



Cast-resin Dry-type Transformers, GEAFOLE

Standards and regulations

GEAFOL® cast-resin dry-type transformers comply with IEC recommendation No. 726, CENELEC HD 464, HD 538 and DIN 42 523.

Advantages and applications

GEAFOL distribution and power transformers in ratings from 100 to more than 20 000 kVA and LI values up to 170 kV are full substitutes for oil-immersed transformers with comparable electrical and mechanical data.

GEAFOL transformers are designed for indoor installation close to their point of use at the center of the major consumers.

They only make use of flame-retardant inorganic insulating materials which free these transformers from all restrictions that apply to oil-filled electrical equipment, such as oil-collecting pits, fire walls, fire-extinguishing equipment, etc.

GEAFOL transformers are installed wherever oil-filled units cannot be used: inside buildings, in tunnels, on ships, cranes and offshore platforms, in ground-water catchment areas, in food processing plants, etc. Often they are combined with their primary and secondary switchgear and distribution boards into compact substations that are installed directly at their point of use.

As thyristor-converter transformers for variable speed drives they can be installed together with the converters at the drive

location. This reduces civil works, cable costs, transmission losses, and installation costs.

GEAFOL transformers are fully LI-rated. They have similar noise levels to comparable oil-filled transformers. Taking the above indirect cost reductions into account, they are also frequently cost-competitive. By virtue of their design, GEAFOLE transformers are completely maintenance-free for their lifetime.

GEAFOL transformers have been in successful service since 1965. A lot of licenses have been granted to major manufactures throughout the world since.

