TRANSFORMERS MAGAZINE'S
INDUSTRY NAVIGATOR

INVESTMENTS, ARTIFICIAL INTELLIGENCE AND SUSTAINABILITY

CONFERENCE 2024

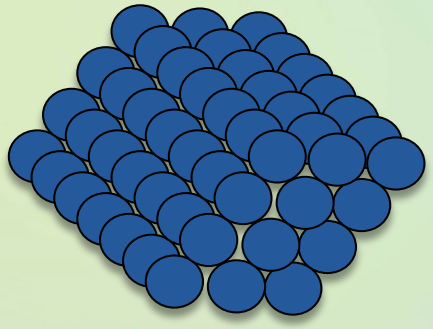
# Amorphous Material: The Solution for Sustainability and Carbon Neutrality

**Eden Tang**

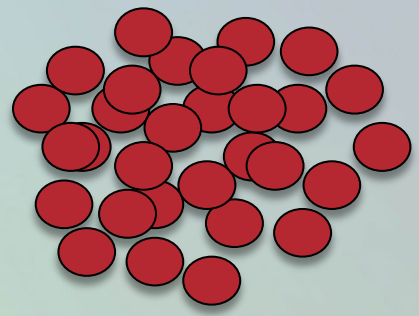
**12 June 2024**

# Contents

# What is amorphous alloy?



Conventional metallic materials exhibit a crystalline structure when in solid state.

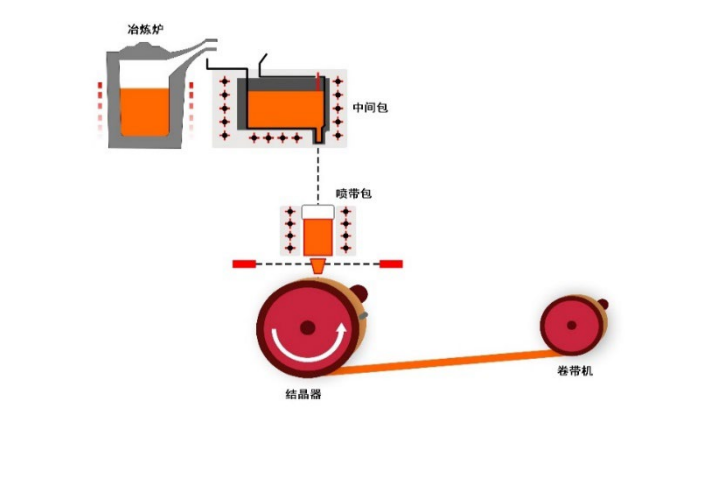


Amorphous alloy metals exhibit a non-crystalline structure when in solid state. This micro structure is very much like that of liquid metal or glass.

Because of the different microstructure, amorphous alloy has excellent soft magnetic properties: **low coercivity, high permeability, high electrical resistance.**
These properties make iron based amorphous alloy ribbon an ideal material for **distribution transformer cores**.

# Advantage of Amorphous alloy: Environmentally friendly Manufacturing

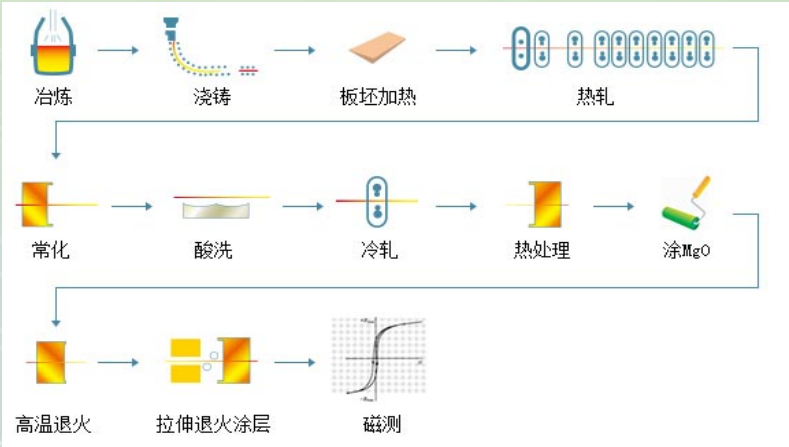
**Amorphous ribbon production process**




~10m

Molten steel is rapidly cooled at a rate of **1,000,000℃/s** , the thickness of ribbon is only **0.03mm**

