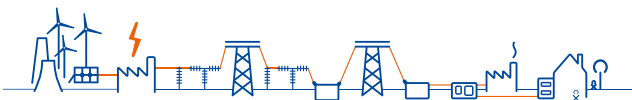
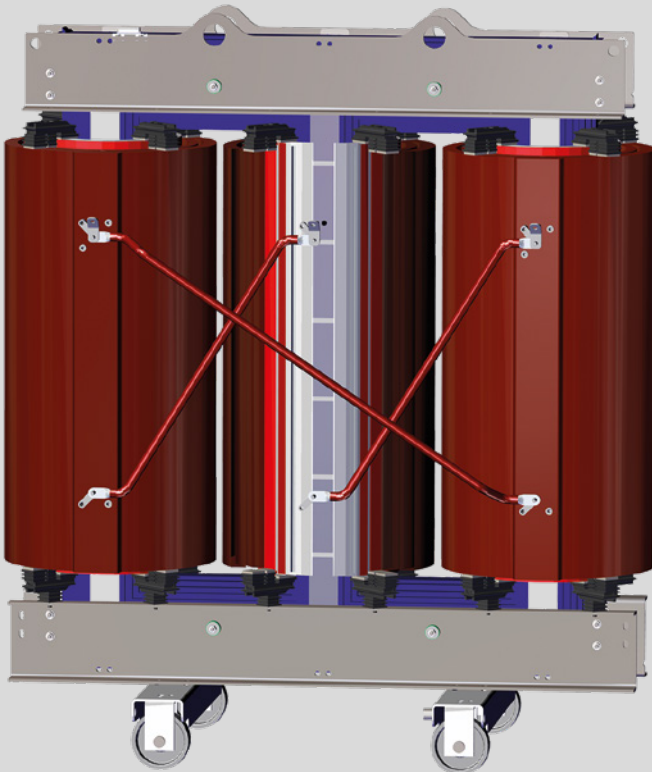


PLANNING GUIDE FOR CAST RESIN TRANSFORMERS



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SGB-SMIT AT A GLANCE

1913



HISTORY

... of steadily growing expertise

3.200



EMPLOYEES

... are the key to our success

14



SITES

We are one of the world's leading manufacturers of power transformers



READY FOR YOUR MARKET

The SGB-SMIT Group manufactures transformers for applications worldwide. Sales and service centers on all continents ensure optimum processes.

Our products meet the requirements in accordance with the applicable national standards.



PRODUCTS

- large power transformers
- medium power transformers
- large liquid-immersed distribution transformers
- liquid-immersed distribution transformers
- dry type transformers
 - cast resin transformers
 - VPI transformers (conventional and compact core)
- shunt reactors
- series reactors
- phase shifters
- Lahmeyer-Compactstationen (compact substations)

Transformers from 30 kVA up to incl. 1,200 MVA in the voltage range up to 765 kV.



QUALITY MANAGEMENT

The SGB-SMIT Group is certified in accordance with:

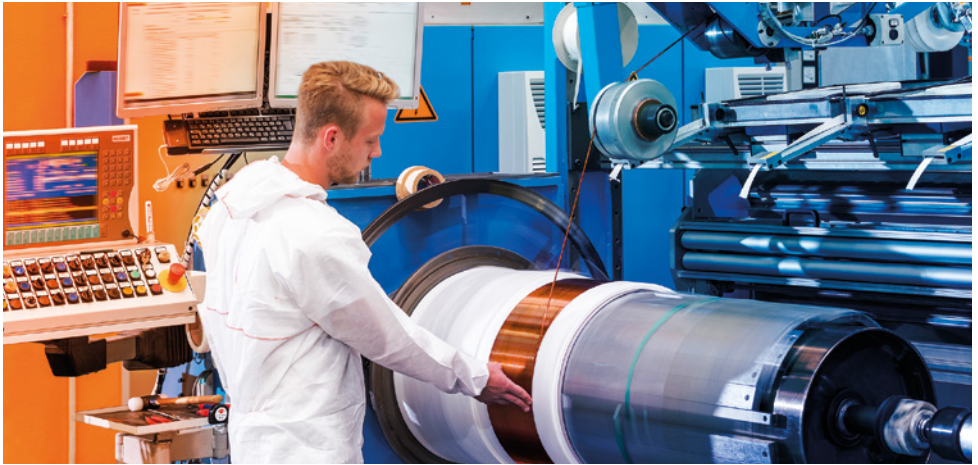
- DIN ISO 9001
- DIN ISO 14001
- DIN ISO 45001



TECHNOLOGIES

Technologies for conventional and renewable energy.

1. RELIABLE QUALITY



1.1. UNIQUE DESIGN OF THE SGB-SMIT LAYER WINDING

Electrically, layer winding is the best and most reliable technology.

Glass fiber reinforced layer winding cast in pure resin

- The highest level of mechanical stability and flexibility
- Significantly more robust with regard to thermal fluctuations, such as load changes or changes in ambient temperatures

Double-layer winding for linear reduction of surge voltage pulses

- For example, for re-ignitions through circuit breakers
- Linear distribution of voltage pulses over the entire winding
- No appreciable partial voltage overshoots within the winding
- Uniform voltage load

Layer winding design with one or more cooling ducts

- Enlargement of the cooling surface
- Reduction of internal mechanical stresses
- Improved material utilization
- Uniform temperature distribution

1.2. DECADES OF EXPERIENCE

SGB-SMIT has been producing cast resin transformers for more than 30 years – thus SGB-SMIT has a level of expertise in this field that is virtually unrivaled worldwide.

- Extensive worldwide operating experience, including international production facilities
- First-class international references in a wide variety of industries
- Extensive know-how and many years of experience with onshore and offshore wind turbines
- Optimal solutions for all industrial applications – whether simple or highly complex design
- Enclosure design according to your needs

1.3. AREAS OF IMPLEMENTATION

SGB-SMIT cast resin transformers offer solutions for:

- Extreme environmental conditions:
 - Very hot climate zones, e.g. desert regions
 - High environmental loads (salt, humidity, gases)
 - Climate zones with extreme low temperatures (to 50°C), e.g. the Arctic, Siberia
- High short-term overload requirement, e.g. up to 450% of rated power
- Moderate long-term loads of up to 140% of rated power through use of fans
- Energy grids that claim to be high availability
- Operation in harmonically-loaded grids
- Loads due to switching over-voltages (vacuum circuit breakers)
- Switching voltages and lightning impulse voltages
- High demands on mechanical vibration loads (crane, excavator, earthquake areas, ships)
- Installation altitude to 1,000 m and higher



NEW STANDARDS FOR CUSTOMER BENEFITS

SGB-SMIT cast resin transformers offer a number of features that technically distinguish them from other cast resin transformers and make them a very reliable and very safe solution.

1.4. APPLICATION AREAS

SGB-SMIT cast resin transformers impose the least demands on the installation site.

Automotive / electro-mobility

Load stations, sub-distribution units and infrastructure projects

Rail

DC power supply for underground and urban railways

Battery storage and charging stations

„Split powerline“ concepts

Mining

Underground and open-cast infrastructure, crane and excavator operations

Chemical industry / pharmaceutical industry

Rectifiers and distribution applications for indoor and outdoor installations

Building technology

For hospitals, schools, department stores, office buildings, etc.

Power plants / public utilities

„Power to...“ applications

Marine

Ship propulsion systems and shore connections for ports

Metal and paper industry

Roller drives and pumps

Oil and gas

Refineries, air separation plants, and oil and gas platforms

Computer centers

Server halls and cooling

Regenerative industry

Photovoltaics, onshore and offshore wind



2. TECHNICAL INFORMATION

2.1. GENERAL TECHNICAL DATA

General implementation spectrum

- Maximum operating voltage: $U_m = 1.1$ to 40.5 kV
- Power spectrum: 50 kVA to 25 MVA (beyond that possible on request)
- Possible frequencies: 16²/3; 50; 60 Hz (deviations possible on request)
- Winding material: Copper or aluminum
- Variable number of systems: 2 to x winders in concentric or multi-level design
- Based on a selection of basic transformer designs the transformers can be efficiently adapted or extended to the respective requirements.



