



ECODESIGN OF
OIL-FILLED TRANSFORMERS
DRY-TYPE AND CAST RESIN INSULATED TRANSFORMER

ELETRAFO SRL
TRASFORMATORI ELETTRICI

THE COMPANY

ELETRAFO was born as a company specialized in the repair of mineral oil-filled transformers.

The production facility is situated in Mesero, within the province of Milan; the establishment is owned and encompasses an area of approximately 800 square meters.

Over the years, in addition to repairs, the company has been able to manage an in-house production of **oil-filled, resin-filled, and dry-type transformers in Class H**. This has been achieved through internal design, utilization of our own technicians, and specialized workforce.

Our production range for oil transformers varies from 20 KVA to 7 MVA, with a class up to 36 KV. As for resin transformers, we offer products with a power ranging from 30 KVA to 1250 KVA, with a class of 24 KV

In a short period, the company has been able to expand its customer base thanks to the offered products, which are of excellent quality, high reliability, and provide an outstanding quality-to-price ratio.

It has successfully developed its sales network both on a national and European level.

ELETRAFO is capable of meeting the needs of every type of clientele through repairs, maintenance, and supplies of any kind of transformer, **both oil-filled and dry-type**, as well as resin-insulated.

It is also able to supply new machines for replacements having the same characteristics and overall dimensions of the transformers to be replaced.

All *transformers* undergo inspections during production and are tested in a testing facility equipped with state-of-the-art equipment, where the corresponding test certificate is issued in compliance with **CEI-IEC 60076 standards**

The company is in constant evolution and is committed to providing its customers with the best possible products and services. To this end, it has obtained **ISO 9001 and ISO 14001 certifications**, which attest to the high level of quality and sustainability of its production processes

Furthermore, **the company** has refined its **studies and designs** on transformers to meet the specific needs of **transformers immersed in mineral oil baths, transformers for converters, traction transformers, and induction furnace transformers**

Through this commitment, the company is proficient in presenting its clientele a comprehensive selection of premium transformers, crafted utilizing finest-grade materials and components. Additionally, the products adhere to the most current safety and environmental regulations. Consequently, the company emerges as a dependable and qualified partner for all enterprises seeking top-tier transformer solutions.



PRODUCTION OF OIL TRANSFORMERS

BUILDING CRITERIA

MAGNETIC CIRCUIT

The cores of our transformers are constructed using cold-rolled grain-oriented laminations, which have a low value of specific losses. This indicates that they are more energy-efficient and generate less heat from an energy perspective.

The cores are also designed to have minimal residual flux, reduced insertion current, and low noise levels.

The insulation between the laminations is achieved using carlyte, an inorganic oxide that is entirely insensitive to high temperatures. This implies that our transformers can operate under elevated temperature conditions without degradation of the insulation.

The material utilized for the cores is of high quality and is meticulously handled and assembled to minimize air gaps. This indicates that our transformers are more reliable and have a longer lifespan.

The meticulous assembly and subsequent core pressing ensure a minimal rate of vibrations and, consequently, a significant reduction in noise levels. This makes our transformers quieter and more comfortable to use.

In conclusion, our transformers are crafted using high-quality materials and components, designed to ensure high energy efficiency, low noise levels, and long-lasting durability.

WINDINGS

The windings of our transformers are constructed **using high-conductivity electrolytic aluminum or copper conductors, insulated with pure cellulose paper or Class 2 enamel.** The types typically manufactured include **layer, helical, or foil windings.**

For medium voltages, layer-type windings are employed, designed and constructed to ensure a uniform distribution of stresses originating from atmospheric or system conditions. This ensures greater reliability and longevity of the transformers.

For low voltages, helical or foil-type windings are employed, designed to ensure excellent resistance to short-circuit stresses. This guarantees increased safety of the transformers in case of unforeseen electrical events.

The axial channels between the layers of windings ensure excellent and uniform circulation of oil for cooling. This guarantees that the transformers operate efficiently and safely even under high load conditions.

The maximum symmetry of any tap connections prevents dangerous current imbalances, eliminating troublesome electrodynamic stresses in case of a short circuit. This ensures the utmost reliability and safety of the transformers.



TANK

The transformer tank is made of sheet steel of adequate thickness to withstand mechanical stress.

The bottom of the tank is equipped with slides or wheels to facilitate handling.

The cover is secured to the enclosure with bolts arranged around the entire perimeter.

The seal between the cover and the enclosure is achieved with a gasket that prevents oil leakage.

The transformer cooling is achieved through waves or radiators placed on the sides of the enclosure.