**Silicon steel production process**

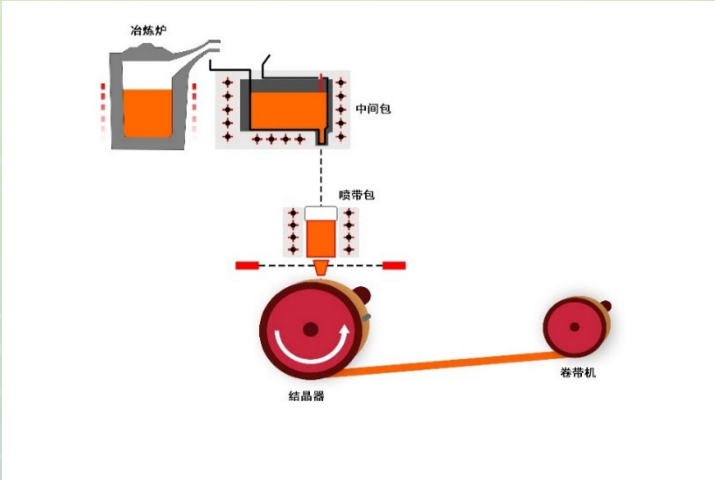



~1000m

The $CO_2$ emission per ton of amorphous ribbon production is **730kg** less than that of silicon steel

# Advantage of Amorphous alloy: Environmentally friendly Manufacturing

Molten steel is rapidly cooled at a rate of **1,000,000℃/s** ,
the thickness of ribbon is only
**0.03mm**




3.10 kg $CO_2$ CQC

CERTIFICATE OF PRODUCT CARBON FOOTPRINT

CERTIFICATE NO.: PCF-2023-CL-0114

Valid from: 3rd August,2023
Valid until: 2nd August,2025

CQC issues a certificate according to related verification procedures to confirm the authenticity and validity of the following contents:

| | |
|---|---|
| *Name/Specification* | Fe-based amorphous alloy ribbon |
| *Applicant/Address* | Qingdao Yunlu Advanced Materials Technology Co., Ltd. No 7, Xinyuan East Road, Lancun Town, Jimo City, Qingdao City, Shandong Province, P.R. China. |
| *Manufacturer/Address* | Qingdao Yunlu Advanced Materials Technology Co., Ltd. No 7, Xinyuan East Road, Lancun Town, Jimo City, Qingdao City, Shandong Province, P.R. China. |
| *Factory/Address* | Qingdao Yunlu Advanced Materials Technology Co., Ltd. No 7, Xinyuan East Road, Lancun Town, Jimo City, Qingdao City, Shandong Province, P.R. China. |
| *Data Collection Period* | 2022.01.01-2022.12.31 |
| *Functional Unit* | 1 kg Fe-based amorphous alloy ribbon |
| *Product Carbon Footprint Data Per Functional Unit* | 3.10 $kgCO_2e$ |
| *Standards and/or Rules Followed in Verification* | ISO14067 / PAS2050 |
| *System Boundary* | Cradle-to-Gate |
| *Carbon Emission Proportion in Each Stage* | 72.45% 原材料获取; 27.55% 产品生产 |

SIGNATURE: 谢肇煦

CHINA QUALITY CERTIFICATION CENTRE

中国质量认证中心 CHINA QUALITY CERTIFICATION CENTRE

http://www.cqc.com.cn Section 9, No.188, Nansihuan Xilu, Beijing 100070 P.R.China Tel: +86 10 83886666

# CERTIFICATE OF PRODUCT CARBON FOOTPRINT

# Shows that Amorphous alloy's:

*Product Carbon Footprint Data Per Functional Unit* **3.10** $kgCO_2e$

**The carbon footprint of silicon steel is about 3.8kg $CO_2$/kg, which is much higher than the carbon footprint data of amorphous ribbon.**

| 材料 | 符 号 | 碳排放因子默认值/($kgCO_2e$/kg) |
|---|---|---|
| 硅钢片 | $EF_{Fe}$ | 3.8 |
| 非晶合金 | $EF_{Aa}$ | 3.07 |