Selection Table – Insulation Level Voltage 12 kV

Power kVA	Type des.	P ₀ W	P _k 120°C W	u _k %	L _w dB [A]	Length* mm	Width* mm	Height* mm	Total weight* kg
400	DTTH1N	750	5500	4	60	1220	820	1770	1450
630	DTTH1N	1100	7600	4	62	1340	820	1950	2000
800	DTTH1N	1300	8000	4	64	1480	820	1980	2450
1000	DTTH1N	1550	9000	6	65	1670	980	1910	2950
1250	DTTH1N	1800	11000	6	67	1750	980	2120	3200
1600	DTTH1N	2200	13000	6	68	1870	980	2250	4250
2000	DTTH1N	2600	16000	6	70	1900	1270	2300	4550
2500	DTTH1N	3100	19000	6	71	2050	1270	2370	5500
3150	DTTH1N	3800	22000	6	74	2270	1270	2520	7450
3160	DTTH1N	PEI 99.348 %		6	70	2300	1270	2425	6000

Selection Table – Insulation Level Voltage 24 kV

Power kVA	Type des.	P ₀ W	P _k 120°C W	u _k %	L _w dB [A]	Length* mm	Width* mm	Height* mm	Total weight* kg
400	DTTH1N	750	5500	6	60	1620	820	1830	2100
630	DTTH1N	1100	7600	6	62	1680	820	1990	2950
800	DTTH1N	1300	8000	6	64	1671	820	2000	2650
1000	DTTH1N	1550	9000	6	65	1800	980	2050	3450
1250	DTTH1N	1800	11000	6	67	1970	980	2150	5050
1600	DTTH1N	2200	13000	6	68	2000	980	2390	4750
2000	DTTH1N	2600	16000	6	70	2120	1270	2350	6275
2500	DTTH1N	3100	19000	6	71	2120	1270	2350	6275
3150	DTTH1N	3800	22000	6	74	2310	1270	2720	7770
3160	DTTH1N	PEI 99.348 %		6	71	2300	1270	2500	6450

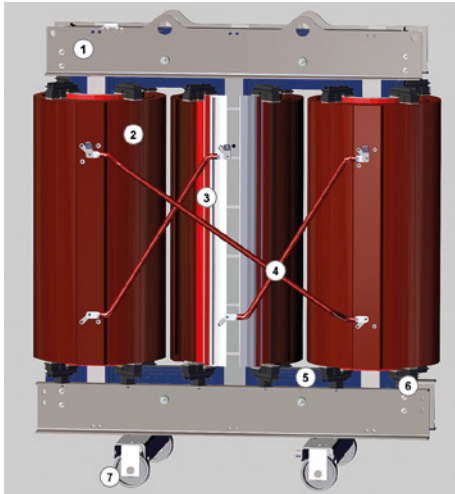
For the tables applies:

- Transformers in design in accordance with IEC 60076-11
- Indoor version E2; C2; F1 with tapplings 2 x 2.5 % as standard ± (can be changed in de-energized status)
- Dimensions and weights are guide values
- Specified sound power levels apply for AN-mode without enclosure (at no-load)

* Guide values

2.2. TRANSFORMER STRUCTURE

Plant operators throughout the world appreciate the extraordinary reliability of SGB cast resin transformers, because they get the highest degree of safety. Unlike oil transformers, cast resin transformers do not have a tank, this means that the active part is directly visible.



Transformer sectional view:

- | | |
|------------------------|-------------------|
| 1 Steel clamps | 5 Core |
| 2 High-voltage winding | 6 Winding support |
| 3 Low-voltage winding | 7 Chassis |
| 4 Circuit connection | |

The core [5], held together by steel clamps [1], consists of high-quality, grain-oriented, cold-rolled, soft magnetic electrical steel laminations, insulated relative to each other. The distinctive feature of cast resin transformers is use of high-voltage windings [2] that are designed as layer windings completely encapsulated in cast resin under vacuum. The low-voltage windings [3] are usually executed in the form of foil windings.

DIMENSIONS AND WEIGHT

The quotation, the order documentation or the order specification is authoritative for the specific design of the cast resin transformers. Of course, the actual dimensions, such as width, height and weight of the transformer are specifically dependent on the respective customer order. This means that the transformer types shown in the selection list, with their respective dimensions and weights, can vary from case-to-case. Dimensional restrictions can be taken into account in the design and must be made known in the quotation stage.



HIGH-VOLTAGE WINDING

The high-voltage winding is the heart of the cast resin transformer. SGB-SMIT's wealth of expertise is incorporated in the double layer winding. Our cast resin transformers stand out because the wires of the high-voltage winding are completely embedded in a closed cast resin body with a smooth surface. The SGB-SMIT manufacturing technology and the materials used are characterized by important unique selling points, which on the one hand distinguish them technically from other cast resin transformers and on the other hand make them a reliable and safe solution.

LOW-VOLTAGE WINDING

The low-voltage winding of SGB-SMIT cast resin transformers is almost always designed as a foil winding. The advantages of this form of winding speak for themselves:

- High current-carrying capacity
- Balanced temperature distribution in the winding
- High short-circuit resistance

There are exceptions for technical reasons, e.g. for lower power ratings below 160 kVA and for higher system voltages ($U_m > 7.2$ kV).



CORE

For calculation of the cores for cast resin transformers, no-load losses, noise, and no-load current are essential, in many cases crucial, quality characteristics.

The engineering of the core design plays a special role. This role includes:

- Precise geometric configuration
- Determination of the material properties of the magnetic sheet to be used
- Design measures to control, for example, vibrations, inclined positions and other mechanical requirements

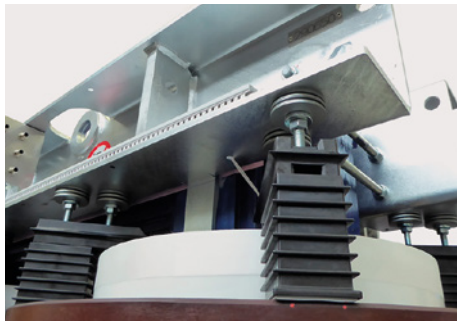
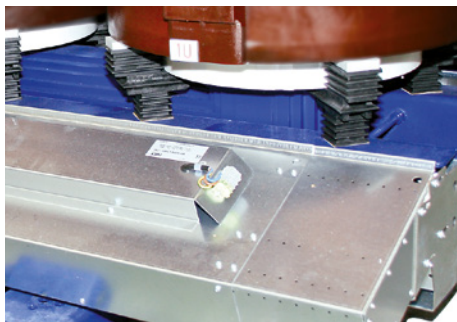
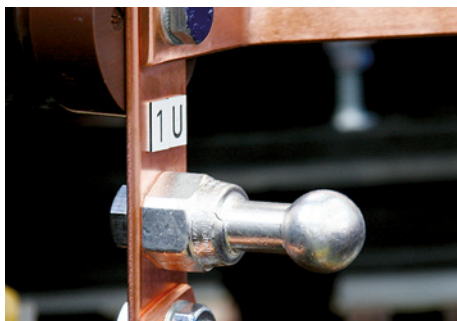


2.3.ACCESSORY OVERVIEW

In addition to the basic components – core, windings, and mechanical holding frame – additional equipment is often required to integrate the transformer into the respective plant.

We offer the following possibilities:

- Castors
- Lift possibility for forklifts
- Locking device
- Transformer bearings
- Machine feet
- Fixed ball points
- Lightning arrestors
- Ground switches, grounding fittings
- Step switch
- Fans (performance increase up to 40%)
- Enclosure
- PTC and/or PT100 temperature sensors
- Touchless temperature measuring
- Dial thermometer
- Vibration damping through vibration dampers
- Vibration-resistant design
- Earth-quake proof design
- Shield winding
- Switchability (e.g. 20 kV to 10 kV)
- Magnetic bias unit
- Current converters (medium-voltage or low-voltage)
- Other custom solutions



3. ENCLOSURES



The portfolio of SGB-SMIT includes different types of enclosures. The selection ranges from various standard enclosures to enclosures especially adapted to customer requirements. The enclosures are designed as supporting frame variants.

STANDARD ENCLOSURES

6 different sizes in different configurations

- IP21 - IP33
- Indoor or outdoor installation
- Floor or chassis installation
- Doors or hatches

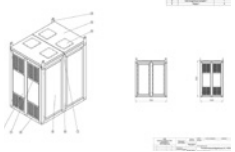
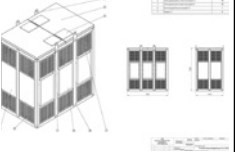
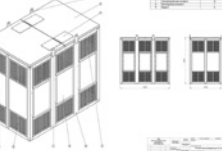
PROJECT ENCLOSURES

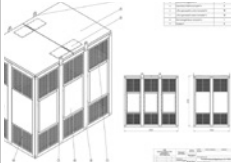
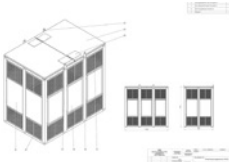
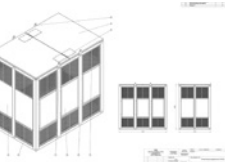
individually adapted according to custom requests

- IP21 - IP54 possible
- Indoor or outdoor installation
- Floor or chassis installation
- Doors or hatches
- Cooling can be individually adapted



