HYGN01-20260305

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10~35kV
Oil Immersed Transformer

TGOOD GLOBAL –ENERGY.FAST!–

www.qdtgood.com

Company Profile

- Founded in 2004,TGOOD (Stock Code: 300001) was the first company listed on the Growth Enterprise Board of the Shenzhen Stock Exchange in 2009.
- The mission of TGOOD is to create the world's top brand of prefabricated power equipment.
- TGOOD's intelligent modular prefabricated substations has occupied a 60% share of power grid and new energy markets.
- TGOOD has delivered product solutions to 6300+ customers, and provided 11,000+ prefabricated substations.
- TGOOD's prefabricated and integrated solutions have been implemented in 50+ countries and regions world wide.

No.1

The world's No.1 brand of prefabricated substation equipment

The largest in World

One of the largest supplier for prefabricated substation

The largest in China

TGOOD is the largest R&D and production base for prefabricated substations in China

Only in China

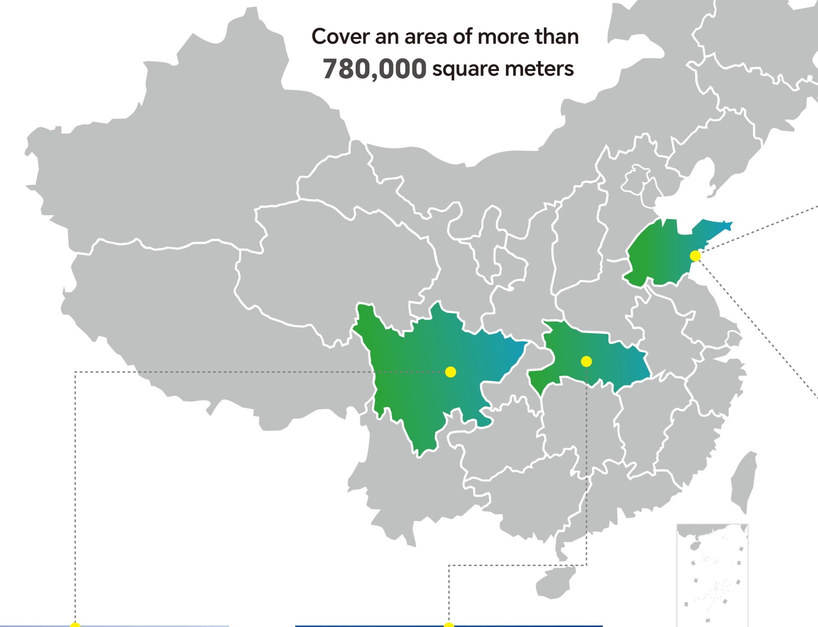
The only manufacturer in China achieving digital, technological, specialized, and large-scale production of prefabricated substation

Champion

MIT manufacturing industry single item champion enterprise

Four Main Manufacture Factories

Cover an area of more than **780,000** square meters



Qingdao West Coast Manufacturing Factory

Qingdao Free Trade Zone (China)

Sichuan Chengdu Manufacturing Factory

Hubei Yichang Manufacturing Factory

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2 Product Overview

2.1 Applicable Standards

- IEC 60076.1-2011 General Power transformers
- IEC 60076.2-1993 Temperature rise
- IEC 60076.3-2000 Insulation levels, dielectric tests and external clearances in air
- IEC 60076.5-2000 Ability to withstand short circuit
- EU NO 548-2014(2017) European Union - (EU) 548/2014 - Power Transformers
- IEC60076.20-2017 Power transformer-Part 20:Energy efficiency
- EN 50588.1-2017 Medium power transformers 50 Hz, with highest voltage foe equipment not exceeding 36 kV-Part 1: General requirements
- EN 50464.1-2007 Three-phase oil-immersed distribution transformers 50 Hz, from 50kVA to 2500kVA with highest voltage foe equipment not exceeding 36 kV-Part 1: General requirements
- IEEE Std C57.12.10 - 2017 Requirements for Liquid-Immersed Power Transformers
- AS2374.1.2 Part 1.2-2003 Australian StandardTM Power transformers Minimum Energy Pertorman-ceStandard(MEPS) requirements for distribution transformers

2 Product Overview

2.2 Reliable Solutions for All Applications

TGOOD has expertise in producing transformers for optimum space utilization, special requirements, and the most demanding conditions. We deliver the most comprehensive range of solutions across all applications, product categories, and customized projects.

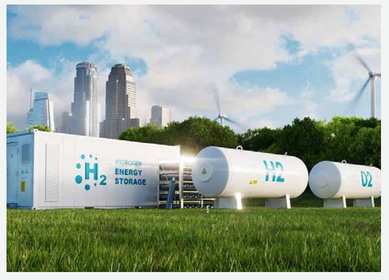
Data Centers

Marine

Wind Power

Solar Power

Railways



Hydrogen

Industries

Utilities

2.3 Certified High Performance for Enhanced Safety and Reliability

TGOOD offers the highest level of compliance to EU NO 548-2014(2017) andIEC 60076 . Utilizing advanced electromagnetic design software, this series of products features automatic optimization of transformer performance and structure, and possesses independent intellectual property rights. Key characteristics include low losses, low noise, high short-circuit withstand capability, leak-free design, on-site installation without core lifting, and maintenance-free operation.

- **Safety for People and Property**
- **No Fire Hazard(Synthetic Ester Transformer Oil)**
- **Environmental Friendly**
- **Maintenance and Pollution Free**
- **Reduced Civil Works**
- **Enhanced Withstand to Short Circuit Stress**
- **Applicable for Damp and Contaminated Areas**
- **No Specific Fire Detection Systems (compact housings)**
- **Improved Performance against Seismic Phenomena**

2.4 Certifications

High Overload Capability

- Designed to meet short-term emergency overload (e.g., 1.3 times rated load for 2 hours) and long-term overload (e.g., 1.1 times continuous operation)
- Calculate hot-spot temperature rise to ensure insulation life is not compromised during overload conditions.

Low Partial Discharge

- Pure insulation system: High-purity insulating oil and corona-resistant materials are used, with strict control over impurities and bubbles during manufacturing.
- Uniform electric field distribution: High-field-strength areas are eliminated through simulation optimization, and partial discharge levels are far below national standards .

High Efficiency (Low Loss)

- **Core Material:**

  High-permeability, low-loss silicon steel sheets are selected to reduce no-load losses.
- **Winding Design:**

  Copper foil or oxygen-free copper conductors are used to minimize load losses.