CNCA

国家认证认可监督管理委员会
Certification and Accreditaion Administration of the P.R.C

CQC

中国质量认证中心
CHINA QUALITY CERTIFICATION CENTRE

# Advantage of Amorphous alloy: Environmentally friendly Manufacturing

**① Recycling scrap cores**

**② Crush**

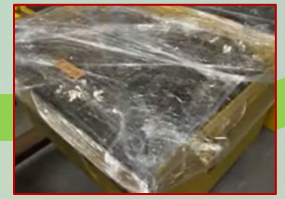
Use machine to grind the scrap cores

**③ Magnetic separation**

Separate useless substances (epoxy) from amorphous bands

**④ Flush and dry**

Clean and dry the amorphous material



**⑤ Packaging**

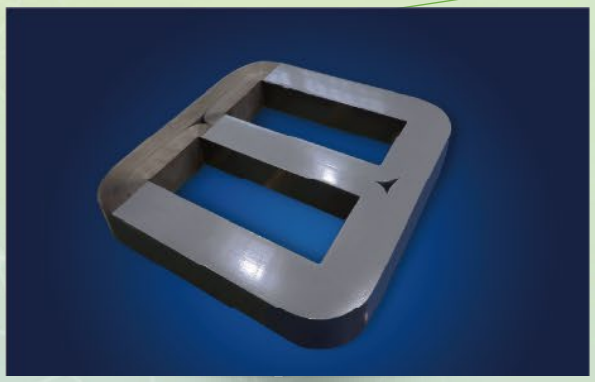
Pack the cleand amorphous ribbon

**⑥ As amorphous raw material, remelting in the furnace**

Remelting in furnace, making full use of production of amorphous ribbon again

# The uses of Amorphous alloy

**Amorphous alloy** is usually called metal glass or liquid metal, which is a new type of high-efficiency soft magnetic material.