3.1. STANDARD ENCLOSURES

Size	1	2	3
Dimension diagram			
RSG-no.	RSG00000001 - 16	RSG00000017 - 32	RSG00000033 - 48
Dimensions (L x W x H)	1,400 mm x 1,000 mm x 1,600 mm	1,800 mm x 1,200 mm x 1,900 mm	2,200 mm x 1,400 mm x 2,050 mm
Weight	approx. 220 kg	approx. 350 kg	approx. 425 kg
Protection classes IP	21/23/31/33	21/23/31/33	21/23/31/33
Floor design	Floor / chassis	Floor / chassis	Floor / chassis
Installation type	Indoor / outdoor	Indoor / outdoor	Indoor / outdoor
Inspection designs	Hatch / door	Hatch / door	Hatch / door
Protective perimeter	1,300 mm x 900 mm x 1,500 mm	1,700 mm x 1,100 mm x 1,800 mm	2,100 mm x 1,300 mm x 1,950 mm
Inlet air surface area (IP2X / IP3X)	0.30 m ² / 0.17 m ²	1.27 m ² / 0.75 m ²	1.67 m ² / 0.98 m ²
Outlet air surface area (IP2X / IP3X)	0.35 m ² / 0.20 m ²	1.47 m ² / 0.86 m ²	1.93 m ² / 1.14 m ²
Corrosion protection class	C4	C4	C4
Material	Dx51D+Z275 (t=1.5 mm)	Dx51D+Z275 (t=1.5 mm)	Dx51D+Z275 (t=1.5 mm)
Heat dissipation	Natural convection	Natural convection	Natural convection
Powder coating	>70 µm	>70 µm	>70 µm
Color scheme	RAL 7035	RAL 7035	RAL 7035
Max. number of inspection openings	4	6	6
Transformer power Voltage series 10 kV	250/10	630/10	1,000/10
Transformer power Voltage series 20 kV	160/20	315/20	630/20

Size	4	5	6
Dimension diagram			
RSG-no.	RSG00000049 - 64	RSG00000065 - 80	RSG00000081 - 96
Dimensions (L x W x H)	2,400 mm x 1,600 mm x 2,250 mm	2,700 mm x 1,800 mm x 2,550 mm	3,000 mm x 2,000 mm x 2,800 mm
Weight	approx. 505 kg	approx. 605 kg	approx. 710 kg
Protection classes IP	21/23/31/33	21/23/31/33	21/23/31/33
Floor design	Floor / chassis	Floor / chassis	Floor / chassis
Installation type	Indoor / outdoor	Indoor / outdoor	Indoor / outdoor
Inspection designs	Hatch / door	Hatch / door	Hatch / door
Protective perimeter	2,300 mm x 1,700 mm x 2,150 mm	2,600 mm x 1,700 mm x 2,450 mm	2,900 mm x 1,900 mm x 2,700 mm
Inlet air surface area (IP2X / IP3X)	2.17 m ² / 1.27 m ²	2.80 m ² / 1.65 m ²	3.52 m ² / 2.07 m ²
Outlet air surface area (IP2X / IP3X)	2.49 m ² / 1.47 m ²	3.24 m ² / 1.90 m ²	4.07 m ² / 2.39 m ²
Corrosion protection class	C4	C4	C4
Material	Dx51D+Z275 (t=1.5 mm)	Dx51D+Z275 (t=1.5 mm)	Dx51D+Z275 (t=1.5 mm)
Heat dissipation	Natural convection	Natural convection	Natural convection
Powder coating	>70 µm	>70 µm	>70 µm
Color scheme	RAL 7035	RAL 7035	RAL 7035
Max. number of inspection openings	6	6	6
Transformer power Voltage series 10 kV	1,600/10	2,500/10	3,150/10
Transformer power Voltage series 20 kV	1,600/20	2,000/20	3,150/20

3.2. PROJECT ENCLOSURES

Fabrication of individual enclosures according to customer requirements is possible in protection classes IP21 to IP54. For installation, you can choose between indoor and outdoor installation.

Moreover there is a distinction between floor and chassis installation. The number of doors and hatches can be adapted to suit the personal preferences. Project enclosures can also be equipped with cooling to dissipate the transformer thermal power loss.

- AN (Air Natural, convection cooled)
- AF (Air Forced, fan cooled)
- AFWF (Air Forced Water Forced, air/water cooling)



4. SPECIAL DESIGNS



4.1. SAFE SYSTEM

SGB-SMIT cast resin transformers are characterized by high reliability, an extremely high level of protection for personnel, and good environmental compatibility. New standards were set through the development of the „Safe System“, particularly for the new megawatt class of off-shore wind turbines.

Numerous environmental factors can be accommodated through the Safe System:

- Salty air
- The occurrence of fire
- Vibration in operation and stresses occurring during transport
- Strong and rapid capacity fluctuations



IMPLEMENTATION SPECTRUM

The Safe System can be delivered up to a maximum operating voltage of $U_m = 40.5 \text{ kV}$ and in the power range up to 10 MVA. The production capacities are geared to industrial production of several hundred units per year.

GENERAL INFORMATION

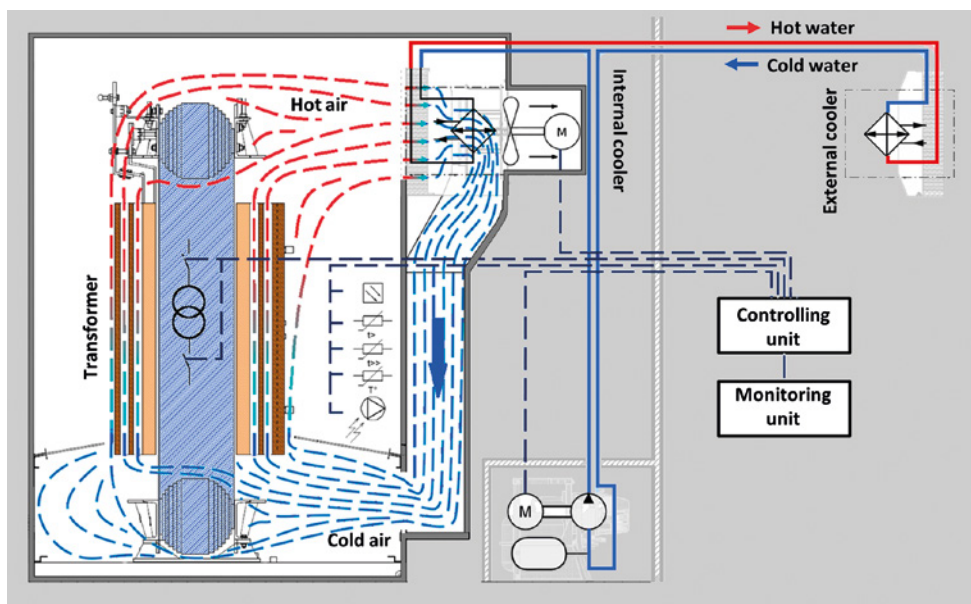
The requirements imposed on long-term reliability are viewed as the top priority, especially with regard to poorly accessible locations, at sea, for example. With the Safe System, the transformer is placed in a protective enclosure with an integrated cooler. In the internal cooling circuit, the heat caused by the transformer losses is fed to the cooler.

This waste heat is then transferred in the cooler to the external cooling medium (water). The re-cooled air is returned to the transformer via the internal cooling circuit. A significant weight reduction was achieved by optimizing the cooling system.

The cooling system is designed in such a manner that only a small portion of the transformer thermal power loss is dissipated to the environment via the enclosure.

Protected against salty air

- Replaceable fans; service life > 5 years
- Hermetically sealed against external, salty, corrosive cooling air (DIN EN 50308)
- Extended maintenance intervals because salt deposits are avoided
- Two redundant fans for internal and external cooling circuits
- Fan decoupling through non-return flaps
- Fan with connections on the outside of the enclosure
- Tube cooler made of highly-resistant material
- Condensation and cleaning water are drained off to the outside



Personal protection

- Metallic enclosure, IP54, can be dismantled
- Protection against contact with electrically live parts
- Inspection openings secured with a locking system
- Overload or excessive temperature control through temperature monitoring
- Excessive temperature shutdown through monitoring devices
- All parts connected to signal ground; safe transformer grounding in de-energized status via the grounding switch with first make/last break auxiliary contacts
- Capacitive test and monitoring system
- Lightning arrestors



Fire protection

- SGB-SMIT cast resin transformers do not contribute significantly to fire occurrence (assessment according to IEC 60076-11)
 - Fire classification F1
 - Significantly lower fire load than oil transformers, for example
 - No danger of fire propagation through escaping liquids
- Effective extinguishing system in the enclosure; coupling with an external fire extinguishing system is possible
- Arc sensors for fast shutdown of the system (overload protection)
- Pressure relief dampers discharge excess pressure to the outside

Transport and vibration

- Testing by accredited testing institutes
- Core yokes secured by bandages and bolts
- Winding fixation, optionally via a support system with disk springs
- Windings and holding constructions with spring elements are exposed and can be easily retightened if required – a clear advantage over oil-insulated transformers

Consideration of strong power fluctuations

- High-voltage winding encapsulated in epoxy resin/glass-fiber insulation
- Expansion of the conductor material and the resin at load change is accommodated by the glass fibers embedded in the epoxy resin

Tests in the plant

- Routine test
- Heating measurement
- Surge voltage test with subsequent partial discharge measurement

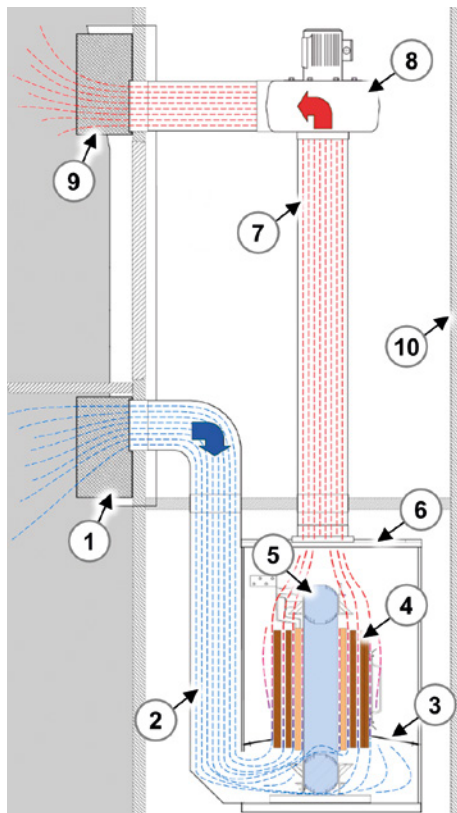
4.2.JET SYSTEM



With the Jet System SGB-SMIT offers an optimized solution for transformers with a cooling system. Ideal for wind turbines for onshore installation. The design can be adapted both to installation in the tower, as well as in the nacelle.

