INSULATING SYSTEMS
FOR DIESEL GENERATOR SETS

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 electrical machines such as diesel generator sets (also known as gensets).

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:

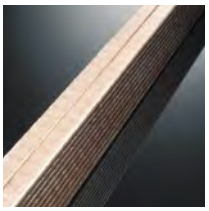
» One single source for all insulating materials
» Thorough expertise from power generation and transmission to its efficient utilization
» Proven compatibility with all system components
» Testing at Von Roll of both materials and systems
» Consulting for applications and technologies
» Training in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

Diesel generator sets, also known as gensets, are available in small portable sizes for private use up to enormous industrial plants, which are up to 10 meters long and weigh over 30 tons. The insulation system of a diesel generator set 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.

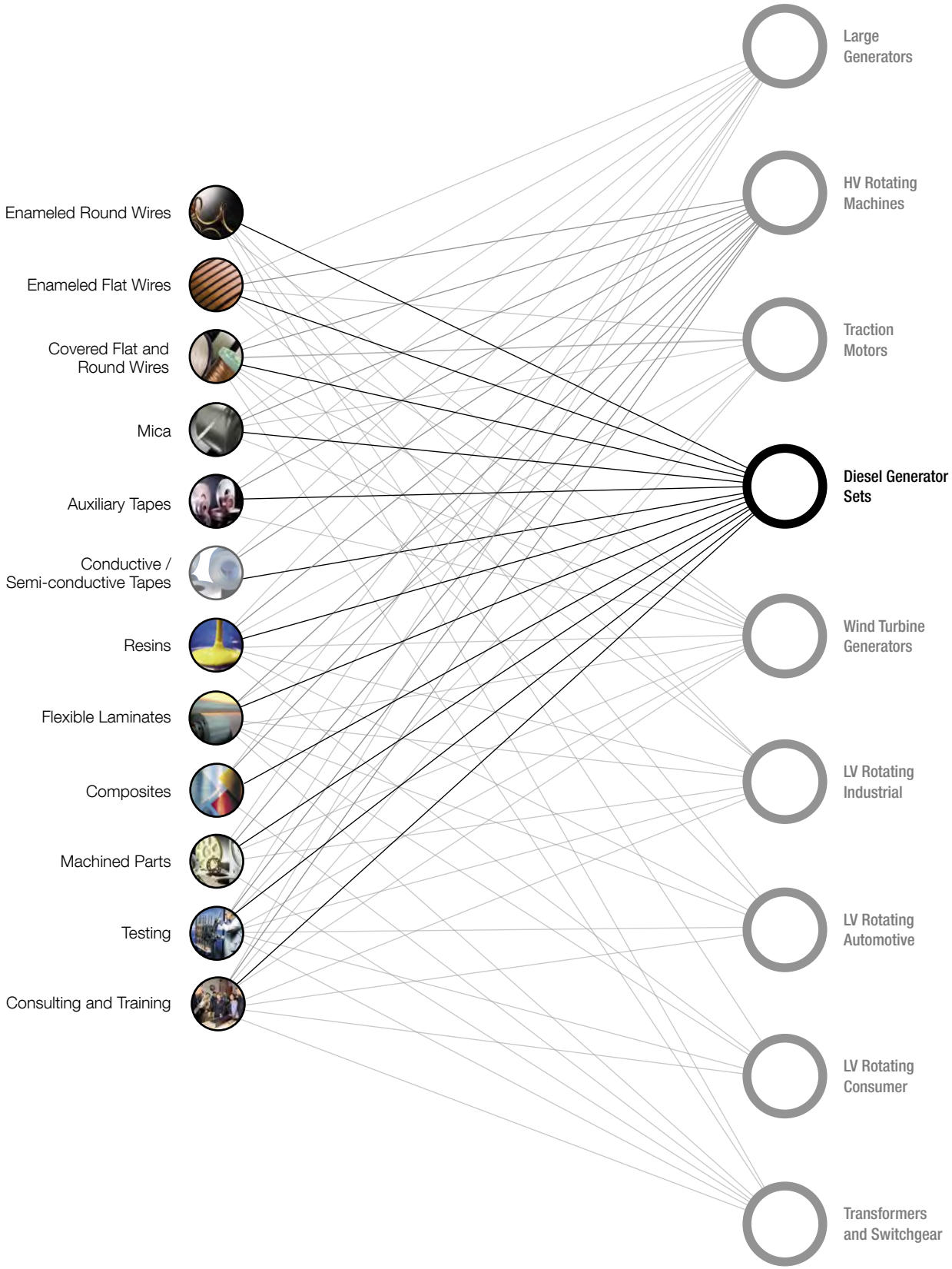
The voltage output of a diesel generator set ranges from 440 V to 15 kV. A variety of insulation systems are available and can be classified according to two different types:

» 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 15 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 Genset Generators

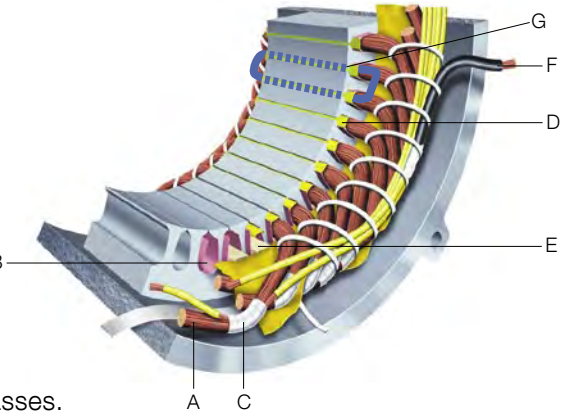


Von Roll offers full system solutions for every market shown in this application tree.
Please contact us or visit our website **www.vonroll.com** for further information.

Low-Voltage Insulating Systems

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

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

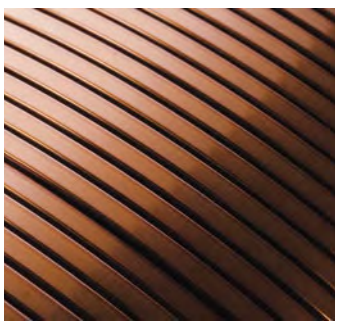


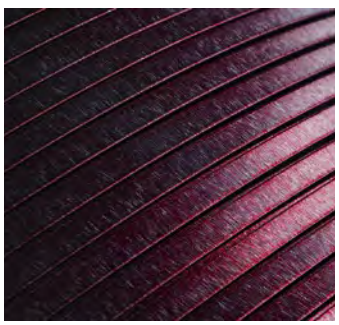
Most of these low-voltage products are listed in UL under different thermal classes.

Conductors for Low-Voltage Alternators

Von Roll's winding wires are at the leading edge of technology. We offer a wide range of high-quality winding wires for diesel generator sets both in round and rectangular forms. The following are the products we recommend for this application:

Product name	Thermal class	Composition	Special properties
Thermex® 220 flatwire	220 (C)	Enameled with polyamide-imide	- Outstanding mechanical, chemical and thermal properties - Suitable for windings which are subjected to constantly high temperatures and mechanical stress
Thermibond TS flat wire	220 (C)	Enameled as Thermex® 220 with a B-stage overvoat	- Outstanding mechanical, chemical and thermal properties - Suitable for windings which are subjected to constantly high temperatures and mechanical stress
SamicaShield® round	180 (H)	Enameled with polyester-imide base coat with a polyamide-imide overcoat and covered with a thin pore-free mica tape insulation	- very high corona resistance compared with standard enamel or filled enamel insulations - Considerably longer life time in low-voltage motors - perfect solution for auxiliary coils
Silix//Daglas round & flat	180 (H)/ 200 (C)	Enameled and glass-covered wires with or without a B-stage overvoat	- good mechanical and electrical properties


Thermex® 220


Rectangular Daglas wire


Reels of wire with SamicasSield®

Slot and Phase Insulation

Von Roll is a world leader in laminated flexible insulations, coated materials and rigid composite materials. Our materials for slot liners, phase insulation, barrier applications and closures for low-voltage gensets are outstanding. We supply them in a wide variety of thicknesses to fit your application perfectly. The following products represent the best choices in this category:

Product name	Thermal class	Composition	Special properties
Myoflex® & Acuflex® NKN (NHN)	220°C (UL 1446)	Three-ply flexible laminate made out of Nomex®[1] paper - polyimide film - Nomex® paper. Bonded with a high performance adhesive system	Outstanding electrical insulation & mechanical properties. Suitable for very high operating temperatures up to 220°C. Designed for automatic insertion
Myoflex® & Acuflex® NMN	155°C (UL 1446)	Three-ply flexible laminate made out of Nomex® paper - polyester film - Nomex® paper. Bonded with a high performance adhesive system	High mechanical & electrical properties. Suitable for operating temperature of 180°C, used as ground & interwinding insulations in UL system 180°C (E308562). Designed for automatic insertion
Myoflex® PVSH	155°C (UL 1446)	Three-ply flexible laminate made out of polyester fleece - polyester film - polyester fleece. Bonded with a high performance adhesive system. Coated wth a high thermal resistant resin	High electrical insulation & good mechanical properties at elevated temperature. Used as minor insulations in UL system 180°C (E308562). Designed for automatic insertion
Myosam®	155°C	Three-ply made of polyester film - mica - polyester film or polyester film - mica - polyester fleece	Very high resistance to coronoa and very high electrical properties

Rigid solutions for slot wedges are also part of the product offering:

Product name	Thermal class	Application	Type
Vetronit EGS 103 Vetronit EGR T23 or G11	155°C to 180°C	Slot wedge, blocking parts, packers	Long strips, sheets or machined parts based on wovenglass and epoxy resin system
Delmat Epoxy 68660	180°C	Slot wedge, blocking parts, packers	Sheets or machined parts based on glass mat and epoxy resin system
Delmat Polyester 68030, 68420	155°C	Slot wedge, blocking parts, packers	Sheets or machined parts based on glass mat and polyester resin system
Delmat 68900	200°C	Slot wedge, blocking parts	Sheets or machined parts based on glass mat and high resin system providing improved aging properties

[1] Nomex® is a registered trademark of DuPont®

Impregnation Resins for Low-Voltage

Impregnation resins are among the most important components in any low-voltage machine. We offer a wide range of impregnation resins for low-voltage genset alternators with particular importance for class H systems highly resistant to mechanical and electrical stresses. All solvent free resins do not contain any VOC and are engineered to be environmentally friendly.

The most suitable materials are listed below:

Product name	Thermal index HC*	Chemistry	Process	Special properties
Damisol® 3040	205°C	Hybride solventless polyesterimide/ epoxy	VPI - Roll Through	- Low viscosity versatile resin - High durable bonding properties
Damisol® 3630	212°C	Solvent free polyesterimide	VPI - Trickle - Roll Through	- Green new high-temperature generation resin - Available at different viscosity, reactivity and thixotrop levels (HTP, HIR, VPI)
Damisol® 3500	180°C	Solvent free epoxy	VPI - Trickle - Roll Through	- Strong bonding & chemical resistance - Available at different viscosity, reactivity and thixotro levels (LoV, HiR, HTC LoD)
Dolphon™ CC-1105; CC-1106	200°C	Solvent free DAP based polyester	VPI - Trickle - Roll Through	- Highly versatile and very stable resin - Available at different viscosity, reactivity and thixotrop levels (LV, OPT, HTC,- 1106)
Dolphon™ XL-2110	200°C	Solvent free polyester	VPI - Trickle - Roll Through	- Universal new green generation resin - Highly versatile and reactive yet very stable

HC*: Helical coil on MW 35 wire (mechanical test)

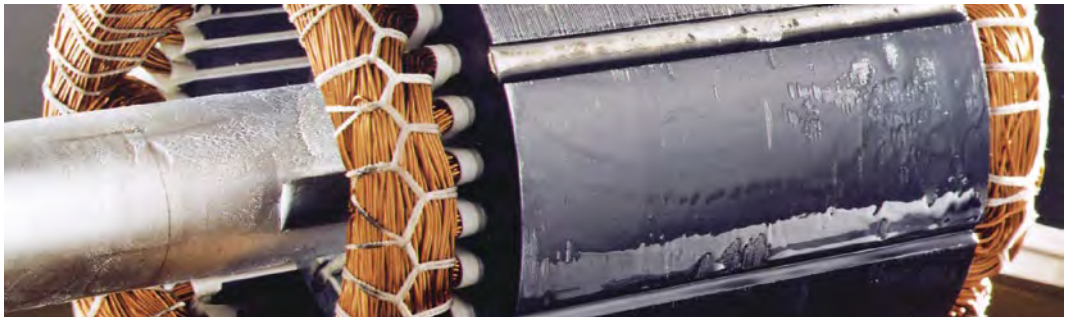
Coating Varnishes for Low-Voltage

Gensets experience terrible external environmental constraints and need specific chemical protection against humidity, salt water, oils, gazoils, and chemicals in general.