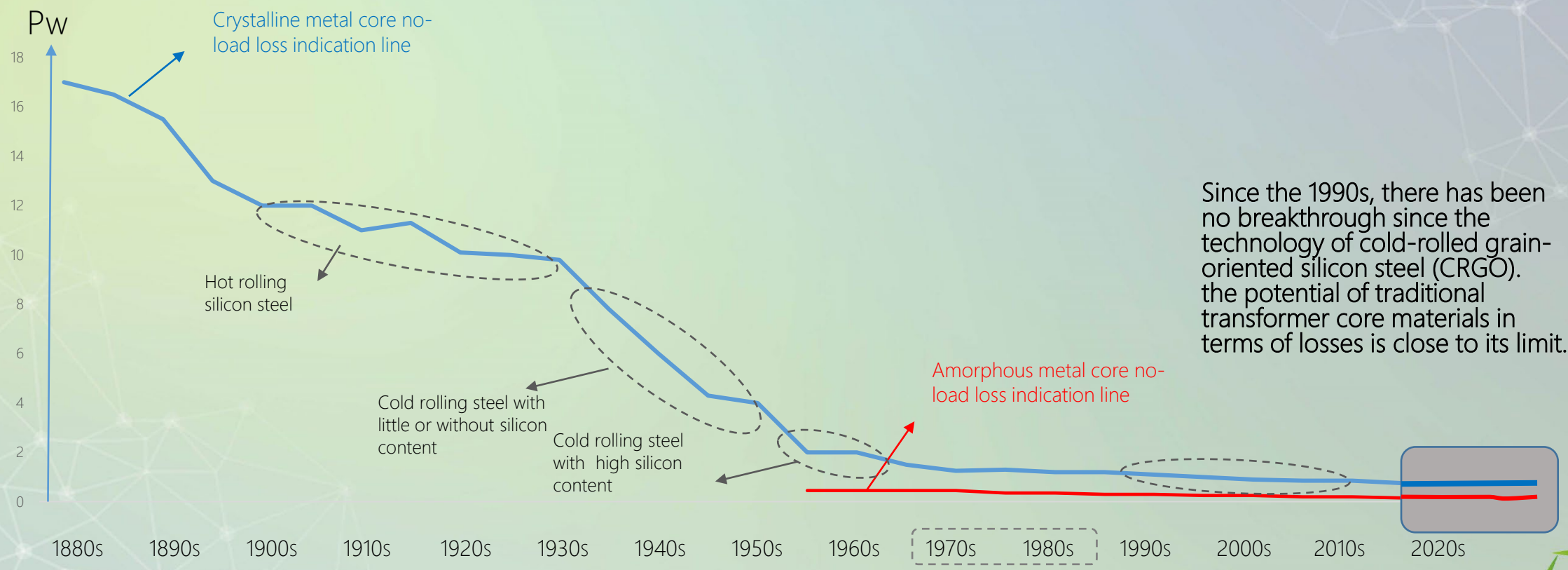
Amorphous evans core

Amorphous wound core

Amorphous 3D core

**Amorphous core** is the product of amorphous alloy and the core component of amorphous transformer. Compared with GOES (grain-oriented silicon steel) core transformers, its no-load loss can be reduced by **60%-80%.**

# The development history of transformer core material



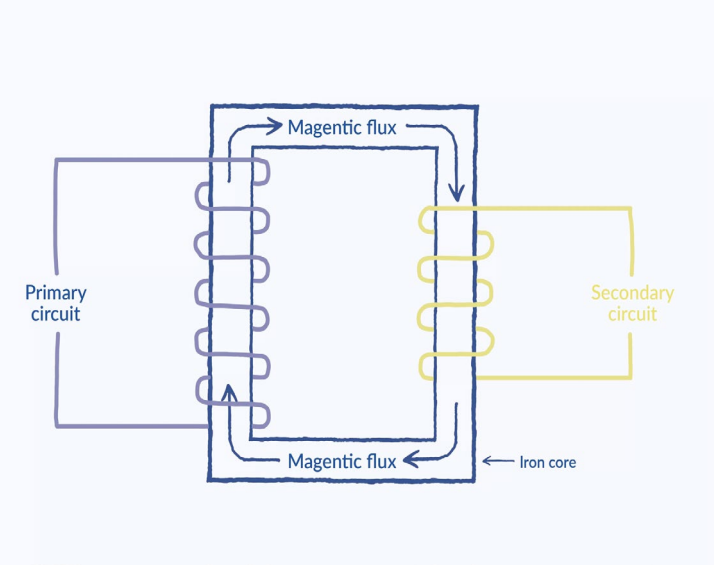

Since the 1990s, there has been no breakthrough since the technology of cold-rolled grain-oriented silicon steel (CRGO). the potential of traditional transformer core materials in terms of losses is close to its limit.

# Comparison of various properties between Amorphous alloy and CRGO

| **Magnetic properties** | CRGO23RK075 | Amorphous alloy |
|---|---|---|
| Saturation magnetic density Bs（T） | 1.9 | 1.63 |
| Coercivity Hc（A/m） | <30 | <4.0 |
| The maximum permeability μ | $4\times10^4$ | $25\times10^4$ |
| Iron loss (W/kg) | P<0.75 W/kg @50Hz,1.4T | P<0.16W/kg @50Hz,1.4T |
| Magneto metric stretch coefficient | $2*10^{-6}$ | $27*10^{-6}$ |

| **Mechanical properties** | CRGO23RK075 | Amorphous alloy |
|---|---|---|
| Lamination factor | 0.95 | 0.88 |
| Resistivity（μΩ· cm） | 45 | 130 |
| density（g/cm3） | 7.65 | 7.27-7.30 |
| Curie temperature（℃） | 746 | 415 |
| tensile strength（Mpa） | 343 | 1645~1767 |
| thickness（μm） | 50-500 | 20-30 |
| Vickers hardness（Hv） | 181 | 984-1000 |

# Basic principle of energy loss in transformer




Schematic diagram of the transformer principle

The most important components of a transformer are the core and coils.