In particular, the following factors, in addition to life-cycle costs, were taken into account in the development:

- Optimized cooling
- Protection of personnel
- Fire protection
- Grid connection requirements
- Transport conditions and vibration



Jet System (example in a wind turbine)

- | | |
|----------------------|-----------------------|
| 1 Air filter (inlet) | 6 Enclosure |
| 2 Cold air | 7 Hot air |
| 3 Air guide plates | 8 Fan |
| 4 Windings | 9 Air filter (outlet) |
| 5 Core | 10 Tower |

IMPLEMENTATION SPECTRUM

The Jet System can be delivered with up to a maximum operating voltage of $U_m = 40.5 \text{ kV}$ and in the power range from 1.6 MVA to 4 MVA.

GENERAL INFORMATION

The SGB-SMIT cast resin transformer is housed in a proven IP44 protective enclosure. The cold supply air is routed from outside, via a supply air box (1) and a pipe system, directly to the enclosure (6). By means of an air guide plate (3), the cooling air (2) is directed specifically into the ducts of the winding (4).

The exhaust air heated by the transformer thermal loss is blown directly into the open air via a pipe system, which also houses a low-noise fan (8). The result is a defined cooling system that can be tested in a factory test.

The no-load losses and low-load losses that occur with a load of up to 30% rated power, can be dissipated without switching on the fan. At higher load, the fan is switched on via temperature sensors in the windings.

In this, the directed air flow results in a low heating of the windings. Thanks to the optimized design of the cooling system considerable savings in material and space requirements can be achieved.

Temperature range from -25 to +40°C
(special cases: Temperatures to -50°C and +50°C)

Environmental class E2 (tested by the institute)
For higher requirements it is possible to fit the device with appropriate filters.

Personal protection

- Metallic enclosure, IP44, can be dismantled
- Protection against contact with electrically live parts
- Overload or excessive temperature control through temperature monitoring
- All parts connected to the grounding system of the plant

Fire protection

- SGB-SMIT cast resin transformers do not contribute significantly to fire occurrence (assessment according to IEC 60076-11)
 - Fire classification F1
 - Significantly lower fire load than is the case with oil transformers
 - No danger of fire propagation through escaping liquids
- Arc sensors for fast shutdown of the system
- Hot gases can escape via aeration and ventilation lines

Grid connection requirements

Grid connection conditions have a considerable influence on the design of a transformer.

By using the optimized cooling of the transformer and through ducts in the windings, and the configuration of the magnetic core, we have succeeded in significantly reducing the additional material required to meet the grid connection requirements.

A certain amount of inductive and capacitive reactive power must be transmitted through the transformer.

Transport and vibration

- Core yokes secured by bandages and bolts
- Winding fixation, optionally via a support system with disk springs
- Windings and holding constructions with spring elements are exposed and can be easily retightened if required – a clear advantage over oil-insulated transformers

4.3. OTHER DESIGNS

TWO-LEVEL TRANSFORMER

Two-level transformers consist of two high-voltage windings that are switched in parallel, and two independent low-voltage systems.

The most common use of two-level transformers is to supply a 12-pulse rectifier that is connected to the low-voltage systems.

In addition to the classic two-level application there is also the version as so-called mechanical two-level. This design is used when the current of the low-voltage systems is so high that it can no longer be handled with a single low-voltage winding. To control the high current, two low-voltage windings, that are arranged axially are switched parallel.

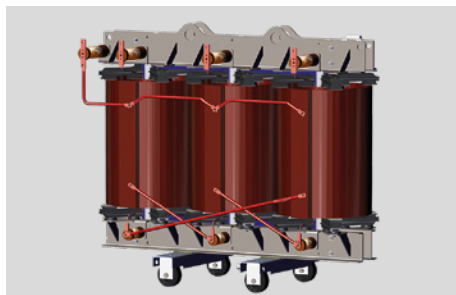
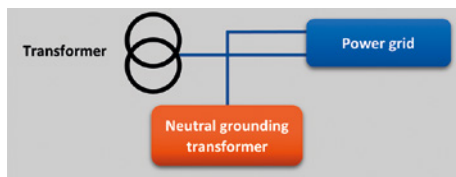


NEUTRAL GROUNDING TRANSFORMER

A neutral grounding transformer is used for realization of the missing neutral point in electrical distribution networks or if the transformer neutral points cannot be fully loaded. However neutral grounding transformers are also used to extinguish a ground fault or to limit the ground fault current via its impedance. Usually they are connected between larger power transformers and the ground.

There are neutral grounding transformers that are only operated in short-term operation, for example for 10 seconds as long as a fault current occurs. Short-circuit losses are also generated here only for the 10 seconds.

However, there are also cases, in which current flows permanently via the neutral point transformer. This current is in the range of 10-20% of the maximum fault current. The customer specifies the operating mode, rated power, switch group, and impedance.



DUAL INDUCTOR

A dual inductor is initially only used for grid coupling with compensating current limitation.

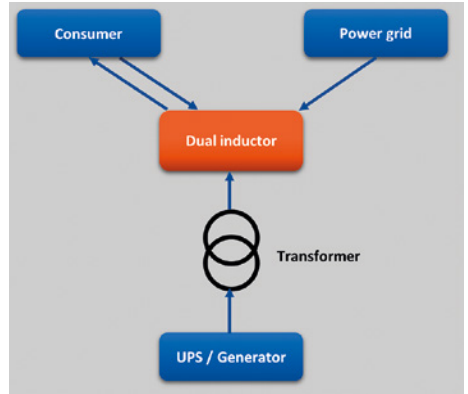
The SGB-SMIT dual inductors have two windings per strand, one main winding and one auxiliary winding. At their connection point, additional energy can be injected from a transformer or generator (e.g. emergency power generator).

Among other things, the dual inductor prevents current from flowing into a collapsing power grid before a (fast-opening) switch that is usually located on the grid side upstream of the dual conductor can be opened. The occurrence of major short-circuit currents to the power grid is prevented here by the dual inductor.

Other functions:

- Filter function in conjunction with generator and transformer
- Safe weakening of grid-side voltage peaks
- Significantly reduced transmission of grid-side voltage harmonics to the consumer side
- Drastic reduction of load-side current harmonics on the grid-side

... AND MUCH MORE...



5. PLANNING INFORMATION



5.1. STANDARDS AND REGULATIONS

SGB-SMIT cast resin transformers fulfill the requirements specified in the customer order in accordance with national, European, and international standards.

REGULATIONS

- 2009/125/EU (Ecodesign Directive)
- 548/2014 (Commission Regulation EU)

STANDARDS IN THE EUROPEAN UNION

- DIN EN 60076-1 (Power transformers)
- DIN EN 60076-11 (Dry-type transformers)

STANDARDS OUTSIDE THE EUROPEAN UNION

- IEEE (Institute of Electrical and Electronics Engineers - USA)
- CSA (Canadian Standards Association - Canada)
- GOST (Gossudarstvenny Standart - Russia)
- GB Standard (China)

OTHER REGULATIONS

The following regulations must also be complied with when constructing and operating installations:

- DIN VDE 0100 (Erection of Power Installations with Nominal Voltages Up To 1000 V)
- DIN VDE 0105-100 (Operation of Electrical Installations)
- DIN VDE 0100-718 (Erection of low-voltage installations - Requirements for special installations or locations - Communal facilities and workplaces)
- EltBauV (Ordinance on the construction of electrical operating areas)
- ArbStättV (Regulations for the Workplace Ordinance)
- TA-Lärm (Instructions for protection against noise)

OTHER PLANNING AND CONFIGURATION INFORMATION

- VDI 2078 (Calculation of thermal loads and room temperatures)
- Customer specifications

5.2. INSTALLATION CONDITIONS

- Indoor installation is intended
- Degree of protection IP00; winding surfaces are not safe to touch
- Enclosure mandatory for outdoor installation, minimum degree of protection IP23C
- Installation with medium-voltage and low-voltage switchgear is possible in one room; short connection paths
- No protective measures necessary for prevention of water pollution because there is no need for oil as the insulation fluid
- No additional measures required for fire protection and oil trays



Extreme installation conditions must be communicated for correct Installation planning, e.g.

