIC-modified polyesterimide base coat and polyamide-imide overcoat with a thermosetting duroplastic adhesive from aromatic polyamide	» the wires are self-bonding by means of a current surge or by being cured in an oven » the bond coat solidifies the windings without impregnation
Litz wires	Various	to customer specification	» for high-frequency applications

These conductors are mostly of copper but alternative materials such as nickel-plated copper or copper based alloys can be used as well. Von Roll supplies enameled, taped and litz wires both in round and rectangular form from its various platforms in America, Asia and Europe.

Flexible Laminates

Von Roll is a world leader in flexible laminates and coated materials. Von Roll materials for slot liners, phase insulation, barrier applications, and closures for low-voltage motors and generators are outstanding. We supply them in a wide variety of thicknesses. The following are some of the suitable products:

	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	» 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 with outstanding thermal indurance	» same as PVS with a higher thermal class
Myoflex® 2N50 and 2N80 Acuflex® NMN	Class H	three-ply flexible laminate made of Nomex® paper, polyester film and Nomex® paper bonded with a synthetic resin	» 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 including mica paper	» exceptional corona resistance properties » very good mechanical properties

For wedges Von Roll recommends composite materials such as Vetronit® G-11 or Delmat Epoxy 68660, which 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.

Flexible laminates

Application Suggestions

Brand names	Small submersible pumps	Tublar and micro motors	Appliance motors	Power tools	Automotive		Commercial motors and generators	Industrial motors and generators	Inverter-driven Motors	Hermetic motors	Industrial and traction DC motors and generators	Aircraft and military motors
Conductors												
	Thermibond® 158	Thermibond® 158	Thermibond® 158	Thermibond® 158	Thermex® 200, 220		Thermex® 200	Thermex® 200, 220	Thermex® CR 201	Thermex® 200	Thermex® 200, 220	ML Enamel
	Thermex® 200	Soldex® 155, 180	Soldex® 155, 180	Thermex® 200	Thermibond® 158				SamicaShield®	Thermibond® 158	Polyimide taped	Thermex® 240
			Thermex® 200								VS 240	
Flexible laminates												
	Myoflex® PV, PVS	Myoflex® PV, PVS	Myoflex® PV, PVS	Myoflex® LS	Myoflex® N/T		Myoflex® NPV	Myoflex® NPV	Myosam®	Myoflex® PVS H	Acuflex® NKN	Acuflex® NKN
	Acuflex® DMD	Acuflex® DMD	Acuflex® DMD	Myoflex® PV, PVS	Myoflex® PV, PVS		Myoflex® PV, PVS	Myoflex® PV, PVS	Myoflex® PV, PVS	Acuflex® NM, NMN	Myoflex® NKN	Myoflex® NKN
	Acuflex® RM	Myoflex® PVS H	Myoflex® PVS H	Acuflex® DMD	Acuflex® DMD		Myoflex® PVS H	Myoflex® PVS H	Myoflex® PVS H	Acuflex® DMDF	Fusa-Fab® 155	Myoflex® NSN
		Acuflex® NMN	Acuflex® NMN	Acuflex® RM	Acuflex® RM		Acuflex® DMD, DMDF	Acuflex® DMD, DMDF	Acuflex® DMD, DMDF	Myoflex® NMN	Fusa-Fab® 180	
			Myoflex® NMN		Acuflex® NM, NMN, NMNM		Acuflex® NM, NMN, NMNM	Acuflex® NM, NMN, NMNM	Acuflex® NM, NMN, NMNM		Mica Mat® mica tapes	
					Myoflex® NMN		Pyrolam® DMD	Pyrolam® DMD	Pyrolam® DMD			
							Pyromid® 180 DMD	Pyromid® 180 DMD	Pyromid® 180 DMD			
							MEMCO DMD	MEMCO DMD	MEMCO DMD			
							Myoflex® NMN	Therm-Al® H Coated glass cloth	Therm-Al® H Coated glass cloth			