Transformer losses represent energy losses during voltage conversion. the loss of transformer is mainly composed of two parts: **no-load loss and load loss**.

**The no-load loss** is determined by the core construction.

**The load loss** is determined by the coil construction.

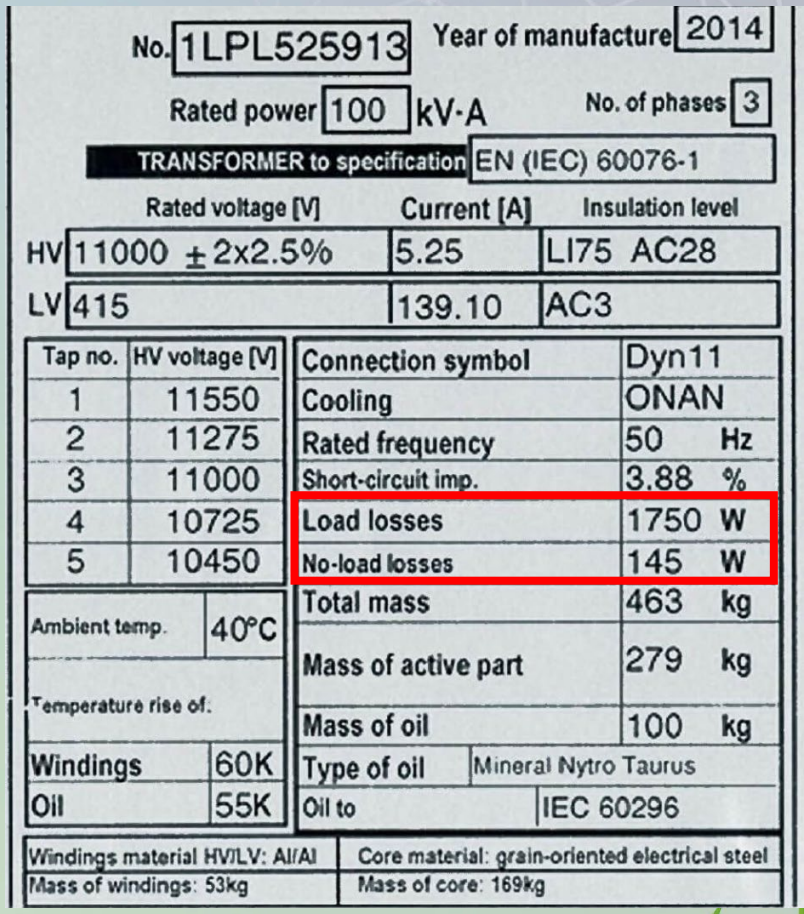
**At present, the core of the distribution transformer is usually made of CRGO (**cold-rolled grain-oriented silicon steel**). Compared to this material, amorphous has much lower no-load losses.**

# How to calculate actual losses in transformers?

The **no-load losses** in a transformer refer to the losses produced by the transformer when no one is drawing energy from the transformer. The **load losses** in the transformer are the additional losses generated when the transformer is fully loaded (maximum output power).

The **total losses in transformer**= no-load loss + load loss * the square of the load rate.

**The total losses generated by the transformer during operation are closely related to the load rate.**
Next, we will discuss the load rate of distribution transformers.



| | | | |
|---|---|---|---|
| No. 1LPL525913 | | Year of manufacture 2014 | |
| Rated power 100 kV·A | | No. of phases 3 | |
| TRANSFORMER to specification EN (IEC) 60076-1 | | | |
| | Rated voltage [V] | Current [A] | Insulation level |
| HV | 11000 ±2x2.5% | 5.25 | LI75 AC28 |
| LV | 415 | 139.10 | AC3 |