All the metal parts of the transformer are treated and painted with European standards -approved paints.

This treatment protects the metal parts from atmospheric agents such as rain, snow, sunlight, and wind, thus increasing their lifespan over time



INSULATING COOLING OIL

The insulating oils normally used are:

- ❖ **Mineral Oil:** This type of oil is obtained through fractional distillation of crude oil. It is an excellent electrical insulator and does not contain PCB, inorganic acids, alkalis, dissolved sulfur, asphaltic products, vegetable or animal oils, or other impurities. It is classified as **Type A.A.** according to **IEC standards**
- ❖ **Tras24 Oil:** This type of oil (modified ester) has excellent insulating properties and the particular characteristic of extinguishing and not propagating flames
- ❖ **Vegetable Oil 7426:** This type of oil (natural ester) is a dielectric fluid based on vegetable oils and is not classified as hazardous according to Regulation **(EC) 1272/2008 (CLP)**. It is a biodegradable product and is not classified as environmentally toxic.

Each type of insulating oil has its own unique characteristics and properties. The choice of the type of oil to use depends on various factors, such as the type of transformer, operating conditions, and applicable regulations.



STANDARD COMPONENTS

The standard components present in our transformers are:



Porcelain bushing (LV) or busbars



Sliding wheels



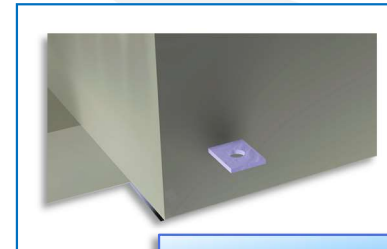
Filling plug for transformers with conservator



Porcelain bushing (HV) or plug-in connectors



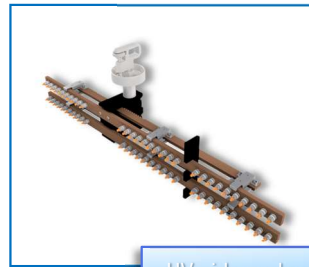
Oil drain valve



Stainless steel grounding sockets



Rating Plate



HV side no load tap changer operated with transformer out of voltage

COMPONENTS ON REQUEST

Our products are available with a variety of optional accessories, including:



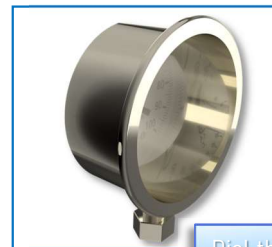
DGPT 2 or DMCR



Box LV - HV



Relais Buchholz



Dial thermometer with two electrical contacts

In addition to the choice of components on request, our customers can also request other specific customizations

REFERENCE STANDARDS FOR OIL TRANSFORMERS



Regulations	Scope of application
CEI 14.4	Mineral oil transformers, from 50 kVA to 2500 kVA, with maximum component voltage not exceeding 36 kV
IEC 60076-1	Power transformers, Part 1: General requirements
EN 50464-1	Three-phase oil-immersed distribution transformers at 50 Hz, from 50 kVA to 2500 kVA with maximum component voltage not exceeding 36 kV
IEC 61378-1	Power transformers, Part 1: General safety requirements
EN 50216	Power transformers, Part 1: General safety requirements
ISO 9001:2015	Quality Management Systems
ISO 14001:2015	Environmental management systems
ANSI C57.12.00	Power transformers, Part 1: General requirements
IEEE Std C57.12.00	Trasformatori di potenza, parte 1: Prescrizioni generali
CEI EN 50588-1:2015	Medium power transformers at 50Hz, with maximum voltage for non-operating equipment above 36 kV - Part 1: General requirements;
EN 548/2014	Medium power transformers, with a frequency of 50 Hz and with a maximum voltage per component not exceeding 36 kV.

**ECO-FRIENDLY DESIGN
REQUIREMENTS FOR OIL
TRANSFORMERS.**



Power Rating (kVA)	Phase 2 (from 1 July 2021)	
	Maximum losses under load P_k (W)	Maximum no-load losses P_0 (W)
≤ 25	A_k (600)	$A_0 - 10\%$ (63)
50	A_k (750)	$A_0 - 10\%$ (81)
100	A_k (1250)	$A_0 - 10\%$ (130)
160	A_k (1750)	$A_0 - 10\%$ (189)
250	A_k (2350)	$A_0 - 10\%$ (270)
315	A_k (2800)	$A_0 - 10\%$ (324)
400	A_k (3250)	$A_0 - 10\%$ (387)
500	A_k (3900)	$A_0 - 10\%$ (459)
630	A_k (4600)	$A_0 - 10\%$ (540)
800	A_k (6000)	$A_0 - 10\%$ (585)
1000	A_k (7600)	$A_0 - 10\%$ (693)
1250	A_k (9500)	$A_0 - 10\%$ (855)
1600	A_k (12000)	$A_0 - 10\%$ (1080)
2000	A_k (15000)	$A_0 - 10\%$ (1305)
2500	A_k (18500)	$A_0 - 10\%$ (1575)
3150	A_k (23000)	$A_0 - 10\%$ (1980)