  Electromagnetic design is optimized to balance eddy current losses and stray losses.
- **Loss Performance:**

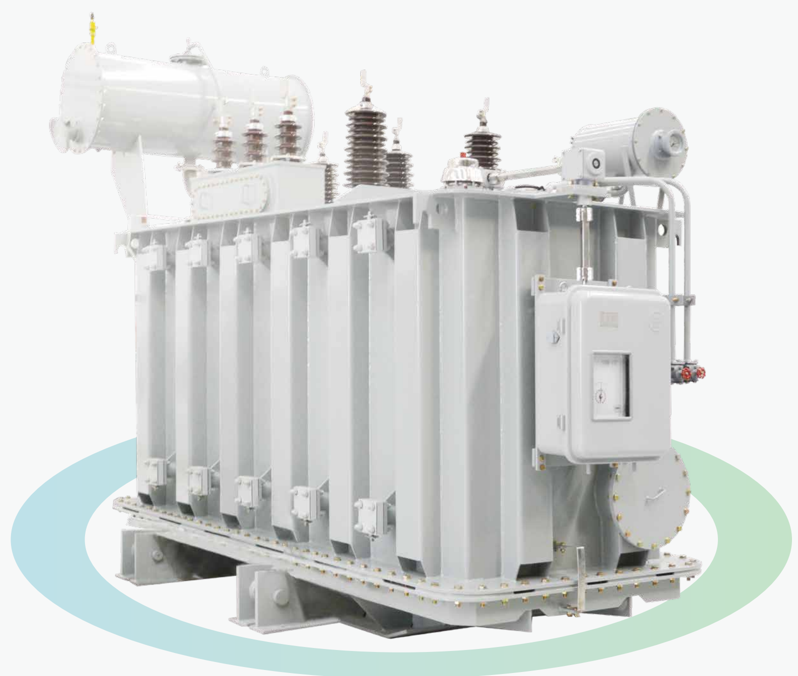
  Loss levels comply with the highest standards such as EU or IEC requirements.

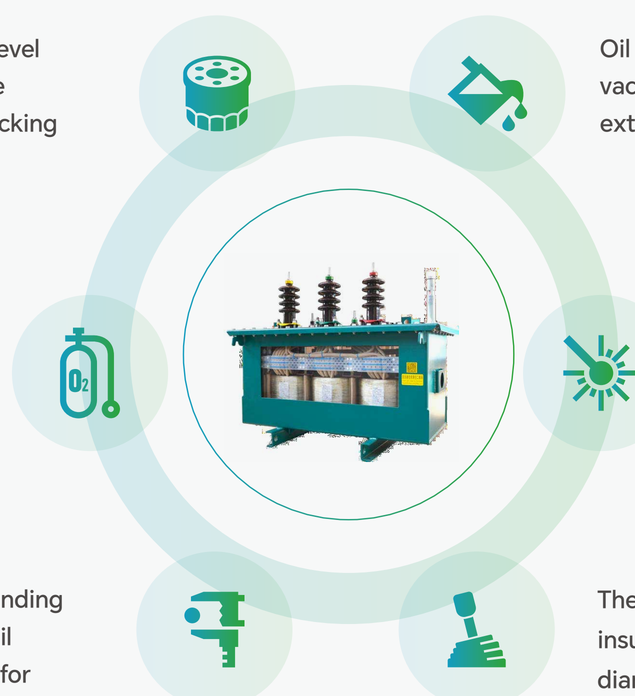
Intelligent Features

- Comprehensive Online Monitoring: Integrates sensors for oil temperature, gas chromatography, and load to collect operational data in real time.
- Accurate Condition Assessment: Analyzes data to predict fault risks, provides early warnings, and enables condition-based maintenance.
- Flexible Remote Control: Supports remote adjustment of cooling systems and tap changers, automatically optimizing operation modes.

3 Technical Features

3.1 Features





The most advanced seven level step-by-step process in the industry, which involves stacking iron cores one by one

Oil filling is performed using vacuum degassing and vacuum extraction processes.

All external components of the tank are filleted; the tank walls are bent to minimize welds.
The surface is treated with shot blasting, strictly dhering to environmental anti-corrosion require-ments.

The transformer core and winding are dried using the transformer oil vapor (hot oil spray) vacuum drying process.

The LV coil adopts a foil winding structure, and the digital coil winding equipment is used for highprecision processing and manufacturing.

The HV coil adopts a Class A insulation system, wound using diamond-pattern dotted paper, Electromagnetic wire, and oil ducts.

3.2 Product Advantages

Low Loss

- High magnetic cold rolled-oriented silicon steel sheet and reasonable magnetic flux density have been adopted in the design, and the burr has been strictly controlled less than 0.02mm during processing, manufactured according to technic requirement to ensure the flatness and verticality of the core, furthermore, its clamp strength met the requirement as well. Select reasonable current density, control wire width and thickness ratio, and especially control the wire thickness to reduce eddy current loss and stray loss.

Low temperature-rise

- Product's cooling way is ONAN or ONAF, there is a longitudinal oil path inside the coil to increase the coil radiating surface, which makes oil flow direction is more reasonable to avoid of partial overheating.

Low noise

The noise is mainly from the core, outspread through the transformer's body and oil tank. Meanwhile, the noise would be increased due to the cooling devices accessories. In order to reduce the noise, following measures have been taken:

- Reasonable magnetic flux density and high permeability, low magnetostrictive high quality silicon steel sheet have been adopted in the design to ensure a certain margin available under normal working voltage, the core does not appear magnetic saturation phenomenon when the system voltage is high,
- which can reduce the hysteresis vibration of silicon steel sheet itself.
  The structural parts are designed with reasonable vibration reduction and anti-loose measures such as the insulation rubber on the core cushion.
- All fasteners adopt the anti-release button and disc type spring washer.
- Control the appropriate clamping force.
- The transformer completely adopts the structure of strong short-circuit withstand capacity and technic measurements to avoid the transmission of mechanical noise.

Strong short-circuit withstand capacity

- One of the hazards of sudden short-circuit of transformer is the rapid heating of winding and all current-carrying conductors, causing the winding temperature to increase sharply. Second, make the winding and its structure components suffer from huge electromagnetic force when the mechanical strength of winding structural components is not high. Under the action of electromagnetic force, winding and its structure components are likely to be damaged, so that the transformer stops operating.

Natural ester oil transformer

- Extend the insulation material and Service life of transformers;
- **Load capacity:** 1.2 times long-term overload;
- **Fire safety:** ignition point of 350 ℃;
- Environmental performance: completely degraded within 28 days;
- When transformer oil uses natural ester oil, the cooling method is KNAN.

3 Technical Features

3.3 Core Cutting and Stacking

The iron core cutting line has one set of industry-leading intelligent and automated vertical cutting equipment, two sets of horizontal cutting equipment, and is equipped with multiple high-precision stacking platforms, as well as fully automatic flipping platforms, fully sealed iron core surface treatment rooms that meet environmental requirements, and drying rooms. It can meet the complete set of operations for cutting, automatic stacking, and overall stacking of iron cores of different thicknesses of silicon steel coils, as well as completing overall surface treatment.

EQUIPMENT ADVANTAGES

Main advantages of the production line

- Adopting high magnetic conductivity cold-rolled oriented silicon steel sheets
- High cutting accuracy, with burrs less than 0.02mm
- It can process silicon steel sheets of different thicknesses within the range of 0.2mm~0.3 5mm , meeting the requirements of high energy effciency and low noise
- Stacking process with seven steps, one piece per stack

3.3 Core Cutting and Stacking

PRODUCT FEATURES

Reduce Iron Core Loss

- **Reduce hysteresis loss**

  Shear stacking reduces magnetic flux by optimizing the seam structure of laminated panels (such as diagonal or stepped seams)The path distortion at the joint reduces local magnetic resistance, thereby reducing hysteresis loss.