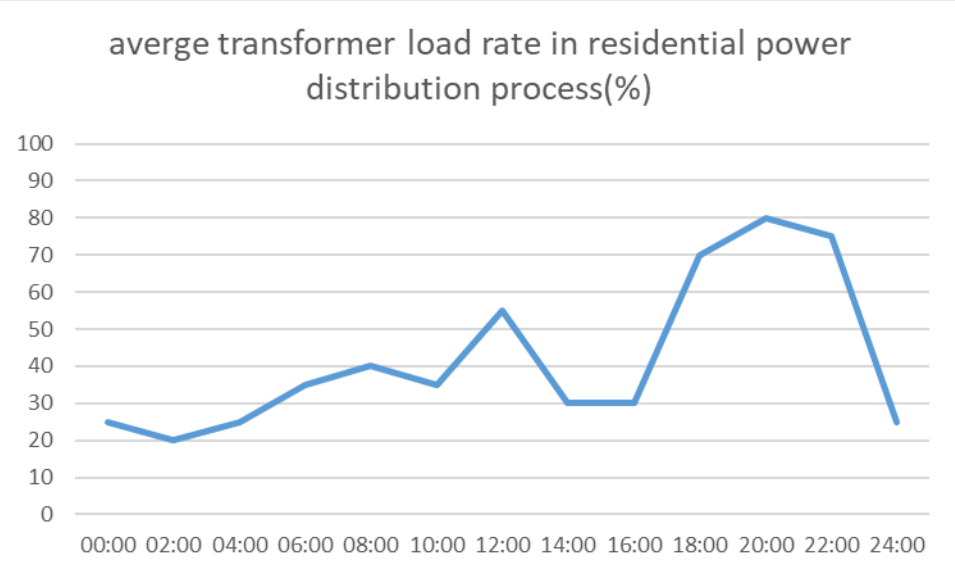
| Tap no. | HV voltage [V] |
|---|---|
| 1 | 11550 |
| 2 | 11275 |
| 3 | 11000 |
| 4 | 10725 |
| 5 | 10450 |

| | |
|---|---|
| Ambient temp. | 40°C |
| Temperature rise of. | |
| Windings | 60K |
| Oil | 55K |

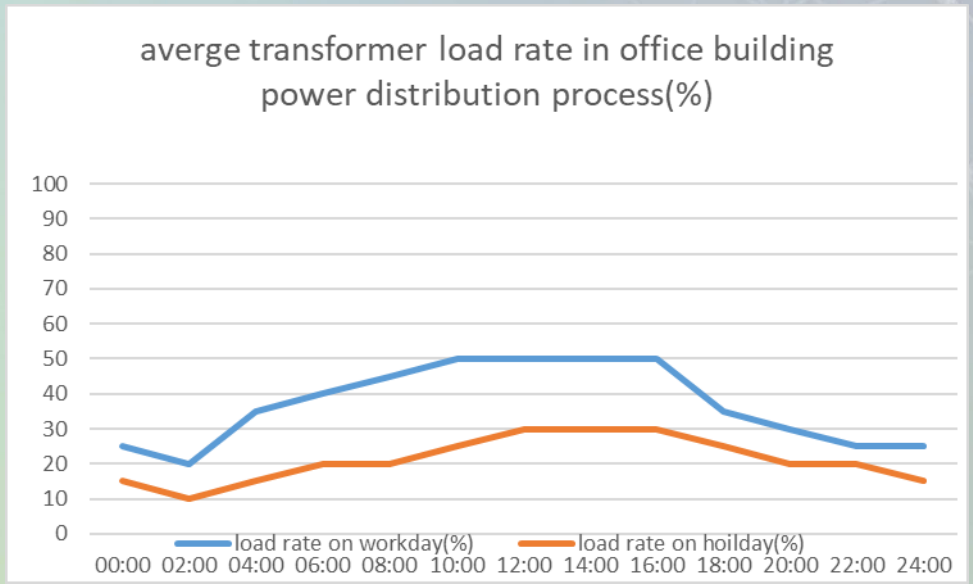
| | |
|---|---|
| Connection symbol | Dyn11 |
| Cooling | ONAN |
| Rated frequency | 50 Hz |
| Short-circuit imp. | 3.88 % |
| Load losses | 1750 W |
| No-load losses | 145 W |
| Total mass | 463 kg |
| Mass of active part | 279 kg |
| Mass of oil | 100 kg |
| Type of oil | Mineral Nytro Taurus |
| Oil to | IEC 60296 |

| | |
|---|---|
| Windings material HV/LV: Al/Al | Core material: grain-oriented electrical steel |
| Mass of windings: 53kg | Mass of core: 169kg |