TEST

Our transformers are subjected to rigorous tests to ensure their quality and safety. The tests are carried out in accordance with **CEI and IEC** standards and include the following tests:

ACCEPTANCE TEST	REGULATIONS
<ul style="list-style-type: none"> ▪ Measurement of winding resistance ▪ Measurement of transformation ratio ▪ Vector group verification ▪ Measurement of short-circuit impedance and load losses ▪ Measurement of no-load losses and current ▪ Dielectric acceptance tests ▪ Insulation test and functional verification of accessories ▪ Insulation test on auxiliary circuits ▪ Overpressure sealing test of the tank ▪ Verification of insulation of the structure and core for transformers immersed in insulating liquid 	<p><u>IEC 60076</u></p>
TYPE TESTS (ON REQUEST)	REGULATIONS
<ul style="list-style-type: none"> • Heating test • Type dielectric tests • Impulse withstand tests • Measurement of no-load losses and current at 90% and 110% of rated voltage 	<p><u>IEC 60076</u></p>
SPECIAL TESTS (ON REQUEST)	REGULATIONS
<ul style="list-style-type: none"> • Determination of noise levels • Special dielectric tests (IEC 60076-3) • Measurement of the dissipation factor ($\tan \delta$) of the insulation system capacitance • Measurement of homopolar impedances of three-phase transformers • Short-circuit withstand test • Measurement of insulation resistance between windings and ground, and between windings • Measurement of frequency response (Frequency Response Analysis or FRA) • External coating inspection (ISO 2178 and ISO 2409 or as per specification) • Measurement of dissolved gases in the dielectric liquid 	<p><u>IEC 60076</u></p>

The test results are recorded and stored in a dedicated register. The register is used to monitor the quality of transformers and to identify any issues that may arise in the future.

We are proud to offer our customers high-quality and reliable transformers. Our transformers are designed to stand the test of time and meet the most demanding requirements.

RESIN-TRANSFORMER PRODUCTION

MAGNETIC CIRCUIT

The cores of our transformers are constructed using cold-rolled grain-oriented laminations, which have a low value of specific losses. This indicates that they are more energy-efficient and generate less heat from an energy perspective. The cores are also designed to have minimal residual flux, reduced insertion current, and low noise levels.

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WINDINGS

LOW VOLTAGE WINDING

Low-voltage (LV) windings are made of aluminum or copper foil, which is insulated with Class F or H materials.

The insulating materials are designed to withstand high temperatures and mechanical stresses generated by short circuits. Class F is the most common insulation class for LV windings, while Class H is used for LV windings that must operate at higher temperatures.

LV windings are protected by a Class H varnish, which is oven-cured. The varnish forms a compact mass that makes the winding resistant to radial stresses from short circuits. This reduces additional losses generated by short circuits. Axial stresses are very low due to the single-foil conductor. The single foil is more resistant to axial stresses compared to wire-wound, which is the most common conductor type in high-voltage windings.

MEDIUM VOLTAGE WINDING

Medium-voltage (MV) windings are made with aluminum or copper tape or wire, which is insulated with interleaved polyester film. The thermal expansion coefficient of aluminum is similar to that of the resin used to encapsulate the coils. This allows the structure to respond uniformly to temperature variations, thereby avoiding dangerous stresses that could damage the transformer over time. The different layers of the winding are stacked and connected in series, forming a phase coil.

This coil is then encapsulated in resin, providing additional insulation and protection. Finally, the coil undergoes an insulation test to verify the absence of partial discharges, which could damage the winding over time.