The overcoating process becomes a must. A large range of Dolph's overcoats have proved their efficiency in this market segment already for many years across the globe. Below is a selection of room temperature overcoats:

Product name	Thermal index HC*	Chemistry	Process	Special properties
SYNTHITE® E(a)-43	180°C	Solvent based alkyd	Spray -Dipping	- Universal use - Class H UL 1446 - Available in many different colors (e.g., red, black, grey)
DOLPHON® CB-1128	NC	Polybutadiene to be diluted in solvent	Spray -Dipping	- Highly flexible protection - Outstanding salt spray test results
DOLPHON® CW-1081	NC	Solvent based epoxy	Spray	- Outstanding chemical protection in general - Good bonding

TP*: Twisted Pair on MW 35 (electrical test)



Adhesive Tapes for Low-Voltage

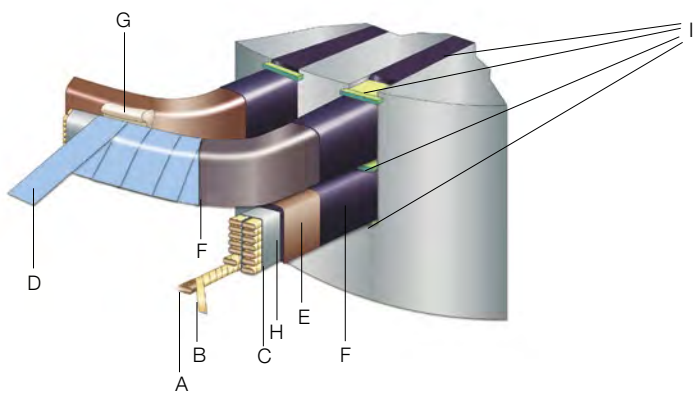
Von Roll offers a wide range of high-quality adhesive tapes for a variety of applications. As end-winding tapes for low-voltage diesel genset alternators we recommend:

Product name	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	5.50
Intertape® 4617	155 (F)	Glass cloth	0.18	Thermosetting acrylic	350	4.40
Isotape 4637 PV3	155 (F)	Glass cloth	0.18	Thermosetting acrylic	235	5.30
Intertape® 4618	200 (H)	Glass cloth	0.18	Thermosetting silicone	325	4.35
Isotape 4638 PV3	200 (H)	Glass cloth	0.19	Thermosetting silicone	180	2.60

High-Voltage Insulation Systems

Von Roll offers a wide range of tested systems.

- 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, packers, separators (I)



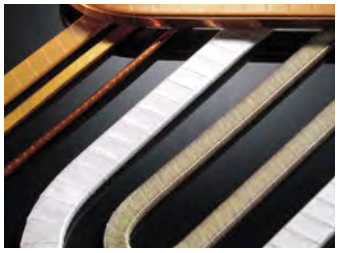
Conductors for High-Voltage

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.

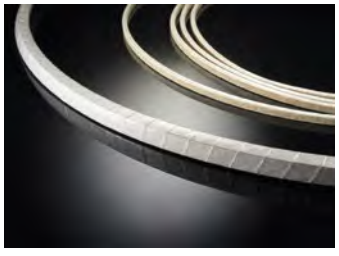
Samicafilm® products are based on Von Roll Samica® mica paper impregnated with modified epoxy resin, reinforced with one or two polyester or polyimide film backings and with or without adhesive coating.

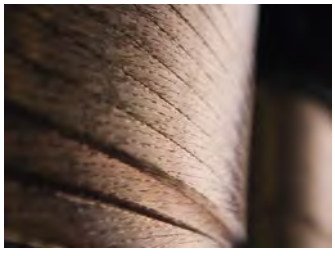
Pressed Rectangular Litz Wires

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, enameled or SST[1] for a very high fill factor
» Total cross section of copper: 1 to greater than 400 mm^2 (width to thickness ratio 1.25:1 to 4:1)
» Additional insulations: one or more layers of mica tape Samicafilm®
» We offer Samicapor® main wall tape directly on the litz wire