								Myoflex® NMN	Myoflex® NMN			
Impregnation and potting resins												
	Damival® 13518 PU Potting	Damisol® 2014 Epoxy/Solvent	Damisol® 2014 Epoxy/Solvent	Damisol® 3026-2 UPI	Damisol® 3030-2 UPI, 3040 UPI		Damisol® 2014 Epoxy/Solvent	Damisol® 2014 Epoxy/Solvent	Damisol® 3040, 3340 UPI	Damisol® 2014 Epoxy/Solvent	Damisol® 3551 Silicone	Damisol® 3308, 3309 UPI
	Damival® 15350 Epoxy Potting		Damisol® 3026-2 UPI, 3030-2 UPI, 3305-2 UPI	Damisol® 3030-2 UPI	Damisol® 3500 HiR Epoxy		Damisol® 2005 HFP Alk/Solvent	Damisol® 2005 HFP Alk/Solvent	Damisol® 3500 HiR Epoxy	Damisol® 3500 HiR Epoxy	Damisol® 2053 HFP UPI	Permafil® 707 UPI
				Damisol® 3007-2 Gel Coat	Damisol® 3630 HTP UPI		Damisol® 3040, 3340, 3032 UPI	Damisol® 3500 HiR Epoxy	Permafil® 74041Thixotropic Epoxy	Permafil® 74041 Thixotropic Epoxy	Damisol® 2005 HFP Alk	Damisol® 3551 Silicone
			Damisol® 3500 HiR Epoxy	Damisol® 3630 HTP UPI			Permafil® 74041 Thixotropic Epoxy	Permafil® 74041Thixotropic Epoxy			Damisol® 3340 UPI	Damisol® 3340 UPI
								Damisol® 3040, 3340, 3032 UPI			Permafil® 707, 747 UP	
							Damisol® 3500 HiR Epoxy	Damisol® 3630 HTP UPI				
							Damisol® 3630 HTP UPI	Damival® 13518 PU Potting				
								Damival® 15350, 15225 Epoxy Potting				
Composites and banding tapes												
				Poly Glas® P30, 76870	Poly Glas® K220, P30, H200, 76870			Bondable Papers			Poly Glas® H220	Vetronite® G30 Polyimide Laminate
								B-stage glass cloth			Poly Glas® 76870	Vetronite® G7 Silicone Laminate
					Vetronite® G-11 Composites			Vetronite® GPO Laminates			Poly Glas® K220	
								Delmat® Composites			Vetronite® GPO Laminates	
								Poly Glas® H200			Delmat® Composites	
								Poly Glas® 76870				
Adhesive tapes, Intertape® and Isotape®												
	Intertape® 51595 Lam PET	Isotape® 51350PV3 PET	Isotape® 51600PV3 PET Cloth	Isotape® 51600PV3 PET Cloth	Intertape® 51587 PET, 54113, 51594		Intertape® 4564 Woven PET	Intertape® 4616, 4618, 4617, glass cloth	Intertape® 4616, 4618, 4617, glass cloth	Intertape® 4618 glass cloth	Intertape® Kapton®[1] 4118	Intertape® Kapton®[1] 4118
	Isotape® 51350PV3 PET	Intertape® 51594 PET	Intertape® 51594 PET, 51587	Intertape® 51594 PET, 51587			Intertape® 4616, 4617, glass cloth			Intertape® Kapton®[1] 4118	Intertape® 4618 glass cloth	Isotape® 4428PV3 Polyimide
	Intertape® 51587 PET	Intertape® Kapton®[1] 4118	Isotape® 51350PV3 PET	Isotape® 51350PV3 PET	Isotape® 51350PV3 PET			Isotape® 4637PV3, 4636PV3, 4638PV3, glass cloth	Isotape® 4637PV3, 4636PV3, 4638PV3, glass cloth	Isotape® 4428PV3 Polyimide	Isotape® 4428PV3 Polyimide	Intertape® 4618 glass cloth
		Isotape® 4428 Polyimide	Intertape® 4616, 4617, glass cloth	Isotape® 4636PV3 glass cloth	Isotape® 4636PV3 glass cloth		Isotape® 4637PV3, 4636PV3, 4638PV3, glass cloth				Isotape® Teflon®[1] 51202PV3	
								Intertape® 4560 silk acetate				
			Isotape® 4637PV3, 4636PV3, glass cloth				Intertape® 4560 silk acetate	Isotape® Nomex[1] 56228PV3				
							Intertape® 4618 glass cloth					
			Intertape® 4560 silk acetate									

UPI= unsaturated polyester-imide; UP= unsaturated polyester; PET=polyester film; * rectangular

[1] ® Registered trademark: DuPont de Nemours

Adhesive Tapes

Von Roll offers a wide range of high-quality adhesive tapes used in low-voltage applications. The following are some examples:

Product	Backing	Adhesive	Total thickness	Insulation class	Properties and applications
51594	polyester	RT	0.051	B 130°C	Economic grade of polyester tape. Recommended for insulation connection, small bobbin wound coils, end insulation or coil outer protective and phase insulation in small motors.
51587	polyester	RT	0.056	B 130°C	Medium grade of polyester tape. Recommended for insulation connection, small bobbin wound coils, end insulation or coil outer protective and phase insulation in small motors.
51350PV3	polyester	AT	0.06	B 130°C	High grade of polyester tape. Designed to provide a better solvent and temperature resistance. Recommended for coil wrapping, tabbing, anchoring, interlayer insulation of motors.
4560	silk acetate	RT	0.18	B 130°C	Acetate offers high adhesion, conformability, printability, insulation properties when varnished and hand tearability. Recommended for end coil wrapping and anchoring wires in motors.
51600PV3	woven polyester	AT	0.18	B 130°C	Woven cloth as alternative solution to glass cloths with high tensile strengh, conformability and resistance to chemicals and oils. Recommended for end-wrapping heavy wires in transformers and motors.
4636PV3	glass cloth	RT	0.18	B 130°C	High tensile strength with a flame retardant backing, conformability, abrasion and puncture resistance. Highly recommended for holding heavy-gauge wires in motors or transformers.
4616	glass cloth	RT	0.18	B 130°C	
4637PV3	glass cloth	AT	0.18	F 155°C	Premium glass cloth tape when higher temperature resistance and solvent resistance are required.
4617	glass cloth	AT	0.18	F 155°C	
4638PV3	glass cloth	SI	0.19	H 180°C	High-temperature-resistant glass cloth for extreme insulation application. Remains conformable and stable in insulation even after a long time period over 180°C. Recommended for outer and inner insulation for heat-resistant transformers and bundling of coils. Also used as high-temperature masking tape.
4618	glass cloth	SI	0.18	C 200°C	
51595	laminated polyester/ woven polyester	AT	0.114	F 155°C	Laminated tapes offer a combination of tear and puncture resistance, medium tensile strength and elongation, and excellent dielectric strength. Ideal for ground and barrier insulation, outer protective wrap and coil end insulation anchoring lead and terminal boards.
4118	Kapton®[1)]	SI	0.063	H 180°C	Ultimate insulation tape. Conformable, tear-, puncture- and extreme high temperature-resistant. Used for ground insulation, repair and reinforcement of enameled or covering wires, insulation of soldering joints.
4428PV3	polyimide	SI	0.064	H 180°C	
4564	nonwoven polyester	AT	0.165	B 130°C	Nonwoven polyester with zone-coated acrylic adhesive to withstand impregnating varnishes. The porous area allows the varnish to pass avoiding aid entrapment. Designed for “trickle” impregnation process for motors. Ground and holding wire applications.
56228PV3	Nomex®[1)]	AT	0.09	F 155°C	High thermal rating and flame retardancy backing and adhesive to provide a thin tape for holding and insulation functions. Mainly used into transformers to hold non adhesive material, hold edge turns in place, coil end and ground insulation in small generators.

[1)] ® Registered trademark: DuPont de Nemours
Adhesive masses, RT: Thermosetting rubber, AT: Thermosetting acrylic, Si: Thermosetting silicone



Resins

Impregnation resins are one of the most important components in any low-voltage machine. We offer a wide range of impregnation resins ideally optimized for every impregnation system, such as vacuum pressure impregnation, trickling, dipping or dip rolling. Below are some materials that are particularly suited to these applications:

	Temperature index UL 1446	Composition	Flash point (°C)	Curing process*	Special properties
Damisol® 3500 HiR	Class H	epoxy	>100	30 min at 170°C	Low-viscosity class H solvent-free resin. High reactivity. Outstanding adhesion and mechanical properties. No VOC. Low organic emission.
Damisol® 3630 HTP	Class H	polyesterimide	>100	30 min at 150°C	Low-viscosity class H solvent-free resin. Excellent storage stability. Outstanding thermal aging properties. No VOC. Low organic emission.
Damisol® 3340	Class H	polyesterimide	53	2h at 150°C	Multipurpose high-temperature-resistant resin. Outstanding mechanical and dielectric properties after aging at high temperature up to class 200°C.
Damisol® 3032	Class H	polyesterimide	32	2h at 140°C	Multipurpose high-temperature-resistant resin. Outstanding dielectric properties after aging at high temperature up to class 200°C.
Damisol® 2014	Class H	epoxy	40	5h at 150°C	Multipurpose class H varnish. Outstanding thermal, mechanical and chemical resistance properties, including all freons.