# Why is it important to reduce no-load losses?

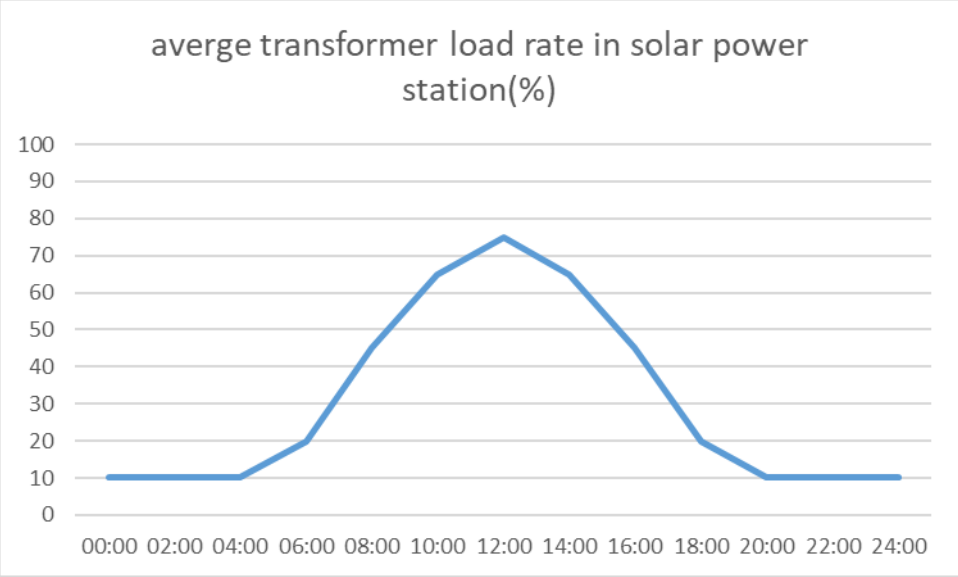



In the **residential power distribution process**, the peak load and valley load of the transformer are quite different. Especially with the popularization of electric vehicles, the load rate of residential distribution transformers usually reaches close to 80% from 18:00 to 22:00 and will be lower during other time periods.

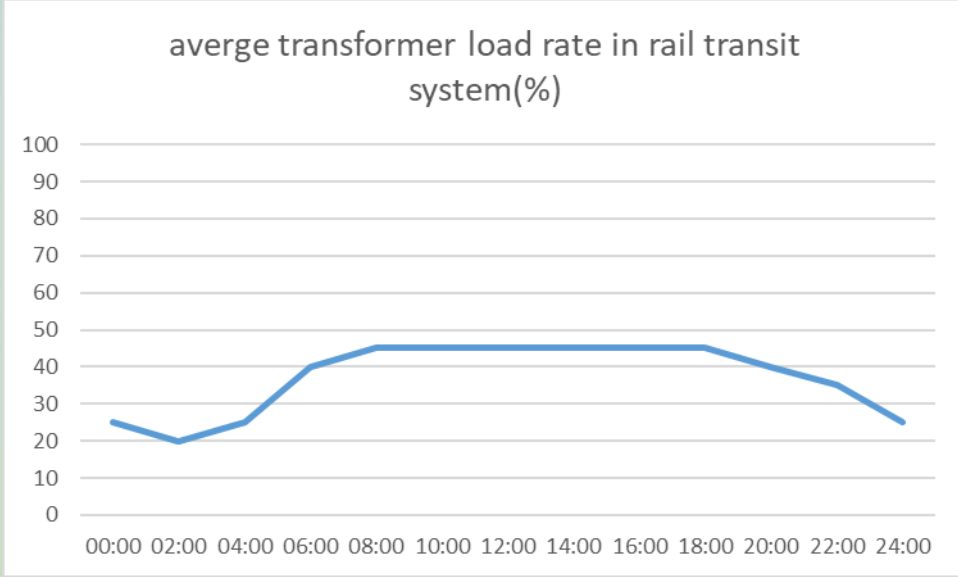



In the **office building power distribution process**, the load rate is higher (close to 50%) on working time (8:00AM to 6:00PM), but lower in other time. On weekends or holidays, it would be lower than 30%for the whole day.