[1] special surface treated

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

	Rated voltage			Weight g/m²		
Product name	< 6 kV	> 6 kV	Thickness mm	Total	Mica	Composition
Samicapor® 366.58	•	•	0.15	195	160	Glass/mica
Samicapor® 366.59-10	•	•	0.15	213	180	Glass/mica
Samicapor® P 315.45	•		0.14	241	160	PET film/mica
Samicapor® 374.04	•		0.18	241	160	Glass/mica/PET fleece
Samicapor® 366.55-12	•	•	0.14	198	160	Glass/mica
Samicapor® P 315.33	•		0.13	241	160	PET film/mica
Samicapor® 374.15	•		0.18	241	160	Glass/mica/PET fleece

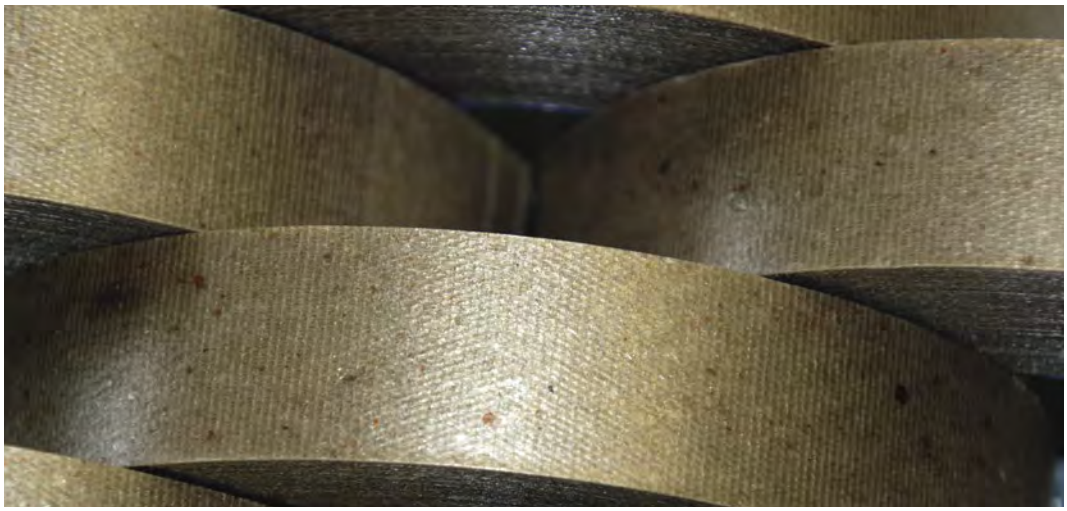
Von Roll's commitment to mica starts with mining and ends with the production of mica-taped wires.

Main Wall Tapes for the RR System

Assuring optimum quality of main wall insulation requires careful selection of mica tapes 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® for use in diesel gen sets.

Main wall tapes for conventional hot pressing:

Product name	Rated voltage			Thickness mm	Weight g/m²		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® 366.24-53 (Thinflex)			•	0.15	234	120	Mica/glass good flexibility and high electrical properties
Samicatherm® P 315.20/315.20-02	•			0.16	252	150	Mica/PET film with/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/m²		Description
		Total	Mica	
Filosam® 326.57-20/50	0.15/0.13	206/177	109/75	PET film/mica/glass threads, highly flexible
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/m²	Description
CoronaShield® 215.71	0.08	1000-5000	Conductive tape, impregnated glass, cured, fabric, class H
CoronaShield® 215.55	0.085	200–400	Conductive tape, impregnated glass, PET fleece, cured. class F
CoronaShield® 217.01/217.21/22/24	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

CoronaShield® conductive and semi-conductive tapes.

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 219.61-10	0.18	Mixed fabric with a polyester film with epoxy resin, not cured, for resin-rich (RR) technology
Epoflex 324.03	0.09	Polyester glass fabric with a polyester film and reduced binder quality, cured, for VPI