- **Reduce eddy current losses**

  The laminations are tightly adhered and have good insulation, effectively suppressing the generation of eddy currents and improving the effciency of the iron core.

Improve Magnetic Flux Distribution

- **Uniform magnetic circuit**

  The stepped seam design ensures a more uniform distribution of magnetic flux in the iron core, avoiding local magnetic flux concentration or saturation caused by traditional straight seams, and reducing no-load current and noise.

- **Reduce magnetic leakage**

  Optimizing the joint shape can reduce magnetic leakage and improve the energy transmission effciency of transformers.

Reduce No-Load Noise

- **Reduce magnetostrictive vibration**

  make the transformer run quieter (can reduce noise by 3-5dB).

Long Term Reliability

- **Reduce local overheating**

  Uniform magnetic flux distribution avoids hot spots, prolongs insulation material life, and improves transformer reliability

3.4 High Voltage Winding

The HV coil of oil-immersed transformers is typically a cylindrical type, wound using high-quality enameled/paper-covered magnet wire, diamond-pattern dotted paper, and oil ducts. The pre-compression and heat curing process ensures a tightly wound and robust coil, delivering excellent electrical performance and mechanical strength. It is widely used in rail transit, power grids, and new energy generation.

PRODUCT FEATURES

Complex insulation structure	Optimized thermal design	High mechanical strength
• Due to the high voltage rating, multi-layer cylindrical or continuous disc windings are typically used. Strict requirements are imposed on inter-layer and inter-turn insulation, often reinforced with materials like diamond-pattern dotted paper and cable paper.	• Radial and axial oil ducts are incorporated within the coil to ensure sufficient circulation of transformer oil, effectively dissipating heat generated during operation.	• High-strength magnet wires are used, secured with compression devices and spacers to withstand the significant electromagnetic forces generated by short-circuit currents and prevent deformation.

3.4 High Voltage Winding

EQUIPMENT ADVANTAGES

- **Automatic adjustment of winding tension**
- **High dimensional accuracy in winding**
- **Digital control of winding process parameters**
- **Digital manufacturing of coils supported by mes system**

Automatic Adjustment of Winding Tension: Ensuring Stable Winding Tension of The Coil

The drawbacks of traditional manual adjustment

- Tension fluctuations cause uneven tension in the coil,affecting insulation performance and heat dissipation
- Over tension strains the wire, while over looseness causes the coil to become loose and deformed

The core goal of automatic adjustment

Maintain a constant tension (within ± 5%) to adapt to different wire diameters, materials, and winding speeds

High Dimensional Accuracy in Winding

- Ensure the accuracy of coil winding, reduce coil size deviation, minimize magnetic leakage, reduce winding eddy current losses, and improve the ability of transformer windings to withstand external shortcircuit electric forces

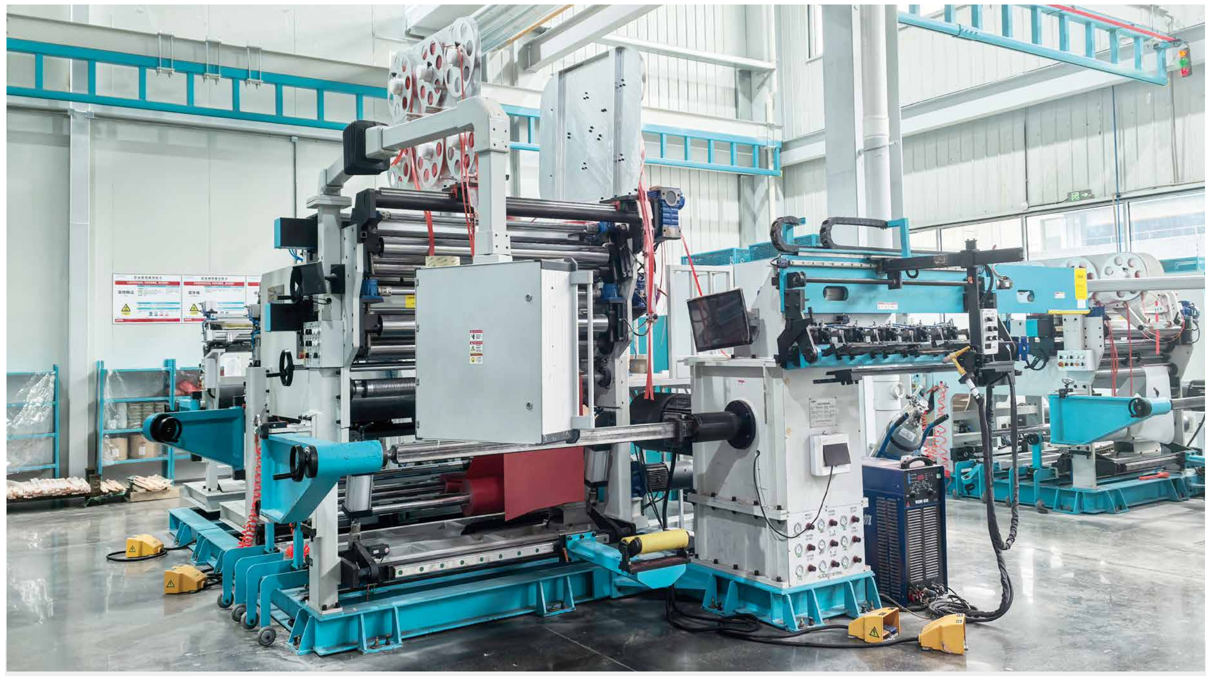
Digital Manufacturing of Coils Supported by Mes System

- The issuance and execution of instructions are digitized to reduce deviations and risks caused by human interference

Digital Control of Winding Process Parameters

- Reduce the risk of misoperation and improve quality reliability

3.5 Low Voltage Winding / Foil Winding



The foil wound coils of dry-type transformers are made of copper foil or aluminum foil as conductors, wound through special processes, and have the characteristics of compact structure, good heat dissipation performance, and strong short-circuit resistance. They are widely used in power distribution, industry, new energy and other fields.

Efficient

High-Precision

Low-Loss

EQUIPMENT ADVANTAGES

Accuracy	± 0.1mm opposite edge	Above ± 0.5mm
Automation	Fully automatic correction/skill count	Manual adjustment is mostly used
Efficiency	50 meters per minute (max)	20-30 meters per minute

3.5 Low Voltage Winding / Foil Winding

PRODUCT FEATURES

Conductor Materials and Structures

Copper foil/aluminum foil conductor:

Using high-purity electrolytic copper foil or aluminum foil (thickness 0.1-3mm), with excellent conductivity (copper foil conductivity ≥ 58MS/m). It can reduce eddy current losses and improve current carrying capacity.

Multi layer continuous winding:

The foil strip and insulation material are alternately stacked to form a coil structure with strong integrity and no joints.

Excellent Heat Dissipation Performance

Horizontal heat dissipation channel:

Reserved ventilation gaps between foil wound coils, with a heat dissipation area 30%~50% larger than that of wire wound coils, and lower temperature rise.

Uniform heat distribution:

Wide width foil strips reduce the generation of hot spots and are suitable for high current applications.