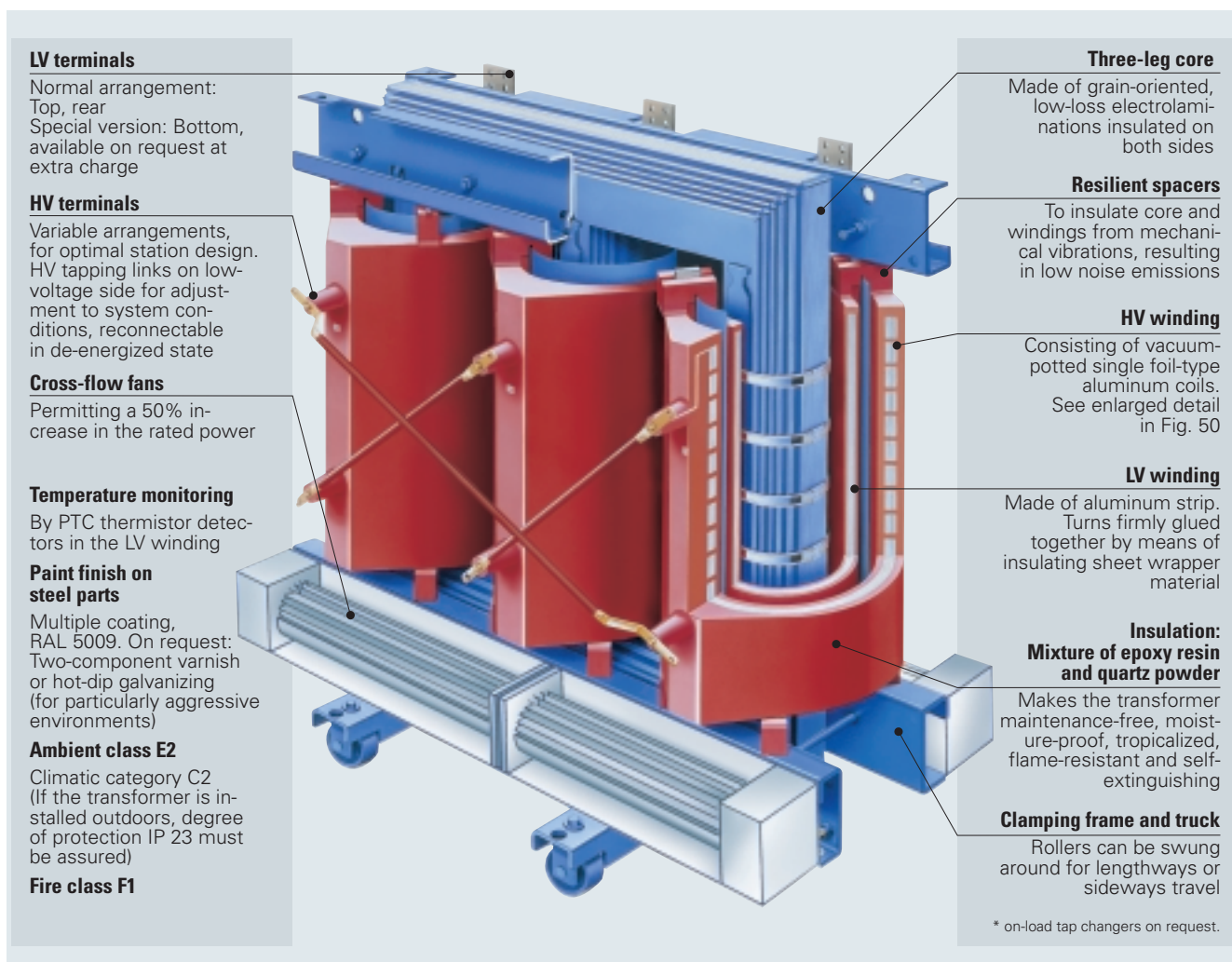


Fig. 49: GEAFOLE cast-resin dry-type transformer

Cast-resin Dry-type Transformers, GEAFOLE

HV winding

The high-voltage windings are wound from aluminum foil, interleaved with high-grade polypropylene insulating foil. The assembled and connected individual coils are placed in a heated mold, and are potted in a vacuum furnace with a mixture of pure silica (quartz sand) and specially blended epoxy resins. The only connections to the outside are copper bushings, which are internally bonded to the aluminum winding connections. The external star or delta connections are made of insulated copper connectors to guarantee an optimal installation design. The resulting high-voltage windings are fire-resistant, moistureproof, corrosion-proof, and show excellent aging properties under all indoor operating conditions. (For outdoor use, specially designed sheet-metal enclosures are available.)

The foil windings combine a simple winding technique with a high degree of electrical safety. The insulation is subjected to less electrical stress than in other types of windings. In a conventional round-wire winding, the interturn voltage can add up to twice the interlayer voltage, while in a foil winding it never exceeds the voltage per turn because a layer consists of only one winding turn. Result: a high AC voltage and impulse-voltage withstand capacity.

Why aluminum? The thermal expansion coefficients of aluminum and cast resin are so similar that thermal stresses resulting from load changes are kept to a minimum (see Fig. 50).

LV winding

The standard low-voltage winding with its considerably reduced dielectric stresses is wound from single aluminum sheets with interleaved cast-resin impregnated fiberglass fabric.

The assembled coils are then oven-cured to form uniformly bonded solid cylinders that are impervious to moisture. Through the single-sheet winding design, excellent dynamic stability under short-circuit conditions is achieved. Connections are submerged-arc-welded to the aluminum sheets and are extended either as aluminum or copper busbars to the secondary terminals.