- Installation altitudes higher than 1,000 m above sea level
- Ships
- Earthquake zones
- Wind turbines
- Extreme temperature conditions (extremely cold, tropical, etc.)
- Special installations – communal facilities and workplaces (DIN VDE 0100-718)
- EX areas

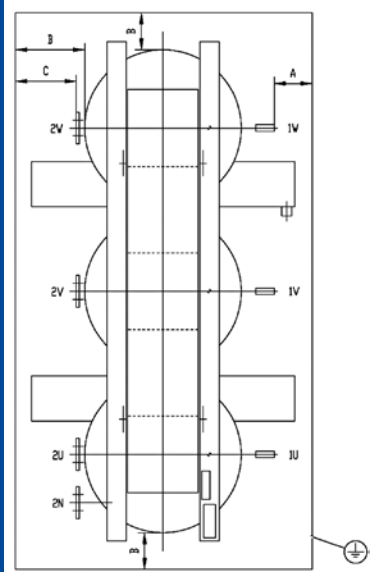


5.3. MINIMUM DISTANCES

In particularly confined spaces, such as in protective enclosures, the minimum distances must be complied with to prevent arcing.

When planning any tasks in the vicinity of the transformers, note that the „protective perimeter“ does not prescribe the limits of the danger zone as defined by DIN EN 50110-1, but only the distance required for trouble-free operation.

The windings of the cast resin transformers are not safe to touch in spite of the cast resin insulation. Cast resin insulation is a functional insulation. This insulation offers no protection against dangerous shock currents when touching or against electrical flashovers when the transformer is approached. Take protective measures to prevent people from entering the danger zone of the windings.



The diagram shows a cross-section of a transformer with three windings. Dimensions A, B, and C are indicated as distances from various parts to grounded conductive parts. A is the distance to the high-voltage winding connection, B is the distance to the surface of the outer encapsulated winding, and C is the distance to the low-voltage winding connection. A ground symbol is shown at the bottom right of the diagram.

Voltage U_m	Lightning surge voltage LI	Minimum air gaps / minimum distances to grounded conductive parts		
		A (mm)	B (mm)	C (mm)
1,1	-	40	20	40
3,6	20	60	30	60
3,6	40	60	30	60
7,2	60	90	45	90
7,2	75	120	65	120
12	75	120	65	120
12	95	160	85	160
12	110	200	115	200
17,5	95	160	85	160
17,5	125	220	115	220
24	125	220	115	220
24	145	270	140	270
24	150	270	140	270
36	170	320	160	320
36	200	380	180	380
40,5	200	380	180	380

All values apply to installation altitudes ≤ 1000 m above sea level

A = Distance to the high-voltage winding connection

B = Distance to surface of the outer encapsulated winding

C = Distance to the low-voltage winding connection

PLANNING INSTRUCTION

When planning and implementing protective measures, treat the windings as unprotected live parts!

5.4. AMBIENT CONDITIONS

Cast resin transformers are rated in different climatic and environmental classes. The required classes must be determined by the plant operator. Configurations up to class C2 and E2 according to IEC are possible as standard, higher classes must be requested.

CLIMATE CLASSES

The climate class takes into account the lowest ambient temperature during transport, storage, and operation.

	Class C1	Class C2	Class C3	Class C4	Class C5	Class Cxy*
Transport & storage						
In accordance with IEC	-25°C	-25°C	-40°C	-50°C	-60°C	-X°C
In accordance with GOST	-25°C	-25°C	-45°C	-60°C	-	-
Operation						
In accordance with IEC	-5°C	-25°C	-25°C	-40°C	-50°C	-Y°C
In accordance with GOST	-5°C	-25°C	-45°C	-60°C	-	-

*The temperatures -X°C and -Y°C can be agreed on a project-specific basis.

ENVIRONMENTAL CLASSES

Air humidity, dripping water, condensation, and contamination are among the environmental influences for dry-type transformers. These influences are important not only during operation, but also during storage before the transformer is installed. With regard to these different environmental conditions, five environmental classes are defined according to IEC 60076-11 for transformers without special external protective measures.

Class E0:

Condensation does not occur on the transformer, contamination is negligible. This condition is usually achieved when installed in a dust-free and dry interior space.

Class E1:

Occasional condensation may occur on the transformer (for example when the transformer is switched off). Contamination to a limited extent is possible.

Class E2:

Frequent condensation or light contamination or a combination of both.

Class E3:

Frequent condensation or medium contamination or combination of both.

Class E4:

Frequent condensation or light contamination or a combination of both.

CONCLUSION

SGB-SMIT cast resin transformers are thus safe to operate in conditions that involve condensation as well as contamination. However, the maintenance intervals should be adapted to the ambient conditions. This means that we recommend cleaning the winding surfaces if there is heavy contamination. Likewise, they are suitable for outdoor installation at temperatures to -50°C with a protective enclosure, starting with IP23, with special paint finish.

5.5. FIRE BEHAVIOR

FIRE CLASSIFICATIONS

The required fire classification must be specified by the plant operator. However, SGB-SMIT cast resin transformers always meet the highest defined class F1.

Class F0:

- No specific fire risk is taken into account.
- No special measures to limit the fire hazard, with the exception of fire hazards due to the design of the transformer.
- Release of toxic substances is limited to a minimum.

Class F1:

- Limitation of the fire hazard is taken into account.
- Release of toxic substances and vision-obstructing smoke is reduced to a minimum.
- SGB-SMIT cast resin transformers do not contribute significantly to the fire.

FIRE SAFETY

Since SGB-SMIT cast resin transformers only have cast resin components in the LV and HV windings, the fire load is essentially determined by these components.

FIRE GAS ANALYSIS

In the laboratories of ALLIANZ AG, the casting resin molding material from an SGB transformer winding, as well as samples of all insulating materials were carbonized and the combustion gases analyzed.

- The possibility of dioxin formation is excluded
- The possibility of sulfur dioxin formation is excluded
- Smoke gas consists mainly of carbon monoxide, carbon dioxide, steam, and soot
- Trace fractions of other hydrocarbons

Comparison of fire load – cast resin transformers and liquid-cooled transformer types for 1000 kVA design:

Transformer type	Insulation quantity [kg]	Calorific value [kWh/kg]	Fire load [kWh]
Cast resin	150	8.2	1230
Mineral oil*	700	12.9	9030
Silicone oil*	800	8.5	6800

*Only insulation fluid is considered

RESULT

The results of the investigation show that the casting resin molding material that we use is to be classified as harmless.

5.6. SEISMOLOGY

If the transformer is installed in a seismically active region, the possible external mechanical stress must be taken into account in the design.

You determine the seismic class. The determination can be made using the following steps:

1st Step:

Determine the relevant zone of earthquake activity according to IEC 60721-2-6.

2nd Step:

Select the ground acceleration of the relevant earthquake activity zone according to IEC 60721-2-6.

3rd Step:

Select the seismic class based on the ground acceleration (see the table below).

IEC 60076-11 describes three different seismic classes.



Seismic class	Earthquake	Ground acceleration AG [m/s ²]	Richter scale	MSK scale
S-I	From earth tremors to medium earthquakes	2	< 5.5	< VIII
S-II	For medium to strong earthquakes	3	5.5 bis 7.0	VIII bis IX
S-III	For strong to very strong earthquakes	5	> 7.0	> IX

5.7. COOLING METHOD

The site where the cast resin transformer is installed must be sufficiently ventilated, as every time the transformer is operated there is heat loss, which must be discharged out of the equipment room.

Here it is necessary to check whether the possibility of natural aeration and ventilation is provided. If the dimensions of a room or enclosure do not ensure proper cooling, the air flow must be ensured by forced ventilation.

		Symbol
Cooling medium	Air	A
	Water	W
Cooling medium movement	Natural	N
	Forced	F

The ventilation system must be dimensioned for the maximum heat loss that occurs. This consists of the no-load losses of the iron core and the thermal energy generated by the windings.

NATURAL AIR CIRCULATION

- Always provide the inlet opening of the supply air at the bottom and with a maximum height up to the beginning of the LV winding. This promotes the chimney effect and circulation of the air flow in the duct between the windings.
- If possible, arrange lower openings for supply air entry all around the transformer.
- Cross-section for the upper opening normally 10 to 15 % larger than the lower openings. This takes into account the lower density of the exhaust air.