Mechanical Strength and Short-Circuit Resistance

Strong integrity:

Epoxy resin vacuum casting or prepreg curing treatment forms a rigid whole of the coil, which is resistant to shortcircuit electric force.

Electrical Performance Advantages

Low eddy current loss:

The width of the foil strip is large, the skin effect is weak,and the additional loss is 20% to 30% lower than that of a wire wound coil.

3.6 Vacuum drying

The transformer core and windings assembly primarily consists of the core, coils, and insulating materials. After assembly and before the addition of transformer oil, it must undergo a drying process to remove moisture and gases from the insulation. This ensures the moisture content is controlled within the limits specified by product quality standards, guaranteeing sufficient dielectric strength and operational lifespan for the transformer.

EQUIPMENT ADVANTAGES

Index	Static Mixing Vacuum Casting
Water content	<0.5%
Vacuum level	< 100pa
Drying temperature	Coil temperature: 105°C

Fully Automated Drying Process

Intelligent control system

- PLC + Industrial computer system: Capable of storing drying process parameters for various voltage levels. It automatically adjusts and executes the drying process based on the voltage rating, selecting the appropriate drying temperature, vacuum level, and drying time automatically. The system can also automatically determine when the drying process is complete).
- Real time monitoring of vacuum degree, material temperature, and flow rate, automatic alarm for abnormalities (such as pipeline blockage and vacuum leakage).

Efficient drying

- Vacuum drying consists of three stages: low-temperature pre-drying, vacuum intermediate drying, and high-vacuum final drying, ensuring the moisture content of the insulation materials is below 0.5%.

Accurate temperature/Vacuum control

- Dual channel PID temperature and Vacuum control (±). Prevent the vacuum level or temperature from falling below the required standards.

3.6 Vacuum drying

PRODUCT FEATURES

Process Characteristics

Vacuum degassing

Eliminate moisture from the coil and insulation in a vacuum environment to ensure thorough drying of the insulating materials and eliminate the risk of partial discharge. and eliminate the risk of partial discharge.

Segmented drying

Adopts a gradient heating drying process (65°C~105°C), utilizing low-vacuum heating, semi-vacuum drying, and high-vacuum dehydration to effectively ensure drying results and enhance the insulation and electrical performance of the windings.

Material Characteristics

Insulation

Diamond-pattern dotted paper is selected for inter-layer insulation. Its surface is coated with high-quality resin to enhance the curing strength of the coil, providing excellent dielectric strength and a heat resistance rating of Class A (105°C).

olL

Natural ester or synthetic ester transformer oil is selected, offering excellent thermal stability, oxidation resistance, low-temperature fluidity, and good compatibility with additives. It is suitable for more demanding operating environments, such as industrial equipment under high loads, high speeds, and wide temperature ranges, as well as for certain special applications.

Structural Characteristics

Strong integrity

After solidification, the coil becomes a rigid whole, with excellent resistance to shortcircuit electrodynamics and seismic performance.

No gap insulation

The internal insulation drying of the windings meets the process requirements. After the wires and interlayer insulation are immersed in oil under anhydrous conditions, the partial discharge level is ≤100pC following vacuum oil filling.

3.7 PEI values for transformers with Um≤36 kV and S,≤3150 kVA

IEC 60076-20 Recommended performance parameters.

	U_m ≤ 24kV		24kV ≤ U_m ≤ 36kV	
Rated power kVA	PEI level 1 %	PEI level 2 %	PEI level 1 %	PEI level 2 %
≤ 25	97,992	98,445	97,742	98,251
50	98,741	99,014	98,584	98,891
100	98,993	99,194	98,867	99,093
160	99,122	99,281	99,012	99,191
250	99,210	99,363	99,112	99,283
315	99,248	99,395	99,154	99,320
400	99,297	99,439	99,209	99,369
500	99,330	99,465	99,247	99,398
630	99,373	99,500	99,295	99,437
800	99,416	99,532	99,343	99,473
1000	99,431	99,541	99,360	99,484
1250	99,483	99,544	99,418	99,487
1600	99,488	99,550	99,424	99,494
2000	99,495	99,558	99,432	99,502
2500	99,504	99,568	99,442	99,514
3150	99,506	99,572	99,445	99,518

NOTE:
Although the values in this table have been developed from 50 Hztransformer data, they are also applicable to 60 Hz transformers.

3.8 PEI values for transformers with Um > 36 kV and S, > 3150 kVA

IEC 60076-20 Recommended performance parameters.

Rated power kVA	PEI level 1 %	PEI level 2 %
> 3150 and ≤ 4000	99,465	99,532
5 000	99,483	99,548
6 300	99,510	99,571
8 000	99,535	99,593
10 000	99,560	99,615
12 500	99,588	99,640
16 000	99,615	99,663
20 000	99,639	99,684
25 000	99,657	99,700
31 500	99,671	99,712
40 000	99,684	99,724
50 000	99,696	99,734
63 000	99,709	99,745
80 000	99,723	99,758
≥100 000	99,737	99,770

NOTE:
Although the values in this table have been developed from 50 Hztransformer data, they are also applicable to 60 Hz transformers.

3.9 Maximum Load Loss and Maximum No Load Loss for Transformers with Rated Frequency Equal to 50 Hz

IEC 60076-20 Recommended performance parameters.

	level 1		level 2	
Rated power kVA	Maximum load losses (in W)	Maximum no-load losses (in W)	Maximum load losses (in W)	Maximum no-load losses (in W)
≤ 25	900	70	63	63
50	1 100	90	750	81
100	1750	145	1 250	130
160	2 350	210	1 750	189
250	3 250	300	2 350	270
315	3 900	360	2 800	324
400	4 600	430	3 250	387
500	5 500	510	3 900	459
630	6 500	600	4 600	540
800	8 400	650	6 000	585
1 000	10 500	770	7 600	693
1 250	11 000	950	9 500	855
1 600	14 000	1 200	12 000	1 080
2 000	18 000	1 450	15 000	1 305
2 500	22 000	1 750	18 500	1 575
3 150	27 500	2 200	23 000	1 980

NOTE:
In some countries, higher losses are allowed in regulations for transformers outside the scope of thistable, for example with a wider tapping range, dual LV windings or higher voltage.

3.10 Load losses Pk(w) at 75℃ for UM 24kV

EN 50464-1 part1: General requirements

Rated power kVA	D_K W	C_K W	B_K W	A_K W	Short circuit impedance %
50	1 350	1 100	875	750	4
100	2 150	1 750	1 475	1 250	
160	3 100	2 350	2 000	1 700	
250	4 200	3 250	2 750	2 350	
315	5 000	3 900	3 250	2 800	
400	6 000	4 600	3 850	3 250	
500	7 200	5 500	4 600	3 900	
630	8 400	6 500	5 400	4 600	
630	8 700	6 750	5 600	4 800	6
800	10 500	8 400	7 000	6 000	
1 000	13 000	10 500	9 000	7 600	
1 250	16 000	13 500	11 000	9 500	
1 600	20 000	17 000	14 000	12 000	
2 000	26 000	21 000	18 000	15 000	
2 500	32 000	26 500	22 000	18 500	

NOTE:
In some countries, higher losses are allowed in regulations for transformers outside the scope of thistable, for example with a wider tapping range, dual LV windings or higher voltage.