Coil Fixing and Bracing

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

Isocords

- 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

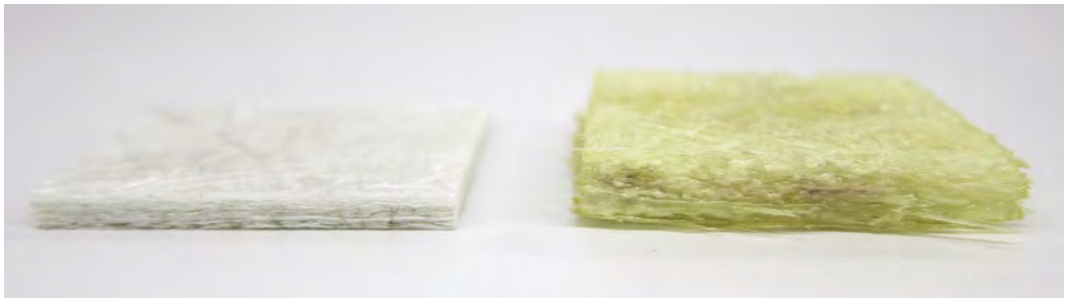
Product name	Type	Diameter mm	Description
Isocord® 151.10	Cord	1.8–50	Braided silane E glass yarn outside with staple glass filler
Isocord® 151.12	Cord	1.5–60	Braided polyester yarn outside with staple glass filler

Glass or glass polyester cords.

Swelling Glass Mat

- Class H
- Expansion of about 150%
- with and without accelerators
- several thicknesses
- in sheets or cut pieces
- for all impregnation systems

Product name	Diameter mm	Description
SwellingGlassMat 261.30	1/2/3 mm	with accelerator
SwellingGlassMat 261.31	1/2/3 mm	without accelerator



Swelling glass mats.

Composite Materials for Genset Alternators

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.

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

Product name	Type	Application	Thermal class environment	Stator	Rotor
Delbond, Acuflex, Glasoflex product range	Fully cured or B-stage rolls, strips based on glass, aramide and thermoset resin	Interturn insulation	155°C to 210°C		•
Vetronit 64170 Vetronit G11	Long strips, sheets or machined parts based on woven glass and epoxy resin system	Slot wedge, blocking parts, packers	155°C to 180°C	•	•
Polyfibrit	Long strips, sheets or machined parts based on woven polyester and epoxy resin system	Bottom and packers parts with no glass content	155°C	•	•
Delmat Epoxy 68660	Sheets or machined parts based on glass mat and epoxy resin system	Slot wedge, blocking parts, packers	180°C	•	•
Delmat Polyester 68030, 68420	Sheets or machined parts based on glass mat and polyester resin system	Slot wedge, blocking parts	155°C	•	•
Vetroferrit F or H	Sheets or machined parts with magnetic characteristics	Slot wedge, blocking parts	155°C and 180°C	•	
Delmat 68900	Sheets or machined parts based on glass mat and high resin system providing improved aging properties	Slot wedge, blocking parts	200°C	•	

Machined parts tailored to customer specifications.

Glass mat laminates.

Impregnating resins for High-Voltage

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 HV gensets we propose:

Product name	Thermal class	Chemistry	Maximum voltage	Special properties
Damisol® 3313	180 (H)	Hybride solventless polyesterimide/ epoxy	15 KV	- Low viscosity highly reactive; yet very stable HV resin - Outstanding thermal & mechanical properties
Damisol® 3418	180 (H)	1K solvent free catalyzed epoxy/ anhydride	18 KV	- Reach* compliant low viscosity epoxy anhydride for room temperature impregnation - Outstanding electrical aging and mechanical performances
Damisol® 3408	155 (F)	2K solvent free uncatalyzed epoxy/anhydride	28 KV	- Highly stable Reach* compliant epoxy anhydride system
Damisol® 3420	155 (F)	Solvent free & anhydride free epoxy	15 KV	- Anhydride free highly stable system

Reach*: Regulation Evaluation & Assessment on Chemicals (Nr1907 / 2006)

Coating varnishes for High-Voltage

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. Below is a selection of room temperature overcoats:

Product name	Color	Chemistry	Process	Special properties
Damicoat® 2404	Red-brown	Isophtalic alkyd	Spray & Dip	Outstanding chemical resistance properties (wind turbine references)
Damicoat® 2407	Red	Modified alkyd	Spray & Dip	High thermal class (H use)

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 and low-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.

Resins
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.

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

Testing
Von Roll provides electrical, thermal and mechanical testing of individual materials as well as complete insulating systems.

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

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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 electrical power generation, transmission, storage and industrial applications. Von Roll's business portfolio is divided into the following businesses: **Von Roll Insulation** offers electrical insulation products, systems and services for generators, high- and low-voltage motors, transformers and other applications. **Von Roll Composites** produces composite materials and parts for a variety of industrial equipment.