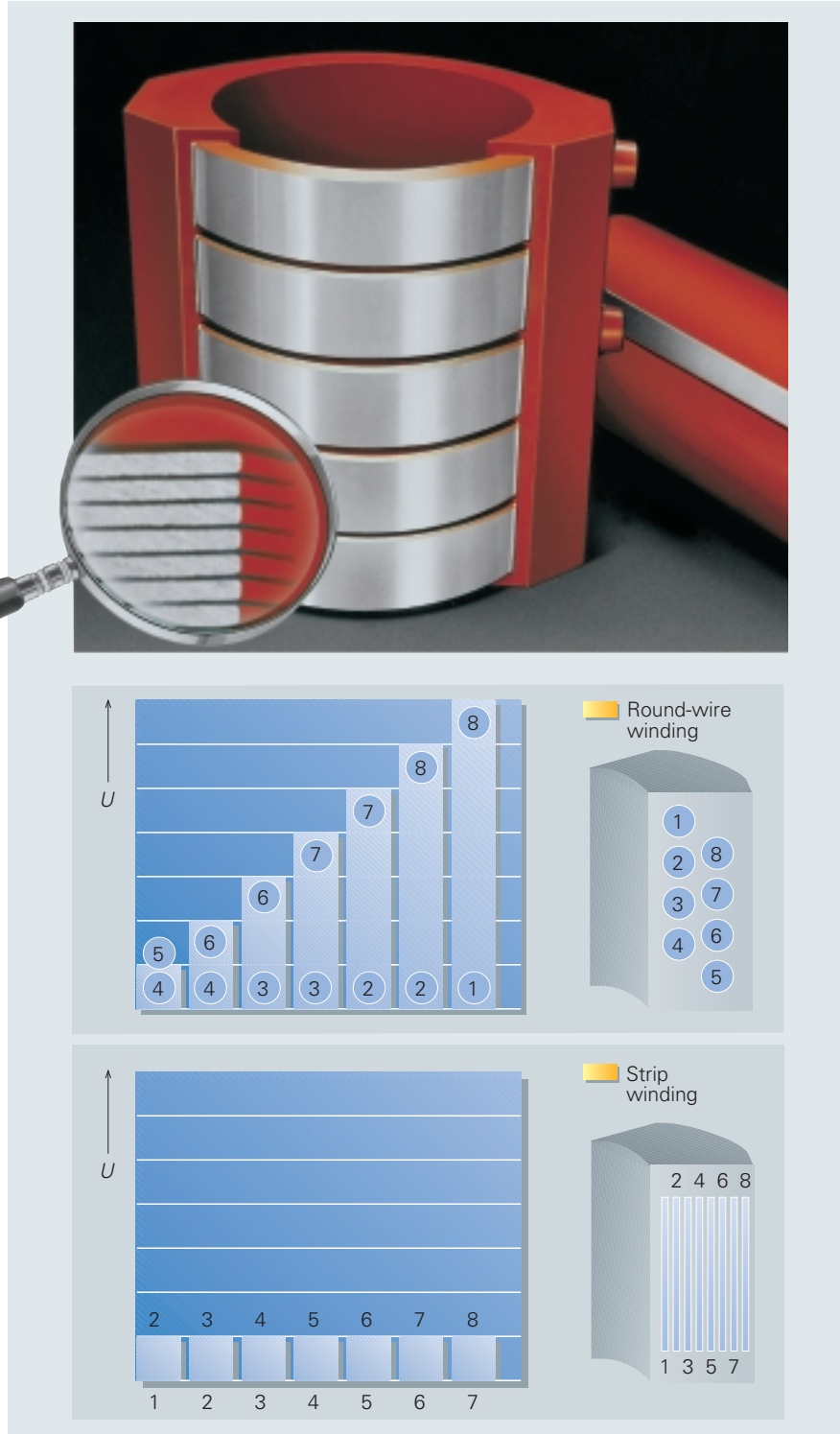


Fig. 50: High-voltage encapsulated winding design of GEAFOLE cast-resin transformer and voltage stress of a conventional round-wire winding (above) and the foil winding (below)



Cast-resin Dry-type Transformers, GEAFOL

Fire safety

GEAFOL transformers use only flame-retardant and self-extinguishing materials in their construction. No additional substances, such as aluminum oxide trihydrate, which could negatively influence the mechanical stability of the cast-resin molding material, are used. Internal arcing from electrical faults and externally applied flames do not cause the transformers to burst or burn. After the source of ignition is removed, the transformer is self-extinguishing. This design has been approved by fire officials in many countries for installation in populated buildings and other structures.

The environmental safety of the combustion residues has been proven in many tests.

Categorization of cast-resin transformers

Dry-type transformers have to be categorized under the sections listed below:

- Environmental category
- Climatic category
- Fire category

These categories have to be shown on the rating plate of each dry-type transformer.

The properties laid down in the standards for ratings within the approximate category relating to environment (humidity), climate and fire behavior have to be demonstrated by means of tests.

These tests are described for the environmental category (code number E0, E1 and E2) and for the climatic category (code number C1, C2) in DIN VDE 0532 Part 6 (corresponding to HD 464). According to this standard, they are to be carried out on complete transformers.

The tests of fire behavior (fire category code numbers F0 and F1) are limited to tests on a duplication of a complete transformer. It consists of a core leg, a low-voltage winding and a high-voltage winding. The specifications for fire category F2 are determined by agreement between the manufacturer and the customer.