The volume required for proper cooling can be calculated as follows:

$$Q = Pt \div (1,15 \times \Delta O) [m^3/s]$$

The effective area of the lower opening can be calculated as follows:

$$S = 10 \times (Pt \div ((H \times \Delta O^3)^{0,5})) [m^2]$$

KEY:

Pt: Total losses to be removed in kW

ΔO : Temperature gradient in K between supply and return air / empirical value approx. 15°C

Q: Air volume flow in m³/s

H: Distance in meters between the centerline of the transformer and the centerline of the upper opening of the cell

S: Useful area of the lower supply air opening (without grille) in m²

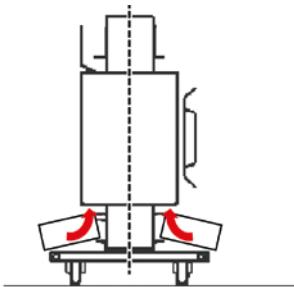
FORCED AIR CIRCULATION WITH FANS

Cast resin transformers can be equipped with fans to increase performance. Through the forced cooling, an increase in performance of up to 40% is possible. With an optimum configuration, a higher value can also be achieved.

The following variants are available for forced cooling of cast resin transformers:

Freestanding cast resin transformer

- Attachment of 2 to 6 fans on the lower steel clamps on both the high-voltage and low-voltage sides of the transformer.
- Fans are intended for short-term operation. If continuous operation is required, this must be specified.



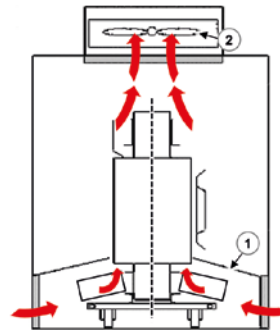
- This is the usual situation when the transformer is installed without an enclosure.
- The average power increase in this case is 40%. This means that for a cast resin transformer with a 1000 kVA AN (natural cooling) power rating, a power rating of 1400 kVA can be assumed if fans are used.

SGB-SMIT has proven this performance increase with fans in many test runs.

Installation of the cast resin transformer in an enclosure with protection class \leq IP33

If the cast resin transformer is installed in an enclosure, or if it stands in a more or less closed room, sufficient ventilation must always be ensured. For enclosures, this mainly depends on the selected degree of protection.

The air guide plates (1) are made to cover the air space between the enclosure wall and the transformer. When the fan (2) is in operation, it ensures that the cool outside air is drawn through the transformer and its windings. In this case as well, additional fans can be mounted that can be switched on as required.



If the solutions presented here do not meet your requirements, we would also be pleased to work with you to develop customer-specific solutions.

Please contact us.

COOLING AIR TEMPERATURE

Climatic conditions, such as extreme cold in winter or strong solar radiation in summer, must be taken into account. The transformer room must be air-conditioned accordingly.

In air-conditioned rooms, avoid blowing the cooled air from the air-conditioning system directly onto the hot windings. This extreme temperature difference can cause cracks in the windings, which in the worst case can result in failure of the cast resin transformer.

If the cooling air is heavily contaminated, it may have to be filtered.

Cast resin transformers are designed according to the relevant standards for the following cooling air values:

The temperature of the cooling air does not exceed:

- 40°C [at any time]
- 30°C in the monthly average of the hottest month
- 20°C annual average

The temperature of the cooling air does not fall below the standard value:

- -25°C for outdoor transformers
- -5°C for indoor transformers

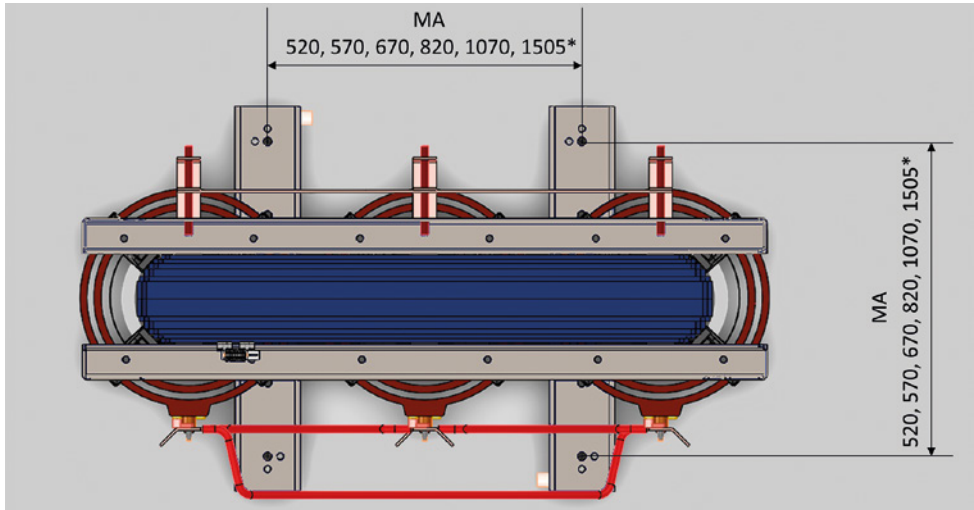
Lower temperatures are possible on request.

If the ambient temperatures deviate from the values defined in the standard, these temperatures should be communicated so that this can be taken into account in the transformer design. If, for example, higher ambient temperatures are not taken into account, this can have a negative effect on the service life.

Ambient temperature (annual average)	Transformer load capacity
-20°C	124%
-10°C	118%
0°C	112%
+10°C	106%
+20°C	100%
+30°C	93%

5.8.CHASSIS CONFIGURATIONS

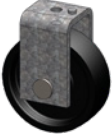
The chassis is available in different track widths. It can be equipped with castors or machine feet. We would also be pleased to develop customer-specific solutions.

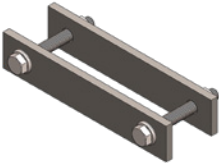
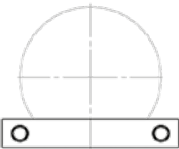



*Standard sizes; customer-specific track widths are possible on request

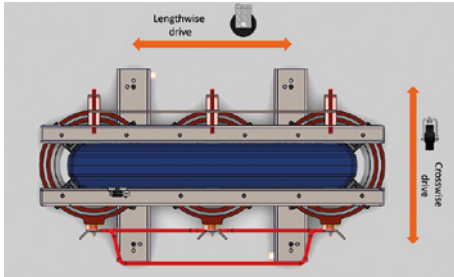
CASTORS

The castors are available in different heights and materials. To protect against rolling off, locking devices are provided.

Castors [4 castors / transformer]	Height [mm]	Material	Max. load capacity
	125	Plastic	2.5 t
	125	Steel	2.5 t
	160	Steel	3.6 t
	200	Steel	6.3 t

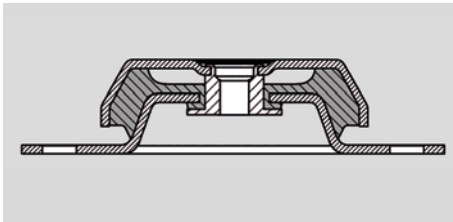
Locking device for castors [2x / transformer]			Height [mm]	
			125	
			160	
				200
				200 with flat roller

The direction of the castors is adjustable. Depending on how the castors are attached on the chassis, the transformer can be moved longitudinally or transversely.



MACHINE FEET

The machine feet simultaneously act as vibration dampers. Moreover, they also insulate against noise. The rubber element in the vibration damper withstands up to max. 5100 kg.



Cross section of a machine foot

TRANSFORMER BEARINGS

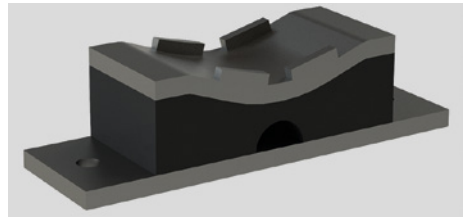
For the bearing arrangement of transformers directly on the ground, or on non-insulated movement rails, the vibration emanating from the transformer generates unpleasant noises and undesired vibration in the environment.

Transformer bearings are used for protection of rolling away and damping of noise and vibration emanating from the transformer.

Noise and vibration damping is achieved through structural separation of the lower part and upper part via a special damping element. The weight of the transformer compresses the rubber, resulting in transverse vibration damping and horizontal damping.

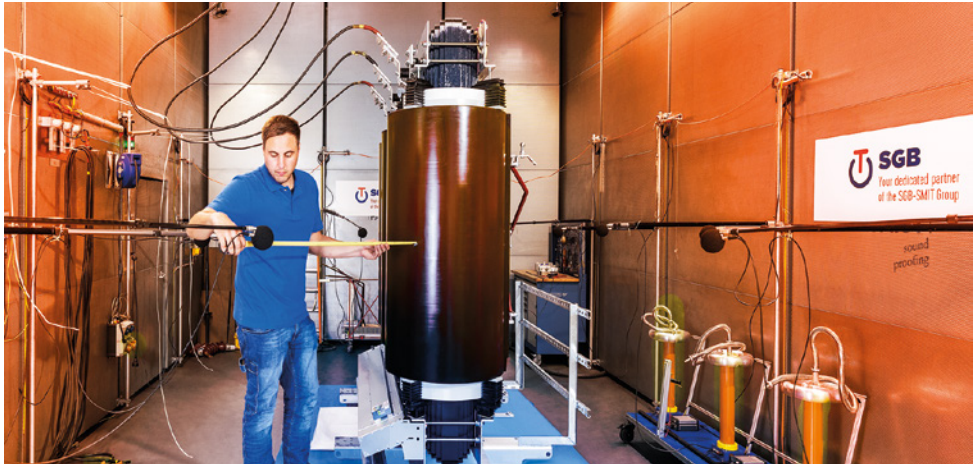
The transformer bearing is selected in accordance with the load capacity. If there is increased mechanical stress, e.g. when used on ships and excavators, in wind turbines, in earthquake regions, etc., additional design measures are necessary.