3 Technical Features

3.11 No load losses P0(w) and sound power level(LWA) for UM 24kV

EN 50464-1 part1: General requirements.

Rated power	E_0		D_0		C_0		B_0		A_0		Short circuit impe-dance
kVA	P_O W	L_{WA} dB(A)	P_O W	L_{WA} dB(A)	P_O W	L_{WA} dB(A)	P_O W	L_{WA} dB(A)	P_O W	L_{WA} dB(A)	%
50	190	55	145	50	125	47	110	42	90	39	4
100	320	59	260	54	210	49	180	44	145	41	
160	460	62	375	57	300	52	260	47	210	44	
250	650	65	530	60	425	55	360	50	300	47	
315	770	67	630	61	520	57	440	52	360	49	
400	930	68	750	63	610	58	520	53	430	50	
500	1100	69	880	64	720	59	610	54	510	51	
630	1300	70	1 030	65	860	60	730	55	600	52	
630	1200	70	940	65	800	60	680	55	560	52	
800	1400	71	1 150	66	930	61	800	56	650	53	6
1 000	1700	73	1 400	68	1 100	63	940	58	770	55	
1 250	2100	74	1 750	69	1 350	64	1 150	59	950	56	
1 600	2 600	76	2 200	71	1 700	66	1 450	61	1200	58	
2 000	3100	78	2 700	73	2 100	68	1 800	63	1450	60	
2 500	3500	81	3 200	76	2 500	71	2 150	66	1750	63	

NOTE:
P_O = no load losses
L_{WA} = sound power level

3.12 Load losses Pk(w) at 75℃ for UM =36kV

EN 50464-1 part1: General requirements

Rated power kVA	C_{K36} W	B_{K36} W	A_{K36} W	Short circuit impedance %
50	1 450	1 250	1 050	4 or 4.5
100	2 350	1 950	1 650	
160	3 350	2 550	2 150	
250	4 250	3 500	3 000	
400	6 200	4 900	4 150	
630	8 800	6 500	5 500	
800	10 500	8 400	7 000	6
1 000	13 000	10500	8 900	
1 250	16 000	13 500	11 500	
1 600	19 200	17 000	14 500	
2 000	24 000	21 000	18 000	
2 500	29 400	26 500	22 500	

NOTE:
In some countries, higher losses are allowed in regulations for transformers outside the scope of thistable, for example with a wider tapping range, dual LV windings or higher voltage.

3.13 No load losses P0(w) and sound power level(LWA) for UM =36kV

EN 50464-1 part1: General requirements.

Rated power	C_{036}		B_{036}		A_{036}		Short circuit impedance
kVA	P_O W	L_{WA} dB(A)	P_O W	L_{WA} dB(A)	P_O W	L_{WA} dB(A)	%
50	230	52	190	52	160	50	4 or 4.5
100	380	56	320	56	270	54	
160	520	59	460	59	390	57	
250	780	62	650	62	550	60	
400	1 120	65	930	65	790	63	
630	1 450	67	1 300	67	1 100	65	
800	1 700	68	1 500	68	1 300	66	6
1 000	2 000	68	1 700	68	1 450	67	
1 250	2 400	70	2 100	70	1 750	68	
1 600	2 800	71	2 600	71	2 200	69	
2 000	3 400	73	3 150	73	2 700	71	
2 500	4 100	76	3 800	76	3 200	73	

NOTE:
P_O = no load losses
L_{WA} = sound power level

3.14 PEI values for transformers with Um > 36 kV and S_r > 3150 kVA

EN 5588-1 part1: General requirements

Rated power (kVA)	PEI (%) A	PEI (%) AA
3150 < S_r ≤ 4000	99,465	99,532
5 000	99,483	99,548
6 300	99,510	99,571
8 000	99,535	99,593
10 000	99,560	99,615
12 500	99,588	99,640
16 000	99,615	99,663
20 000	99,639	99,684
25 000	99,657	99,700
31 500	99,671	99,712
40 000	99,684	99,724

NOTE:
In some countries, higher losses are allowed in regulations for transformers outside the scope of thistable, for example with a wider tapping range, dual LV windings or higher voltage.

3.15 Minimum power efficiency levels for oil-immersed Transformers

AS2374.1.2 Part 1.2-2003 Australian Standard™ Power transformers Minimum Energy Pertormance Standard(MEPS) requirements for 24kV distribution transformers

Type	kVA	Power efficiency @ 50% load
Single phase (and SWER)	10	98.30
	16	98.52
	25	98.70
	50	98.90
Three phase	25	98.28
	63	98.62
	100	98.76
	200	98.94
	315	99.04
	500	99.13
	750	99.21
	1000	99.27
	1500	99.35
	2000	99.39
	2500	99.40

NOTE: For intermediate power ratings the power efficiency level shall be calculated by linear interpolation.

3.16 Maximum load and no-load losses for liquld Immersed power transformers

EU 548-2014:

1.1. Requirements for three-phase medium power transformers with ratedpower ≤3150 kVA

Table 1.1: M2 Maximum load and no-load losses (in W) for three-phase liquid-immersed medium power transformers with one winding with Um ≤24kV and the other with Um≤3,6 kV

	Tier 1 (from 1 July 2015)		Tier 2 (from 1 July 2021)	
Rated power (kVA)	Maximum load losses P_k (W) (*)	Maximum no-load losses P_o (W) (*)	Maximum load losses P_k (W) (*)	Maximum no-load losses P_o (W) (*)
≤25	C_k (900)	A_o (70)	A_k (600)	A_o - 10 % (63)
50	C_k(1100)	A_o (90)	A_k (750)	A_o - 10 % (81)
100	C_k (1750)	A_o (145)	A_k (1 250)	A_o - 10 % (130)
160	C_k (2350)	A_o (210)	A_k (1750)	A_o - 10 % (189)
250	C_k (3 250)	A_o (300)	A_k (2 350)	A_o - 10 % (270)
315	C_k (3900)	A_o (360)	A_k (2 800)	A_o - 10 % (324)
400	C_k (4 600)	A_o (430)	A_k (3 250)	A_o - 10% (387)
500	C_k (5 500)	A_o (510)	A_k (3 900)	A_o - 10 % (459)
630	C_k (6 500)	A_o (600)	A_k (4 600)	A_o - 10 % (540)
800	C_k (8 400)	A_o (650)	A_k (6 000)	A_o - 10 % (585)
1 000	C_k (10 500)	A_o (770)	A_k (7 600)	A_o - 10 % (693)
1 250	B_k (11 000)	A_o (950)	A_k (9 500)	A_o - 10 % (855)
1 600	B_k (14 000)	A_o (1 200)	A_k (12 000)	A_o - 10% (1 080)
2 000	B_k (18 000)	A_o (1 450)	A_k (15 000)	A_o - 10 % (1 305)
2 500	B_k (22 000)	A_o (1 750)	A_k (18 500)	A_o - 10 % (1 575)
3 150	B_k (27 500)	A_o (2 200)	A_k (23 000)	A_o - 10% (1 980)

(*) Maximum losses for kVA ratings that fall in between the ratings given in Table 1.1 shall be obtained by linear interpolation.