Siemens have carried out a lot of tests.

The results for our GEAFOL transformers are something to be proud of:

- Environmental category E2
- Climatic category C2
- Fire category F1

This good behavior is solely due to the GEAFOL cast-resin mix which has been used successfully for decades.

Insulation class and temperature rise

The high-voltage winding and the low-voltage winding utilize class F insulating materials with a mean temperature rise of 100 K (standard design).

Overload capability

GEAFOL transformers can be overloaded permanently up to 50% (with a corresponding increase in impedance voltage) if additional radial cooling fans are installed. (Dimensions increase by approximately 200 mm in length and width.) Short-time overloads are uncritical as long as the maximum winding temperatures are not exceeded for extended periods of time.

Temperature monitoring

Each GEAFOL transformer is fitted with three temperature sensors installed in the LV winding, and a solid-state tripping device with relay output. The PTC thermistors used for sensing are selected for the applicable maximum hot-spot winding temperature. Additional sets of sensors with lower temperature points can be installed for them and for fan control purposes. Additional dial-type thermometers and Pt100 are available, too. For operating voltages of the LV winding of 3.6 kV and higher, special temperature measuring equipment can be provided.

Auxiliary wiring is run in protective conduit and terminated in a central LV terminal box (optional). Each wire and terminal is identified, and a wiring diagram is permanently attached to the inside cover of this terminal box.

Installation and enclosures

Indoor installation in electrical operating rooms or in various sheet-metal enclosures is the preferred method of installation. The transformers need only be protected against access to the terminals or the winding surfaces, against direct sunlight, and against water. Sufficient ventilation must be provided by the installation location or the enclosure. Otherwise forced-air cooling must be specified or provided by others.



Fig. 51: Flammability test of cast-resin transformer

Cast-resin Dry-type Transformers, GEAFOLE

Instead of the standard open terminals, insulated plug-type elbow connectors can be supplied for the high-voltage side with LI ratings up to 170 kV. Primary cables are usually fed to the transformer from trenches below, but can also be connected from above.

Secondary connections can be made by multiple insulated cables, or by busbars, from either below or above. Secondary terminals are either aluminum or copper busbar stubs, drilled to specification.

A variety of indoor and outdoor enclosures in different protection classes are available for the transformers alone, or for indoor compact substations in conjunction with high- and low-voltage switchgear cubicles.

Recycling of GEAFOLE transformers

Of all the GEAFOLE transformers manufactured since 1965, even the oldest units are not about to reach the end of their service life expectancy. In spite of this, a lot of experiences have been made over the years with the recycling of coils that have become unusable due to faulty manufacture or damage. These experiences show that all the metallic components, i.e. approx. 90% of all materials, can be fully recovered economically. The recycling method used by Siemens does not pollute the environment. In view of the value of the secondary raw materials, the procedure can be economical even considering the currently small amounts.



Fig. 52: GEAFOLE transformer with plug-type cable connections



Fig. 53: Radial cooling fans on GEAFOLE transformer for AF cooling



Fig. 54: GEAFOLE transformer in protective housing to IP 20/40



GAEFOL Cast-resin Selection Tables, Technical Data, Dimensions and Weights

- Standard: DIN 42523
- Rated power: 100–20000 kVA*
- Rated frequency: 50 Hz
- HV rating: up to 36 kV
- LV rating: up to 780 V; special designs for up to 12 kV are possible
- Tappings on HV side: $\pm 2.5\%$ or $\pm 2 \times 2.5\%$
- Connection: HV winding: delta
LV winding: star
- Impedance voltage at rated current: 4–8 %
- Insulation class: HV/LV = F/F
- Temperature rise: HV/LV = 100/100 K
- Color of metal parts: RAL 5009 (other colors are available)