When installing the transformer on a rubber bearing, the spring deflection must be taken into account, as this can change the position of the connections somewhat. This is critical when connecting transformers to existing rail systems.



Transformer bearings

6. SAFETY DEVICES



6.1. GROUNDING

Grounding (equipotential bonding) of the core and the metal parts of the cast resin transformer always occurs. A connection for grounding to the chassis is provided as standard equipment. Customer desires can of course be taken into account, such as grounding on the steel clamps.

Fixed ball points can be attached to the conductor connections to ground the windings when the transformer is disconnected:

- 20 mm diameter
- 25 mm diameter
- Straight
- Angled

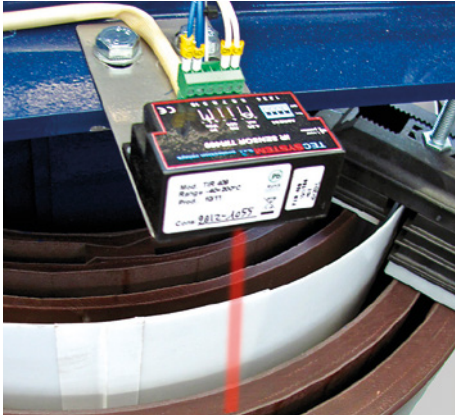


In addition, grounding switches can be mounted on the LV connection side and on the HV connection side of the windings, or on the wall in the course of the HV cable connection.

The grounding or equipotential bonding on the transformer must be properly connected or checked. In this regard the tightening torques of the mounting screws and the minimum cross-sections of the potential equalization conductors must be complied with. The cross-section of the potential equalization conductor must be at least half as large as the protective conductor cross-section of the installation, but no less than 6 mm² copper for mechanical reasons.

Assignment of the minimum cross-sections of protective conductors and neutral conductors to the cross-section of the outer conductors according to VDE 0100-540.

6.2. TEMPERATURE MONITORING



Touchless temperature measuring

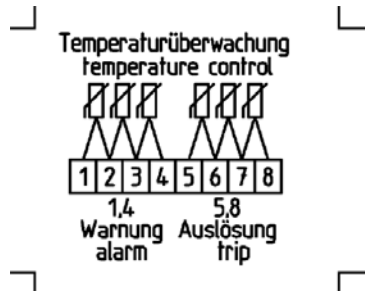
Under certain conditions, any cast resin transformer, just like liquid-filled types, can be overloaded.

The temperature monitoring system limits the overload capacity of cast resin transformers by switching off the transformer at a specified nominal response temperature.

Temperature monitoring by means of PTC sensors (resistors whose resistance value changes rapidly when the response temperature is reached) is generally provided for each cast resin transformer. Sensors are installed in the low-voltage windings and by selecting the appropriate tripping temperatures, the vacuum-encapsulated high-voltage windings are also protected against unacceptably high temperatures, which can occur in the event of overload, inadequate cooling, and high ambient heat.

- On customer request, PT100 and core monitoring by means of PT100 or PTC sensors is also possible.
- Touchless temperature measuring is also available.

As a rule, monitoring takes place in two stages:



Warning

This system signals the overshoot of the temperature that is the basis of normal service life consumption, i.e. continuous rated load at 20°C cooling medium temperature. It is intended to warn the plant operator and motivate the plant operator to implement off-load measures.

Tripping

This second system is adapted to the limit temperature of the declared temperature class. In this case the transformer must be switched off. Operation at excessive temperature shortens the service life. The lines of the three resistors (here 1 sensor per phase) are connected in series to a terminal strip. From this point a two-wire connection is made to the analysis unit, which is supplied loose for free installation in the switchgear.

6.3. ELECTROMAGNETIC COMPATIBILITY (EMC)

Transformers generate electrical and magnetic fields during operation. These electromagnetic fields can reach values for which the Federal Emissions Control Act (BlmSchG) applies.

Limit values of a low-frequency installation with 50 Hz fields at the point of exposure* according to specification 26. BlmSchV:

- 5 kV/m electrical field strength
- 100 μ T magnetic induction

*The place of impact is the place with the highest exposure, where a not just temporary presence of personnel must be expected.

The electric field outside the cast resin transformer and its connections is not very effective outside the transformer cell. The protective enclosure of SGB-SMIT cast resin transformers acts as a Faraday cage. This also applies to a great extent for the ceilings and walls of the transformer cells, provided they are not made of electrical insulation material.

The magnetic stray fields of the transformer, which essentially consist of three sources, can give rise to interference:

- Stray field at idle
- Stray field from the connection lines
- Stray field from current-carrying windings

The idle stray field is negligible. The windings through which the load current flows generate the largest portion of the stray field, which is superimposed by fields of the undervoltage-side arrestors.

The magnetic field around low-voltage connections dominates the level of the entire field.

For connection of the transformer, field compensation through double low-voltage conductor routing with point-symmetrical phase assignment is recommended, if it is required. According to IEC 60076, transformers are considered as passive elements with regard to electromagnetic emissions and immunity and CE marking is not permitted.

According to measurements and calculations, the magnetic field around SGB-SMIT cast resin transformers is considerably below the limit value set by the 26th Ordinance on the Implementation of the Federal Immission Control Act (26th Ordinance of the Federal Republic of Germany).

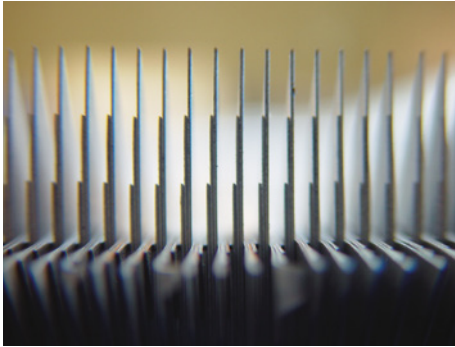
Under defined measuring conditions, the magnetic field of a cast resin transformer, e.g. 630 kVA/20 kVA–0.4 kV, is approx. 5 μ T according to our own measurements at a distance of 2 m from the cast resin surface of the winding.

Technical interference limits for the following are:

- Cardiac pacemakers 50 Hz, 4 – 6 μ T
- Hearing aids 50 Hz, 2 – 20 μ T
- ECG 50 Hz, 0.4 μ T

The 26th BlmSchV applies to „Stationary installations for transformation and transmission of electricity“. It covers in its field of application „Electric substations, including control panels, with a frequency of 50 Hz and a maximum voltage of 1 kV or more“. Since power transformers must be viewed as components of an overall system, i.e. of an appropriate installation, they are excluded from this regulation.

6.4. NOISE



Step lap

Noise is generated by magnetostriction of the core metal sheets. It is mainly dependent on induction in distribution transformers. The reduction of noise emitted into the surrounding air of the transformer is becoming more and more important. SGB-SMIT cast resin transformers are therefore offered both in standard design, according to DIN EN 50588, and with reduced losses and noise.

In addition to the choice of induction and core material, the tapering of columns and yokes in the „step lap“ process has a positive effect on the noise behavior of the transformers.

Sound pressure and sound power levels, and the manner in which the noise measurement must be carried out are specified in DIN EN 60076-10.

The operating noises of the cast resin transformer propagate on site as airborne and structure-borne noise, with different sound reduction measures being applied for each form of sound.

AIRBORNE SOUND

The airborne sound is dependent on:

- Total surface of the transformer room
- Surface of the transformer
- Sound absorption of building materials used

Reduction of airborne noise:

- Reduction of sound reflection by lining the transformer room e.g. with slag wool
- Reduction of sound pressure level outside the transformer room via a thick outer wall
- Continuous reduction of sound pressure level with increasing distance

STRUCTURE-BORNE SOUND

Structure-borne sound is a transmission of noise via the contact surface of the transformer to the floor to walls and other parts of the transformer room.

Reduction of structure-borne noise:

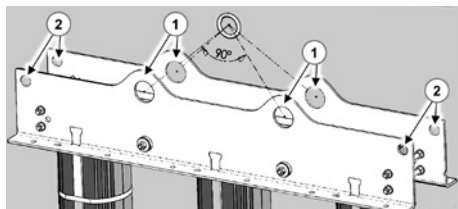
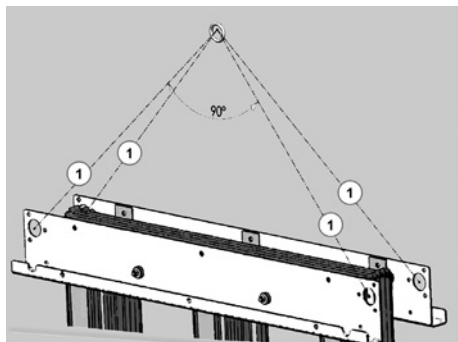
- Expansion straps interposed at the undervoltage connection to protect against structure-borne noise transmission.
- Structure-borne sound insulation for optimizing room insulation, e.g. transformer bearings, machine feet

7. TRANSPORT



7.1. LIFTING LUGS ON THE TRANSFORMER

There are four lifting and lashing lugs on the upper steel clamps.