3.17 Min Peak Efficiency（PE I）for liquld Immersed power transformers

EU 548-2014:
1.2. Requirements for medium power transformers with rated power >3150 kVA

Table 1.4:
Minimum Peak Efficiency Index (PEI) values for liquld Immersed medium power transformers

Rated power (kVA)	Tier 1 (from 1 July 2015)	Tier 2 (from 1 July 2021)
	Minimum Peak Efficiency Index (%)	
3150 < S_r ≤ 4000	99,465	99,532
5 000	99,483	99,548
6 300	99,510	99,571
8 000	99,535	99,593
10 000	99,560	99,615
12 500	99,588	99,640
16 000	99,615	99,663
20 000	99,639	99,684
25 000	99,657	99,700
31 500	99,671	99,712
40 000	99,684	99,724

NOTE:
Minimum PEI values for kVA ratings that fall in between the ratings given inTable I.4 shall be calculated by linear interpolation.

3.18 Rated voltage 35 kV oil Power Transformer (NLTC)

<table>
<tr><th colspan="9">35kV class 630kVA to 31500kVA no-load tap-changing power transformer</th></tr>
<tr><th rowspan="2">rated capacity (kVA)</th><th colspan="3">Voltage combination and tap range</th><th rowspan="2">Connection group number</th><th rowspan="2">no-load loss (kW)</th><th rowspan="2">Load loss (kW)</th><th rowspan="2">no-load current (%)</th><th rowspan="2">short circuit impedance (%)</th></tr>
<tr><th>high voltage (kV)</th><th>High voltage tap range(%)</th><th>low voltage (kV)</th></tr>
<tr><td>630</td><td rowspan="7">33~38.5</td><td rowspan="11">±2×2.5
±5</td><td rowspan="11">3.15
6.3
10.5</td><td rowspan="11">Yd11
Dyn11</td><td>0.660</td><td>7.47</td><td>0.52</td><td rowspan="7">6.5</td></tr>
<tr><td>800</td><td>0.780</td><td>8.93</td><td>0.52</td></tr>
<tr><td>1000</td><td>0.920</td><td>10.9</td><td>0.52</td></tr>
<tr><td>1250</td><td>1.12</td><td>13.2</td><td>0.44</td></tr>
<tr><td>1600</td><td>1.35</td><td>15.8</td><td>0.36</td></tr>
<tr><td>2000</td><td>1.74</td><td>17.4</td><td>0.36</td></tr>
<tr><td>2500</td><td>2.05</td><td>18.6</td><td>0.36</td></tr>
<tr><td>3150</td><td rowspan="11">33~38.5</td><td>2.40</td><td>21.9</td><td>0.36</td><td rowspan="3">7.0</td></tr>
<tr><td>4000</td><td>2.90</td><td>25.9</td><td>0.36</td></tr>
<tr><td>5000</td><td>3.50</td><td>29.7</td><td>0.36</td></tr>
<tr><td>6 300</td><td>4,20</td><td>33.3</td><td>0.36</td><td rowspan="5">8.0</td></tr>
<tr><td>8000</td><td rowspan="7">±2×2.5</td><td rowspan="7">3.15
3.3
6.3
6.6
10.5</td><td rowspan="7">YNd11
Dyn11</td><td>5.80</td><td>36.5</td><td>0.28</td></tr>
<tr><td>10 000</td><td>7.00</td><td>43,0</td><td>0.28</td></tr>
<tr><td>12 500</td><td>8.00</td><td>51.1</td><td>0.24</td></tr>
<tr><td>16.000</td><td>9.70</td><td>62.5</td><td>0.24</td></tr>
<tr><td>20 000</td><td>11.5</td><td>75.5</td><td>0.24</td></tr>
<tr><td>25 000</td><td>13.6</td><td>89.3</td><td>0.20</td><td rowspan="2">10.0</td></tr>
<tr><td>31 500</td><td>16.2</td><td>106.4</td><td>0.20</td></tr>
</table>

NOTE:
For transformers with a low voltage of 10.5 kV.

3 Technical Features

3.19 Rated voltage 35kV oil Power Transformer (OLTC)

35kV class 630kVA to 31500kVA no-load tap-changing power transformer

rated capacity (kVA)	Voltage combination and tap range			Connection group number	no-load loss (kW)	Load loss (kW)	no-load current (%)	short circuit impedance (%)
	high voltage (kV)	High voltage tap range(%)	low voltage (kV)					
2 000	33~38.5	± 3 × 2.5	6.3 10.5	Yd11 Dyn11	1,84	18.2	0.40	6.5
2 500					2.18	19.6	0.40	
3 150	33~38.5				2.60	23.5	0.40	7.0
4 000					3.10	27.6	0.40	
5 000					3.70	32.5	0.40	
6 300					4.50	34.9	0.40	7.5/8.0
8 000			6.3 6.6 10.5	YNd11 Dyn11	6.30	38.6	0.32	
10 000					7.40	45.6	0.32	
12 500					8.70	54.0	0.28	
16 000					10.5	66.8	0.28	
20 000					12.4	78.6	0.28	
25 000					14.6	92.9	0.24	10.0
31 500					17.4	110.2	0.24	

NOTE:
For transformers with a low voltage of 10.5 kV.

3.20 Containerized Transformer Information

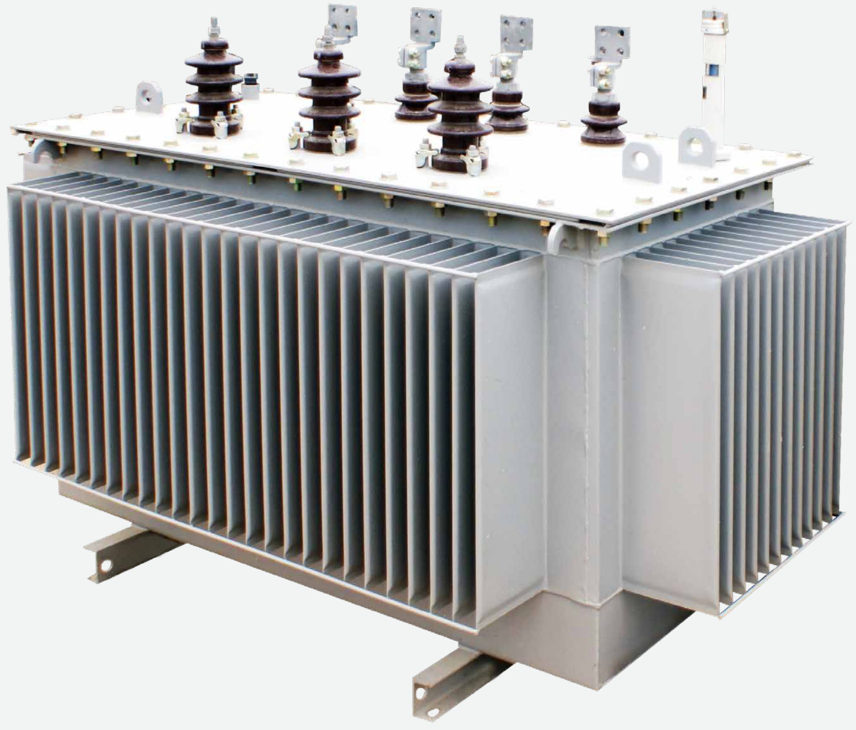
Containerized Transformer Information

rated capacity (kVA)	Specification	External Dimension (L x W x H)(mm)
≤9 000	20-foot High Cube	6058×2438×2896
≤10 000	40-foot High Cube	12000×2438×2896