U_m [kV]	LJ [kV]	AC [kV]
1.1	–	3
12	75	28
24	95**	50
36	145**	70

* power rating > 2.5 MVA upon request
** other levels upon request

Fig. 55: Insulation level

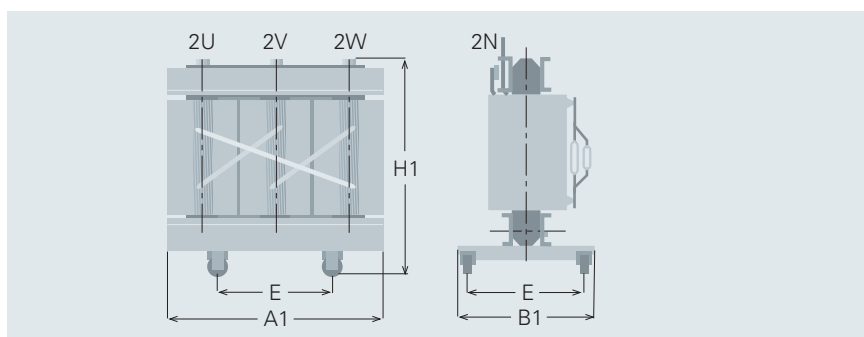


Fig. 56: GAEFOL cast-resin transformer

Rated power	Rated voltage	Impedance voltage	Type	No-load losses	Load losses	Load losses	Sound press. level 1 m tolerance + 3 dB	Sound power level	Total weight	Dimensions			Distance between wheel centers
										Length	Width	Height	
S_n [kVA]	U_m [kV]	U_2 [%]	4GB...	P_0 [W]	$P_k 75^*$ [W]	$P_k 120^{**}$ [W]	L_{PA} [dB]	L_{WA} [dB]	GGES [kg]	A1 [mm]	B1 [mm]	H1 [mm]	E [mm]
100	12	4	.5044-3CA	440	1600	1900	45	59	630	1210	705	835	without wheels
			.5044-3GA	320	1600	1900	37	51	760	1230	710	890	without wheels
		6	.5044-3DA	360	2000	2300	45	59	590	1190	705	860	without wheels
			.5044-3HA	300	2000	2300	37	51	660	1230	710	855	without wheels
	24	4	.5064-3CA	600	1500	1750	45	59	750	1310	755	935	without wheels
			.5064-3GA	400	1500	1750	37	51	830	1300	755	940	without wheels
		6	.5064-3DA	420	1800	2050	45	59	660	1250	750	915	without wheels
			.5064-3HA	330	1800	2050	37	51	770	1300	755	930	without wheels
160	12	4	.5244-3CA	610	2300	2600	47	62	770	1220	710	1040	520
			.5244-3GA	440	2300	2600	39	54	920	1290	720	1050	520
		6	.5244-3DA	500	2300	2700	47	62	750	1270	720	990	520
			.5244-3HA	400	2300	2700	39	54	850	1300	725	985	520
	24	4	.5264-3CA	800	2200	2500	47	62	910	1330	725	1090	520
			.5264-3GA	580	2200	2500	39	54	940	1310	720	1095	520
		6	.5264-3DA	600	2500	2900	47	62	820	1310	725	1075	520
			.5264-3HA	480	2500	2900	39	54	900	1350	765	1060	520

Dimensions and weights are approximate values and valid for 400 V on the secondary side, vector-group can be Dyn 5 or Dyn 11.

Rated power figures in parentheses are not standardized.