CONSTRUCTION CRITERIA




CLASS
ENVIRONMENTAL
(E3)


CLIMATIC
CLASS
(C2)


FIRE BEHAVIOR CLASS
(F1)

RESIN COMPONENTS

Our products are available with a variety of optional accessories, including:



VENTILATION BARS



CONTROL UNIT MT 200



PT 100 PROBE CASSETTE



CONTAINMENT BOX

In addition to the choice of components on request, our customers can also request other specific customizations

REFERENCE STANDARDS FOR RESIN TRANSFORMERS



Regulations	Scope of application
CEI EN 60076-1	Power transformers. Generality
CEI EN 60076-3	Power Transformers - Part 3: Insulation Levels, Dielectric Tests and Insulation Distances in Air
CEI EN 60076-5	Three-phase oil-immersed distribution transformers at 50 Hz, from 50 kVA to 2500 kVA with maximum component voltage not exceeding 36 kV
CEI EN 60076-6	Power Transformers - Part 6: Reactors
CEI EN 60076-8	Power Transformers - Part 8: Application Guide
CEI EN 60076-10-1	Power Transformers - Part 10-1: Determination of Noise Levels - Application Guide;
CEI EN 60076-11	Power transformers - Part 11: Dry-type transformers;
CEI EN 60076-12	Power Transformers - Part 12: Load Guide for Dry-Type Power Transformers ;
CEI EN TS 60076-19	Power transformers - Part 19: Rules for determining uncertainties in the measurement of losses of power transformers and reactors
CEI EN TR 60616	Marking of power transformer terminals;
CEI EN 61378-1	Conversion transformers - Part 1: Transformers for industrial applications;
CEI EN 61378-3	Conversion Transformers - Part 3: Application Guide;
CEI EN 62032	Application Guide, Specifications and Tests of Phase Shift Transformers;
CEI EN 60529	Enclosure Protection Ratings (IP Code)
CEI EN 60068-3-3	Fundamental Climatic and Mechanical Tests - Part 3-3: Guide - Seismic Test Methods for Equipment;
CEI EN 50588-1:2015	Medium power transformers at 50Hz, with a maximum voltage for the equipment not exceeding 36 kV - Part 1: General requirements;

**ECO-FRIENDLY DESIGN
REQUIREMENTS FOR RESIN
TRANSFORMERS.**



Power Rating(kVA)	Phase 2 (from 1 July 2021)	
	Maximum losses under load P_k (W)	Maximum no-load losses P_0 (W)
≤ 50	A_k (1500)	$A_0 - 10\%$ (180)
100	A_k (1800)	$A_0 - 10\%$ (252)
160	A_k (2600)	$A_0 - 10\%$ (360)
250	A_k (3400)	$A_0 - 10\%$ (468)
400	A_k (4500)	$A_0 - 10\%$ (675)
630	A_k (7100)	$A_0 - 10\%$ (990)
800	A_k (8000)	$A_0 - 10\%$ (1170)
1000	A_k (9000)	$A_0 - 10\%$ (1395)
1250	A_k (11000)	$A_0 - 10\%$ (1620)
1600	A_k (13000)	$A_0 - 10\%$ (1980)
2000	A_k (16000)	$A_0 - 10\%$ (2340)
2500	A_k (19000)	$A_0 - 10\%$ (2790)
3150	A_k (22000)	$A_0 - 10\%$ (3420)

TEST

Our transformers are subjected to rigorous tests to ensure their quality and safety. The tests are carried out in accordance with **CEI and IEC** standards and include the following tests:

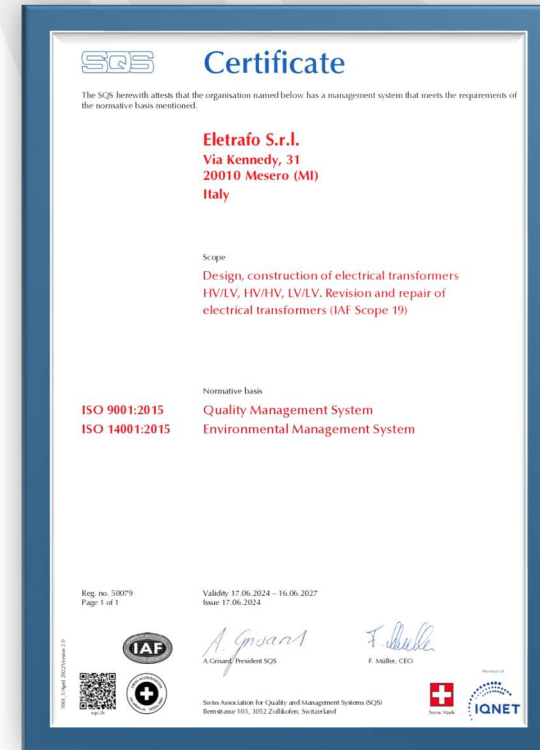
ACCEPTANCE TEST	REGULATIONS
<ul style="list-style-type: none">• Measurement of winding resistance• Measurement of voltage ratio and short-circuit voltage control• Measurement of short-circuit voltage and load losses• Measurement of no-load losses and no-load current• Applied AC voltage withstand test• Induced AC voltage withstand test• Measurement of partial discharges	<u>IEC 60076</u>
TYPE TESTS (ON REQUEST)	REGULATIONS
<ul style="list-style-type: none">• Atmospheric impulse test• Over-temperature test	<u>IEC 60076</u>
SPECIAL TESTS (ON REQUEST)	REGULATIONS
<ul style="list-style-type: none">• Noise level assessment	<u>IEC 60076</u>

The test results are recorded and stored in a dedicated register. The register is used to monitor the quality of transformers and to identify any issues that may arise in the future.