3.21 Natural ester oil transformer

PRODUCT FEATURES

- The transformer features an extended service life, achieved throughthe use of enhanced insulation materials and natural ester oil. It isdesigned for a load capacity of 1.2 times the nominal rating, allowing for long term over load operation without compromising performance.Inter msoffiresafety, the materials employed have an ignition point of350°C,significantlyreducingthe risk of combustion.
- Environmentally,the transformer excels as it is fully degradable within 28 days,minimizinge co logical impact. The cooling method is KNAN (Kraftpa-per,Natural ester,Air Natural), leveraging the properties of natural ester oil for efficient and sustainable thermal management.



3.21 Natural ester oil transformer

APPLICATION CONTEXT

- Enhanced Safety and Reliability: With a high ignition point of 350°C, natural ester fluid dramatically reduces the risk of fire, making it exceptionally suitable for transformers locatedindoors, near residential areas, or in fire-sensitive industrial sites.
- Environmental Sustainability: As a fully biodegradable fluid (degrading completely within 28days), it presents a responsible choice for projects requiring environmental protection,particularly in ecologically sensitive areas.
- Extended Equipment Life span and Overload Capability: Natural ester's chemical proper ties allow transformers to withstand long-term overloads of up to 1.2 times their rated capacity. This,combined with its positive effect on paper insulation, effectively extends the transformer's service life, ensuring long-term operational efficiency.

3.22 PEI values for natural ester oil transformers with Um≤36 kV and S,≤3150 kVA

IEC 60076-20 Recommended performance parameters.

	$U_m \leq 24kV$		$24kV \leq U_m \leq 36kV$	
Rated power kVA	PEI level 1 %	PEI level 2 %	PEI level 1 %	PEI level 2 %
≤ 25	97,992	98,445	97,742	98,251
50	98,741	99,014	98,584	98,891
100	98,993	99,194	98,867	99,093
160	99,122	99,281	99,012	99,191
250	99,210	99,363	99,112	99,283
315	99,248	99,395	99,154	99,320
400	99,297	99,439	99,209	99,369
500	99,330	99,465	99,247	99,398
630	99,373	99,500	99,295	99,437
800	99,416	99,532	99,343	99,473
1000	99,431	99,541	99,360	99,484
1250	99,483	99,544	99,418	99,487
1600	99,488	99,550	99,424	99,494
2000	99,495	99,558	99,432	99,502
2500	99,504	99,568	99,442	99,514
3150	99,506	99,572	99,445	99,518

NOTE:
Although the values in this table have been developed from 50 Hztransformer data, they are alsoapplicable to 60 Hz transformers.The cooling method of natural ester is KNAN.The cooling method of mineral oil is ONAN.

3.23 PEI values for natural ester oil transformers with Um>36 kV and S,＞3150kVA

IEC 60076-20 Recommended performance parameters.

Rated power kVA	PEI level 1 %	PEI level 2 %
＞3150 and ≤ 4000	99,465	99,532
5 000	99,483	99,548
6 300	99,510	99,571
8 000	99,535	99,593
10 000	99,560	99,615
12 500	99,588	99,640
16 000	99,615	99,663
20 000	99,639	99,684
25 000	99,657	99,700
31 500	99,671	99,712
40 000	99,684	99,724
50 000	99,696	99,734
63 000	99,709	99,745
80 000	99,723	99,758
≥100 000	99,737	99,770

NOTE:
Although the values in this table have been developed from 50 Hztransformer data, they are alsoapplicable to 60 Hz transformers.The cooling method of natural ester is KNAN.The cooling method of mineral oil is ONAN.

3.24 Core amorphous alloy

The core materials are primarily silicon steel and amorphous alloy, with amorphous alloy showing significant performance in reducing no-load losses in recent years.

The iron core cutting line has one set of industry-leading intelligent and automated vertical cutting equipment, two sets of horizontal cutting equipment, and is equipped with multiple high-precision stacking platforms, as well as fully automatic flipping platforms, fully sealed iron core surface treatment rooms that meet environmental requirements, and drying rooms. It can meet the complete set of operations for cutting, automatic stacking, and overall stacking of iron cores of different thicknesses of silicon steel coils, as well as completing overall surface treatment.

Working Principle

- An amorphous alloy transformer is a high-efficiency and energy-saving power equipment that uses amorphous alloy strips as its core material. Its core advantage lies in extremely low no-load loss (60%-80% lower than that of traditional silicon steel transformers), earning it the reputation of a "green revolution" in the power industry. Its working principle is based on the law of electromagnetic induction. When the primary coil is connected to an AC power source, an alternating magnetic flux is generated in the iron core. Owing to the excellent magnetic properties of the amorphous alloy core, which enables efficient conduction and conversion of magnetic field energy, the alternating magnetic flux induces a corresponding electromotive force in the secondary coil, thereby realizing voltage transformation. In this process, the low-loss characteristic of the amorphous alloy core significantly reduces the energy wasted during the energy conversion of the transformer, improving the energy utilization efficiency of the entire power system.

Core Material

- Amorphous alloy is a new type of metallic material. Unlike traditional crystalline materials with a regular lattice structure, its atoms are arranged in a disordered glassy structure—this is the reason it is called "amorphous". This special structure endows amorphous alloy with excellent magnetic properties: it has high magnetic permeability and low coercivity, which means the hysteresis loss is significantly reduced in an alternating magnetic field. Compared with traditional silicon steel sheets, amorphous alloy strips have a thickness only 1/10 that of silicon steel sheets and a resistivity 3 times higher, greatly reducing eddy current loss. Amorphous alloy also features a small hysteresis loop area; its coercivity is merely 1/7 that of silicon steel sheets, resulting in extremely low energy consumption for magnetization and demagnetization. The combined effect reduces the no-load loss by 60–80% compared with silicon steel transformers and decreases the no-load current by approximately 20%. Meanwhile, amorphous alloy also exhibits good corrosion resistance and wear resistance, which ensures transformers maintain stable performance during long-term operation.

3.24 Core amorphous alloy

Key Structural Design

- **Core Type:**
  Three-phase five-limb wound core structure with a rectangular cross-section. The lower yoke can be opened to facilitate coil assembly, and the stacking factor is relatively low (0.75–0.8).
- **Coil Technology:**
  Low-Voltage Winding: Copper wires are used for small-capacity models; for large-capacity models (e.g., above 500 kVA), a cylindrical structure wound with copper foil is adopted to enhance mechanical strength and short-circuit resistance[24].
  High-Voltage Winding: Multi-layer cylindrical structure, with a tightening tape wound on the outer layer to prevent bulging[47].
- **Sealing & Heat Dissipation:**
  Fully Sealed Corrugated Oil Tank: The oil conservator is eliminated, and a built-in air cushion is used to balance the pressure from oil volume expansion, enabling maintenance-free operation.
  Innovative Cooling Design: Serpentine insulating oil channels are arranged between the high-voltage and low-voltage windings to extend the oil flow path and improve heat dissipation efficiency.