* In case of short-circuits at 75 °C
** In case of short-circuits at 120 °C

Fig. 57: GAEFOL cast-resin transformers 50 to 2500 kVA

GFAFOL Cast-resin Selection Tables, Technical Data, Dimensions and Weights

Rated power	Rated voltage	Impe- dance voltage	Type	No-load losses	Load losses	Load losses	Sound press. level 1 m toler- ance + 3 dB	Sound power level	Total weight	Dimensions			Distance between wheel centers
										Length	Width	Height	
S_n [kVA]	U_n [kV]	U_2 [%]	4GB...	P_0 [W]	P_k 75* [W]	P_k 120** [W]	L_{PA} [dB]	L_{WA} [dB]	GGES [kg]	A1 [mm]	B1 [mm]	H1 [mm]	E [mm]
250	12	4	.5444-3CA	820	3000	3500	50	65	1040	1330	730	1110	520
		4	.5444-3GA	600	3000	3400	42	57	1170	1330	730	1135	520
		6	.5444-3DA	700	2900	3300	50	65	990	1350	740	1065	520
		6	.5444-3HA	570	2900	3300	42	57	1120	1390	745	1090	520
	24	4	.5464-3CA	1050	2900	3300	50	65	1190	1390	735	1120	520
		4	.5464-3GA	800	2900	3300	41	57	1230	1400	735	1150	520
		6	.5464-3DA	880	3100	3600	50	65	990	1360	735	1140	520
		6	.5464-3HA	650	3100	3600	41	57	1180	1430	745	1160	520
	36	6	.5475-3DA	1300	3800	4370	50	65	1700	1900	900	1350	520
	(315)	12	4	.5544-3CA	980	3300	3800	52	67	1160	1370	820	1125
4			.5544-3GA	720	3300	3800	43	59	1320	1380	820	1195	670
6			.5544-3DA	850	3400	3900	51	67	1150	1380	830	1140	670
6			.5544-3HA	680	3400	3900	43	59	1290	1410	830	1165	670
24		4	.5564-3CA	1250	3400	3900	51	67	1250	1410	820	1195	670
		4	.5564-3GA	930	3400	3900	43	59	1400	1440	825	1205	670
		6	.5564-3DA	1000	3600	4100	51	67	1190	1410	825	1185	670
		6	.5564-3HA	780	3600	4100	43	59	1300	1460	830	1195	670
36		6	.5575-3DA	1450	4500	5170	51	67	1900	1950	920	1400	670
400		12	4	.5644-3CA	1150	4300	4900	52	68	1310	1380	820	1265
	4		.5644-3GA	880	4300	4900	44	60	1430	1380	820	1290	670
	6		.5644-3DA	1000	4300	4900	52	68	1250	1410	825	1195	670
	6		.5644-3HA	820	4300	4900	44	60	1350	1430	830	1195	670
	24	4	.5664-3CA	1450	3900	4500	52	68	1410	1440	825	1280	670
		4	.5664-3GA	1100	3900	4500	44	60	1570	1460	830	1280	670
		6	.5664-3DA	1200	4100	4700	52	68	1350	1480	835	1275	670
		6	.5664-3HA	940	4100	4700	44	60	1460	1480	835	1280	670
	36	6	.5675-3DA	1700	5100	5860	52	68	2100	2000	920	1440	670
	(500)	12	4	.5744-3CA	1350	4900	5600	53	69	1520	1410	830	1320
4			.5744-3GA	1000	4900	5600	45	61	1740	1450	835	1345	670
6			.5744-3DA	1200	5600	6400	53	69	1470	1460	845	1275	670
6			.5744-3HA	980	5600	6400	45	61	1620	1490	845	1290	670
24		4	.5764-3CA	1700	4800	5500	53	69	1620	1500	835	1330	670
		4	.5764-3GA	1270	4800	5500	44	61	1830	1540	840	1350	670
		6	.5764-3DA	1400	5000	5700	53	69	1580	1540	850	1305	670
		6	.5764-3HA	1100	5000	5700	45	61	1720	1560	850	1320	670
36		6	.5775-3DA	1900	6000	6900	53	69	2600	2050	940	1500	670

Dimensions and weights are approximate values and valid for 400 V on the secondary side, vector-group can be Dyn 5 or Dyn 11.

Rated power figures in parentheses are not standardized.