We are proud to offer our customers high-quality and reliable transformers. Our transformers are designed to stand the test of time and meet the most demanding requirements.

QUALITY CONTROL AND CERTIFICATIONS

All **ELETRAFO** production is based on the application of the **UNI EN ISO 9001** quality system in all phases of the process.



This system ensures that our products meet the highest standards of quality and safety, and are manufactured in accordance with environmental regulations

ELETRAFO is committed to providing its customers with the best possible products and services.

Our quality system is a fundamental tool to achieve this goal, and allows us to guarantee our customers maximum reliability and satisfaction.

TESTS

During the production process, tests are carried out in accordance with the operating instructions of the quality system.

All transformers are tested in compliance with **CEI-IEC standards** with routine tests performed in our test room.



Type tests can be performed in an external laboratory (for example, CESI - Milan), with an additional cost for each test.

At the end of the tests, a test report is printed showing the results of the tests and the technical characteristics of the transformer.

The test report is issued to the customer together with the transformer.

ELETRAFO
SRL
TRASFORMATORI ELETTRICI

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TRANSFORMER TEST RECORD

serial number reference standard customer
EN 60076 - UE 548/2014-eco 2021 tier 2

RATING POWER	2500	kVA	TYPE	
PRIMARY VOLTAGE	33 ±2 X 2.5%	kV	SECONDARY VOLTAGE	480 V
	43.7	A	SECONDARY CURRENT	3007 A
INSULATION CLASS	FI 70 IA 170	kV	INSULATION CLASS	FI 3 IA
Vcc%	6	%	FREQUENCY	50 Hz
	Dyn11		COOLING TYPE	ONAN

Measurement transformer ratio

tap position	primary voltage (Volt)	Y secondary voltage (Volt)	Y ratio value
1	34650	480	124,935
2	33825	480	121,944
3	33000	480	118,938
4	32175	480	115,944
5	31350	480	112,944

No load losses and current Io%		Energized winding		L.V.	Hz:	50	temp:	23	°C
U 1-2-3	V	A1	A2	A3	Am	W	0		
k= 1	k= 1	k= 1	k= 1	k= 1	k= 1	k= 1		Measured	Guaranteed
480	480	3,76	2,64	4,25	3,6	1726		Po= 1726 W	Po = 1810 W
								Io% =	

Load losses and impedance voltage Vcc%		Energized winding		H.T.	Hz:	50	temp:	23	°C
U 1-2-3	V	A1	A2	A3	Am	W	0	Data Guaranteed at	75
k= 1	k= 1	k= 1	k= 1	k= 1	k= 1	k= 1		Measured	Guaranteed
750	750	16,54	16,53	16,48	16,52	2415		Pcc= 20009 W	Pcc= 20350 W
								Vcc= 6,03 %	Vcc= 6 %

Insulation test

Applied voltage	Induced voltage	Winding	Induced voltage
H.V. - (L.V. + Ground)		volt	960
volt			
Time:			
		Energized winding:	L.V.
L.V. - (H.V. + Ground)		Frequency	100 Hz
volt		Time:	1'
Time:			

MEASUREMENT OF THE RESISTANCES

		temp:	23	°C
H.V.	R-1U1V	2,941	Ohm	
	R-1V1W	2,938	Ohm	
	R-1W1U	2,933	Ohm	
L.V.	R 2U-2V	0,561	mOhm	
	R 2U-2V	0,558	mOhm	
	R 2U-2V		mOhm	

COVER AND TANK TEST

PAINING :	RAL 7033	<input checked="" type="checkbox"/>
TREATMENT :	CSM	<input checked="" type="checkbox"/>
OVERPRESSURE:	30 Kpa- 8h	<input checked="" type="checkbox"/>

TOLLERANCE :STANDARD IEC 60076-1; UE 548/2014-eco 2021 tier 2

INTERNAL TECHNICIAN TESTER Date SIGNATURE