Technical Specifications

Executive Standards	• **IEC60076-1** General Requirements for Power Transformers • **IEC60076-2** Temperature Rise of Power Transformers • **IEC60076-3** Insulation Levels, Insulation Tests and External Clearances of Power Transformers • **IEC60076-5** Short - Circuit Withstand Capability of Power Transformers • **GB/T 25446** Technical Parameters and Requirements for Oil - immersed Amorphous Alloy Core Distribution Transformers
Rated Capacity	2500 kVA and below
Rated High Voltage	10 kV
Rated Low Voltage	0.4 kV
Frequency	50 Hz
Connection Group Symbol	Dyn11
Tap Range	±5%; ±2×2.5%
Insulation Level	LI75AC35/AC5
Insulation Class	Class A
Cooling Method	ONAN
Service Conditions	**Altitude:** Not exceeding 1000 m **Ambient Temperature:** - 30℃ ~ + 40℃ **Relative Humidity:** In accordance with national standards **[Note] Special design can be carried out according to user requirements if exceeding normal service conditions**

3.24 Core amorphous alloy

Planar Core of Amorphous Alloy Oil-Immersed Transformer

Amorphous Alloy Three-Dimensional Wound Core

Planar Core of Amorphous Alloy Dry-Type Transformer

Performance Advantages

Parameter	Amorphous Alloy	Silicon Steel	Advantage Magnitude	Physical Significance
Coercive Force (Hc)	1.2~1.8 A/m	8~12 A/m	↓ 85%	Magnetization/Demagnetization Energy Consumption ↓ → Hysteresis Loss Sharply Reduced
Resistivity (ρ)	120~140 μΩ·cm	40~50 μΩ·cm	↑ 3 Times	Eddy Current Suppression Capability ↑ → High - Frequency Loss Reduced
Hysteresis Loop Area	Extremely Narrow	Relatively Wide	↓ 75%	Energy Loss Integration ↓ → No - Load Loss Reduced
Saturation Magnetic Flux Density (Bs)	1.56 T	2.03 T	↓ 23%	Larger Cross - Section Area Needed for Compensation at Same Power
Initial Permeability (μi)	20,000	7,000	↑ 185%	Easy to Magnetize → No - Load Current ↓ 75%

3.24 Core amorphous alloy

Performance Advantages

Index	Amorphous Alloy Transformer	Traditional Silicon Steel Transformer
No - load Loss	Extremely low, about 60% - 80% lower than that of silicon steel transformers	Relatively high
Applicable Load	Suitable for scenarios with low load rate and long no - load time	Suitable for scenarios with stable or relatively high load
Operating Cost	Low (due to extremely low no - load loss), payback period is about 2 - 3 years	Relatively high (due to relatively high no - load loss)
Rated Current Harmonic	Excellent（THD<2%）	THD<5%
Reliability	High (low temperature rise, slow insulation aging, long service life)	High, mature technology, widely applied and proven over time
Initial Cost	Relatively high, approximately 110% - 130% of that of silicon steel transformers	Relatively low, more economical
Short - circuit Withstand Capability	Relatively weak	Relatively strong, with a more robust and stable structure
Noise Level	Relatively high (due to the large magnetostriction of amorphous materials)	Relatively low, with better noise control
Weight	Relatively heavy, approximately 130% of that of silicon steel transformers with the same capacity	Relatively light
Impact Resistance and Maintainability	Poorer; the core should avoid collision or extrusion during transportation, installation, and maintenance	Relatively strong; the core has high impact resistance

3.25 Performance Characteristics of Natural Ester versus Mineral Oil in Power Transformers

parameter	Natural Ester Insulating Oil	Mineral Insulating Oil
Raw Material	Oilseed crops	Petroleum by-products
Flash Point (℃)	≥350	≤160
Dielectric Strength	≥60	≥40
Moisture Content	≤300	≤30
Relative Permittivity	3.2	2.2
Biodegradability	>98%	<30%
Volatility	Low	High
Reliability	High	Low
Safety	High	Low
Fire Resistance	Self-extinguishing	Combustible
Decommissioning Treatment	Environmentally friendly oil	Hazardous waste
Carbon Emission Level	K/55	K

3.26 Features and Benefits

Enhances transformer performance and grid reliability

- Significantly extends the lifespan of the insulation system by reducing thermal and oxidative stress.
- Improves overload capacity, enabling transformers to handle higher loads without compromising-performance or safety.
- Enhances grid stability by maintaining consistent performance under fluctuating load conditions and reducing the risk of unplanned outages.

Improves transformer safety

- Features a high fire point of 350℃, greatly reducing the risk of ignition under extreme conditions.
- Has no recorded fire incidents in field applications, demonstrating exceptional fire resistance andoperational safety.
- Minimizes explosion risks due to its high thermal stability and self-extinguishing properties in theevent of internal arcing faults.

Enhances environmental friendliness

- Fully biodegradable in soil and aquatic environments, minimizing ecological impact in case of leakage.
- Non-toxic and harmless to water, soil, and air, supporting sustainable infrastructure and greeninitiatives.
- Enables environmentally responsible disposal at end-of-life, aligning with circular economy principles and reducing long-term environmental liability.

Lower carbon emissions

- Emits only 1/55 of the carbon compared to mineral insulating oil throughout its lifecycle.
- Each ton of natural ester used reduces carbon emissions by approximately 1.12 tons, contributing toclimate goals and corporate sustainability targets.
- Supports carbon footprint reduction strategies for utilities and industrial operators, aiding compliance-with increasingly stringent environmental regulations.

Specification of TGOOD Oil Transformer

Standardand Tech.Agreement		Accordingto GB1094.11-2007 GB/T10228-2015 IEC60076-11 GB20052-2013 JB/T3837-2016 GB/T22072-2018		
Client Name				
Project Name				
Type				
Quantity		Set		
Number of Phase		Phase		
Frequency		Hz		
Rating		kVA		
Voltage Ratio		kV		
Tapping On HV		%		
Cooling Method				
Highest System Voltage		kV		
Power Frequency Withstand Voltage		kV		
Rated Lightning Impulse Withstand Voltage		kV		
Vector Group				
No Load Loss		kW		
Load Loss		kW		At ℃
Short Circuit Impedance		%		
Noise Level		dB		
Winding Material				HV Winding
Insulation Class				LV Winding
Temperature Rise		k		
Oil type				
Tank	Enclosure Protection Class			
	Terminal Incoming/Outgoing			
	Painting color			
	Anti-corrosion			
Thermometer	The output type of thermometer			
Special Test				
If any special requirements of the size or weight for location and transportation passage				
If the customer has a equipment number				
Environment Temperature			Min	Max
Altitude				
Packing Method				
Transportation				
Attached Documents	Quantity			
	Language			
The final destination of the goods				
Remarks:				

Certificates