Lifting lugs and lashing lugs on the upper steel clamp

- 1 Lifting lugs for lifting the transformer
- 2 Lashing lugs

Version 1

The lifting lugs (1) are located at the outer edges of the upper steel clamps.

In this version, the lifting lugs also serve as lashing lugs.

Version 2

For larger transformers it is possible to have lashing lugs and lifting lugs separate from each other. In these cases, the lashing lugs (2) remain on the outer edges of the steel clamps. The lifting lugs (1) are arranged in the middle.

7.2. REQUIREMENTS IMPOSED ON THE TRUCK

Transport vehicles must meet the requirements listed here:

- Technically faultless condition
- Comply with all statutory regulations
- Air suspension
- Closed construction (tarpaulin vehicle)
- Can be loaded from above (it must be possible to temporarily dismantle the superstructure and tarpaulin)
- For each transformer to be transported, use at least four lashing straps (according to DIN EN 12195-2) and four anti-slip mats at least 8 mm thick
- Have a sufficient number of lashing lugs (at least four per transformer)

7.3. LOADING OPTIONS FOR TRANSFORMERS

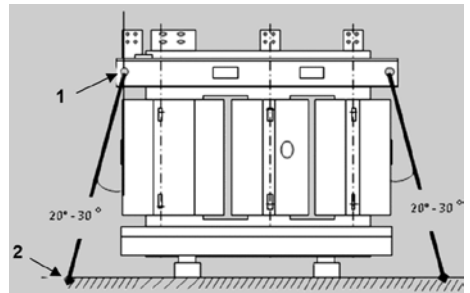
- With crane
- With forklift for special chassis design

7.4. FASTENING THE TRANSFORMER ON THE TRUCK

The load must be positioned and the inertial forces occurring during transport must be contained. When driving, the load is subjected to stresses that act longitudinally (forces from acceleration and braking processes), transversely (forces from cornering) or vertically (forces from driving over uneven ground) in relation to the direction of travel.

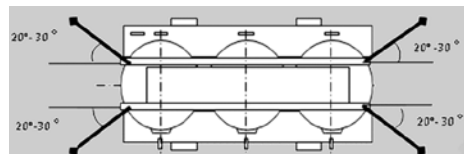
Transformer is fastened with four lashing lugs (accessories of the forwarding company or truck) to four lashing lugs of the upper steel clamps with a tensioning angle of approx. 30 degrees downwards to the existing lashing lugs of the truck.

Select load securing equipment in accordance with DIN EN 12195-2.



Lashing the transformer:

- 1 Lashing lug on the transformer
- 2 Lashing lugs of the truck



8. QUALITY ASSURANCE



INHOUSE TEST FACILITIES

In the standard situation SGB-SMIT cast resin transformers are designed and manufactured according to IEC 60076-11. At SGB-SMIT the tests specified in the standard are carried out in our own modern test facility:

Routine tests

- Testing with applied withstand AC voltage
- Voltage ratio measurement and phase shift control
- Measurement of winding resistance
- Testing with induced withstand AC voltage
- Partial discharge measurement
- Measurement of no-load losses and no-load current
- Measurement of short-circuit impedance and short-circuit losses
- Checking the temperature sensors

Type tests

- Lightning impulse voltage test with Marxgenerator up to 400 kV and 20 kJ charging energy
- Heating measurement





Special tests

Measurement of the harmonic oscillations of the no-load current in % of the fundamental oscillation

- Measurement of the magnetizing characteristic curve
- Measurement of commutation reactance
- Measurement of insulation resistance
- Partial discharge measurement
- Determination of the A-weighted no-load noise level using the sound pressure method
- Determination of the capacities of the windings against earth and between the windings, as well as the loss factors ($\tan \delta$)
- SFRA [Sweep Frequency Response Analysis]
- Measurement of the electrical resonance frequency
- Measurement of structure-borne sound (vibration measurement)

Noise measurement

- The noise measuring chamber has a length of 10 m and a height of 5 m. The basic level is 37 dB(A).

Verification of climate and environmental class

- Test possibility up to climate class C5
- Test possibility up to environment class E4



SGB-SMIT cast resin transformers are supplied to more than 50 countries – the relevant standards in these countries, such as ANSI, IEEE, GOST, etc. are used as a basis for design, manufacture, and testing.

DETAILED TESTS IN EXTERNAL INSTITUTES

Together with external institutes, we can also carry out detailed measurements for important technical areas:

- Fire behavior test (destructive test)
- Dynamic short-circuit test according to IEC and GOST
- Electromagnetic compatibility EMC
- Fire gas analysis or smoldering gas analysis
- Vibration-resistant design

PARTICULARITY

SGB-SMIT is the first transformer manufacturer worldwide with its own test facility for climate classes and environmental classes.

9. CHECKLIST PLANNING

PLANNING MEASURES

(Notes from IEC 60076-11)

Restrict access to transformer to avoid contact with live or hot parts and to limit the presence of persons in the event of a fault.

Dimension the cooling system sufficiently to keep the ambient air temperature below the specified maximum limits.

Observe the degree of pollution of the ambient air of the transformer (possibly provide an enclosure to protect against dust, salt, moisture, etc.).

Ensure the ventilation function of the protective enclosure.

Plan for sufficient protection against transient over-voltages generated by the system or by lightning.

Determine the overcurrent protection and the inherent short-circuit resistance of the transformer.

Comply with other protective measures on the transformer (contacts on temperature indicators, etc.) and during installation (relays, fuses, etc.).

Consider the danger and consequences of fire from the transformer itself or that originates from another location. Take all possible precautions.

Limit noise emissions outside the installation.

Avoid the formation and accumulation of gases.

Ensure protection against emissions from magnetic fields (mainly from cables or outlets) outside the installation by means of shielding elements in the installation or through sufficient distances.

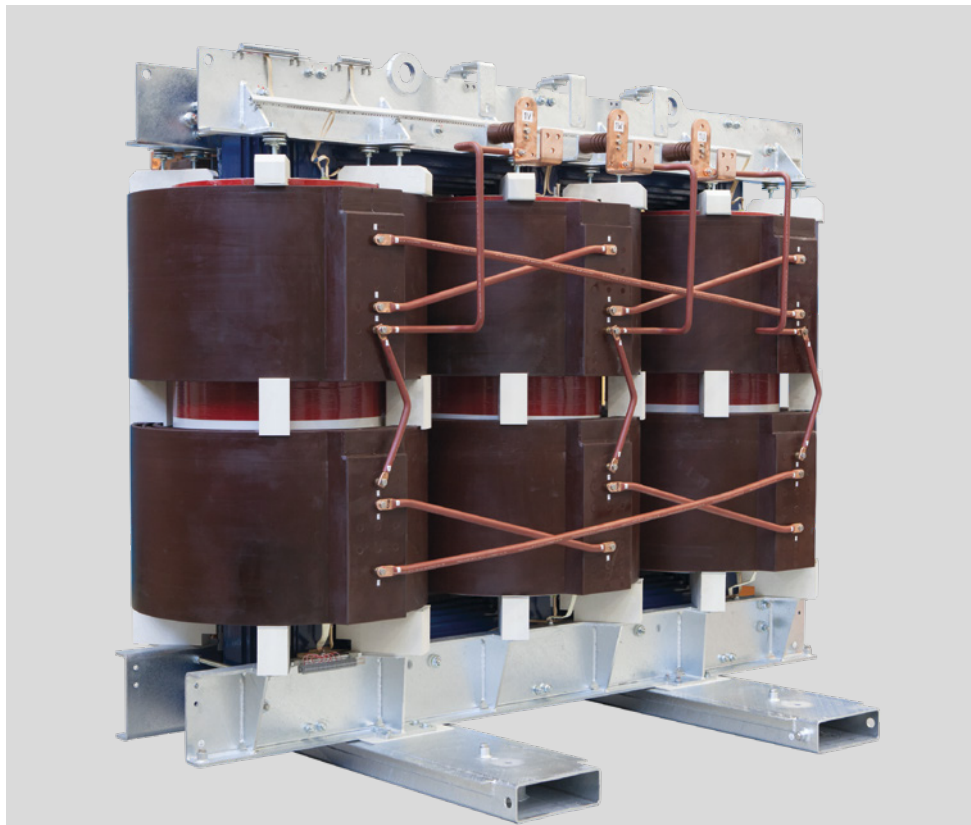
The list is not exhaustive. These are merely proposals.

10. CERTIFICATIONS

SGB not only satisfies the standards regarding production technology and occupational health and safety, but also has high self-imposed standards and takes the challenge also in environmental matters – which is highlighted by awards and certificates issued by various institute



All certificates are renewed on a regular basis



Up to and incl.

25 MVA

POWER

Up to and incl.

36 KV

OPERATING VOLTAGE

Up to

200 KV

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