* In case of short-circuits at 75 °C
 ** In case of short-circuits at 120 °C

Fig. 58: GFAFOL cast-resin transformers 50 to 2500 kVA



GFAFOL Cast-resin Selection Tables, Technical Data, Dimensions and Weights

Rated power	Rated voltage	Impedance voltage	Type	No-load losses	Load losses	Load losses	Sound press. level 1 m tolerance + 3 dB	Sound power level	Total weight	Dimensions			Distance between wheel centers
										Length	Width	Height	
S_n [kVA]	U_m [kV]	U_2 [%]	4GB...	P_0 [W]	$P_k 75^*$ [W]	$P_k 120^{**}$ [W]	L_{PA} [dB]	L_{WA} [dB]	GGES [kg]	A1 [mm]	B1 [mm]	H1 [mm]	E [mm]
630	12	4	.5844-3CA	1500	6400	7300	54	70	1830	1510	840	1345	670
		4	.5844-3GA	1150	6400	7300	45	62	2070	1470	835	1505	670
		6	.5844-3DA	1370	6400	7400	54	70	1770	1550	860	1295	670
		6	.5844-3HA	1150	6400	7400	45	62	1990	1590	865	1310	670
	24	4	.5864-3CA	1950	6000	6900	53	70	1860	1550	845	1380	670
		4	.5864-3GA	1500	6000	6900	45	62	2100	1600	850	1400	670
		6	.5864-3DA	1650	6400	7300	53	70	1810	1580	855	1345	670
		6	.5864-3HA	1250	6400	7300	45	62	2050	1620	860	1370	670
36	6	.5875-3DA	2200	7000	8000	53	70	2900	2070	940	1650	670	
	(800)												
	12	4	.5944-3CA	1850	7800	9000	55	72	2080	1570	850	1560	670
		4	.5944-3GA	1450	7800	9000	47	64	2430	1590	855	1640	670
6		.5944-3DA	1700	7600	8700	55	72	2060	1560	865	1490	670	
6		.5944-3HA	1350	7600	8700	47	64	2330	1600	870	1530	670	
24	4	.5964-3CA	2100	7500	8600	55	72	2150	1610	845	1580	670	
	4	.5964-3GA	1600	7500	8600	47	64	2550	1650	855	1620	670	
	6	.5964-3DA	1900	7900	9100	55	71	2110	1610	860	1590	670	
	6	.5964-3HA	1450	7900	9100	47	64	2390	1630	865	1595	670	
36	6	.5975-3DA	2600	8200	9400	55	72	3300	2140	950	1850	670	
	1000												
	12	4	.6044-3CA	2200	8900	10200	55	73	2480	1590	990	1775	820
		4	.6044-3GA	1650	8900	10200	47	65	2850	1620	990	1795	820
6		.6044-3DA	2000	8500	9700	56	73	2420	1620	990	1560	820	
6		.6044-3HA	1500	8500	9700	47	65	2750	1660	990	1560	820	
24	4	.6064-3CA	2400	8700	10000	55	73	2570	1660	990	1730	820	
	4	.6064-3GA	1850	8700	10000	47	65	3060	1680	990	1815	820	
	6	.6064-3DA	2300	9200	10500	55	73	2510	1680	990	1620	820	
	6	.6064-3HA	1750	9600	11000	47	65	2910	1730	990	1645	820	
36	6	.6075-3DA	3000	9500	10900	55	73	3900	2200	1050	1900	820	
	(1250)												
	12	6	.6144-3DA	2400	9600	11000	57	75	2900	1780	990	1605	820
		6	.6144-3HA	1850	10500	12000	49	67	3370	1790	990	1705	820
24	6	.6164-3DA	2700	10000	11500	57	75	3020	1820	990	1635	820	
	6	.6164-3HA	2100	10500	12000	49	67	3490	1850	990	1675	820	
36	6	.6175-3DA	3500	11000	12600	57	75	4500	2300	1060	2000	520	

Dimensions and weights are approximate values and valid for 400 V on the secondary side, vector-group can be Dyn 5 or Dyn 11.

Rated power figures in parentheses are not standardized.