*Measured on copper

Von Roll provides as well a wide range of potting materials perfectly suited for low-voltage motors and generators. The following is an example of these high quality products:

	Color	Viscosity at 25°C (mPa.s)	Gel time (min at 25°C)	Shore D	Special properties
Damival® 13518	all	2000	35–90	87	rigid-UL94V0-I3F1
Damival® 15350	black	2300	50	86	UL94 V0 high thermal conductivity
Damival® 15225	black	2500	25 min at 120°C	75	high thermal shock resistance

Potting resin and impregnation resins

Other Materials

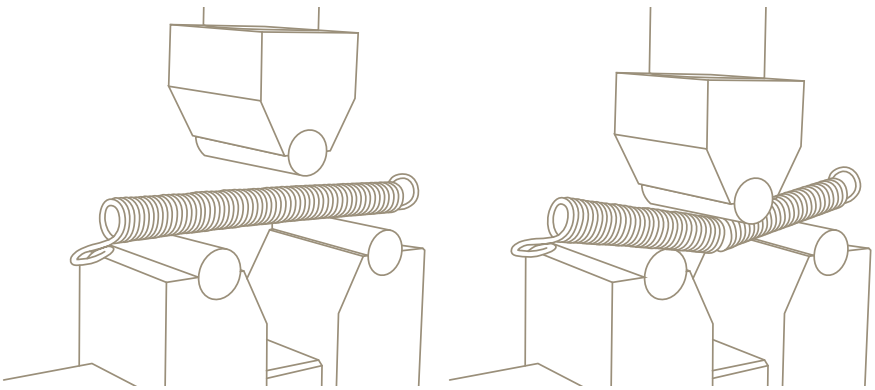
Other applicable materials for low-voltage applications supplied by Von Roll are:
Mica tapes – The use of mica-based tapes in low-voltage applications is mainly for traction and inverted-driven motors. The value of these tapes is very important to protect these machines from voltage peaks that can be 2 to 3 times higher than the rated voltage. Mica is an excellent insulator that is commonly used for high-voltage applications. The commitment of Von Roll to mica is unique, starting with the mining of this raw material followed by the production of paper and mica tapes and going as far as taping conductors.

Structural materials – A wide range of structural materials can be used for low-voltage applications. Rigid laminates and molded parts as well as prepregs and B-staged materials are the answer to many design challenges in blocking and reinforcements, terminals, switch insulations and others. Polyglas b-stage banding tapes are useful for reinforcements of rotating parts such as armatures, generator exciters and rotor components.

Testing and UL

Von Roll has specialized low-voltage applications labs that are focused on customer needs and requirements. We can process customer parts in the lab by dipping, trickle, roll-through, vacuum-aided dipping or VPI processing methods to produce prototype parts. In the USA, we have a certified UL testing center where we develop and maintain the many Von Roll UL 1446 insulation systems as well as customize systems for customers. Von Roll can provide:

- tests per UL 1446 standard
- long thermal aging – full system testing
- short-term component aging (sealed-tube test)
- full system testing: GPM/Motorette
- twisted pair testing (TP)
- helical coil testing (HC)



Round wire pieces being tested with regard to the adhesive power of the wire coating

Testing in the Von Roll laboratory

Training

We offer a unique program of low-voltage insulation training, known as Von Roll Corporate University. The objectives of this training are:

» Better understanding of low-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.

Dates and further information are available in a separate brochure.

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

We Enable Energy

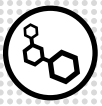
Von Roll is the sole full-range supplier of materials and systems for the insulation of electrical machines as well as high-performance products for various high-tech industries.

Mica
Materials related to high-voltage insulation. Von Roll's commitment is extensive, including all the steps in the manufacturing process.

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.



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.

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

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 for its customers.

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

Europe, Middle East, Africa

Von Roll Holding AG
Steinacherstrasse 101
8804 Au ZH
Schweiz/Switzerland
P +41 44 204 3500
F +41 44 204 3010

Asia/Pacific

Von Roll Asia Pte Ltd.
6 Serangoon North Avenue 5
#03-01 Singapore 554910
Singapore
P +65 6556 4788
F +65 6556 4959

Americas

Von Roll USA, Inc.
8480 East Orchard Road
Suite 1000
Greenwood Village, CO 80111
USA
P +1 303-689-8441
F +1 303-689-8458

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.