* In case of short-circuits at 75 °C

** In case of short-circuits at 120 °C

Fig. 59: GFAFOL cast-resin transformers 50 to 2500 kVA

GFAFOL Cast-resin Selection Tables, Technical Data, Dimensions and Weights

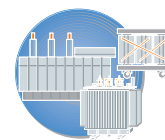
Rated power	Rated voltage	Impe- dance voltage	Type	No-load losses	Load losses	Load losses	Sound press. level 1 m toler- ance + 3 dB	Sound power level	Total weight	Dimensions			Distance between wheel centers
										Length	Width	Height	
S_n [kVA]	U_m [kV]	U_2 [%]	4GB...	P_0 [W]	P_k 75* [W]	P_k 120** [W]	L_{PA} [dB]	L_{WA} [dB]	GGES [kg]	A1 [mm]	B1 [mm]	H1 [mm]	E [mm]
1600	12	6	.6244-3DA	2800	11000	12500	58	76	3550	1840	995	2025	1070
	6	6	.6244-3HA	2100	11400	13000	50	68	4170	1880	1005	2065	1070
	24	6	.6264-3DA	3100	11800	13500	58	76	3640	1880	995	2035	1070
	6	6	.6264-3HA	2400	12300	14000	49	68	4080	1900	1005	2035	1070
	36	6	.6275-3DA	4300	12700	14600	58	76	5600	2500	1100	2400	1070
(2000)	12	6	.6344-3DA	3600	14000	16000	59	78	4380	1950	1280	2150	1070
	6	6	.6344-3HA	2650	14500	16500	51	70	5140	1990	1280	2205	1070
	24	6	.6364-3DA	4000	14500	16500	59	78	4410	2020	1280	2160	1070
	6	6	.6364-3HA	3000	14900	17000	51	70	4920	2040	1280	2180	1070
	36	6	.6375-3DA	5100	15400	17700	59	78	6300	2500	1280	2400	1070
2500	12	6	.6444-3DA	4300	17600	20000	62	81	5130	2110	1280	2150	1070
	6	6	.6444-3HA	3000	18400	21000	51	71	6230	2170	1280	2205	1070
	24	6	.6464-3DA	5000	17600	20000	61	81	5280	2170	1280	2160	1070
	6	6	.6464-3HA	3600	18000	20500	51	71	6220	2220	1280	2180	1070
	36	6	.6475-3DA	6400	18700	21500	61	81	7900	2700	1280	2400	1070

Dimensions and weights are approximate values and valid for 400 V on the secondary side, vector-group can be Dyn 5 or Dyn 11.

Rated power figures in parentheses are not standardized.

* In case of short-circuits at 75 °C
 ** In case of short-circuits at 120 °C
 Rated power >2500 kVA to 20 MVA on request.

Fig. 60: GFAFOL cast-resin transformers 50 to 2500 kVA



Special Transformers

GEAFOL cast-resin transformers with oil-free tap-changers

The voltage-regulating cast-resin transformers connected on the load side of the medium-voltage power supply system feed the plant-side distribution transformers. The tap-changer-controlled transformers used in these medium-voltage systems need to have appropriately high ratings. Siemens offers suitable transformers in its GEAFOL design which has proved successful over many years and is available in ratings of up to 20 MVA. With forced cooling it is even possible to increase the power ratings still further by 40%. The range of rated voltage extends to 36 kV and the maximum impulse voltage is 200 kV. The main applications of this type of transformer are in modern industrial plants, hospitals, office and apartment blocks and shopping centers.

Linking single-pole tap-changer modules together in threes by means of insulating shafts produces a triple-pole tap-changer in either star or delta connection for regulating the output voltage of GEAFOL transformers. In its nine operating positions, this type of tap-changer has a rated through-current of 500 A and a rated voltage of 900 V per step. This allows voltage fluctuations of up to 8100 V to be kept under control. However, the maximum control range utilizes only 20% of the rated voltage.



Fig. 61: 16/22-MVA GEAFOL cast-resin transformer with oil-free on-load tap changer

Special Transformers

Transformers for thyristor converters

These are special oil-immersed or cast-resin power transformers that are designed for the special demands of thyristor converter or diode rectifier operation. The effects of such conversion equipment on transformers and additional construction requirements are as follows:

- Increased load by harmonic currents
- Balancing of phase currents in multiple winding systems (e.g. 12-pulse systems)
- Overload factor up to 2.5
- Types for 12-pulse systems, if required.

Siemens supplies oil-filled converter transformers of all ratings and configurations known today, and dry-type cast-resin converter transformers up to more than 20 MVA and 200 kV LI.

To define and quote for such transformers, it is necessary to know considerable details on the converter to be supplied and on the line feeding it. These transformers are almost exclusively inquired together with the respective drive or rectifier system and are always custom-engineered for the given application.

Neutral grounding transformers

When a neutral grounding reactor or ground-fault neutralizer is required in a three-phase system and no suitable neutral is available, a neutral must be provided by using a neutral grounding transformer.

Neutral grounding transformers are available for continuous operation or short-time operation.

The zero impedance is normally low. The standard vector groups are zigzag or wye/delta. Some other vector groups are also possible.

Neutral grounding transformers can be built by Siemens in all common power ratings.

Normally, the neutral grounding transformers are built in oil-immersed design, however, they can also be built in cast-resin design.



Fig. 62: Dry-type converter transformer GEAFOLE

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