# Why is it important to reduce no-load losses?




In **solar power stations**, transformers will only have an effective load during the day (6:00 to 18:00), and the load rate will reach the peak at 12:00 noon, usually 75%-80%. If the different seasons and weather are taken into consideration, the average load rate is even lower.




In the field of **rail transit**, the load rate of the transformers will be below 50%. Compared with other occasions, the change is not drastic. This is because rail transit usually requires higher equipment reliability and will install extra transformers as redundancy.

# Advantage of Amorphous alloy: Economical benefit

| Material | CRGO (23RK075) | Amorphous AYFA-N |
|---|---|---|
| Average FOB price in the first quarter of 2024 (EUR/kg) | 4.5 | 2.6 |

The price of CRGO will rise in the short term this year and remain stable. According to predictions, the market price will be around 4.5 EUR/kg.

**Amorphous alloy prices have been in a stable range last year and will not change much this year too.**

# Advantage of Amorphous alloy: Economical benefit

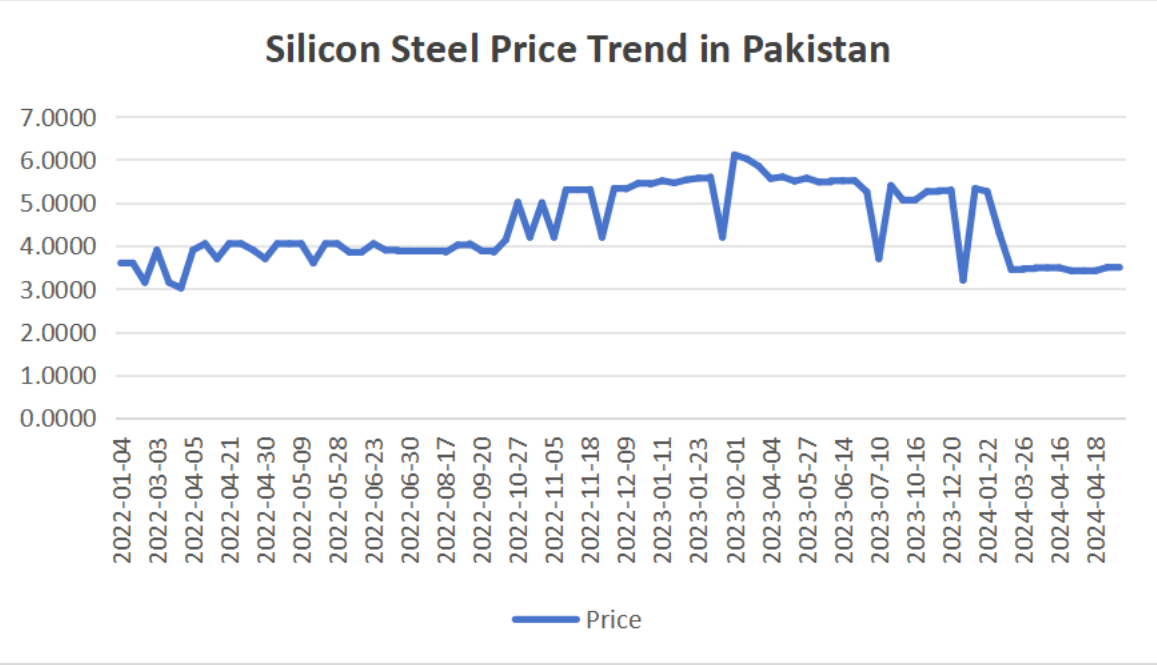
The manufacturing cost of amorphous transformers is higher than that of silicon steel transformers. But the electrical energy saved during its operation far exceeds its excess manufacturing cost. Calculated using average electricity prices in Europe (0.32 EUR/kWh), Life span of transformer is assumed 30 years:

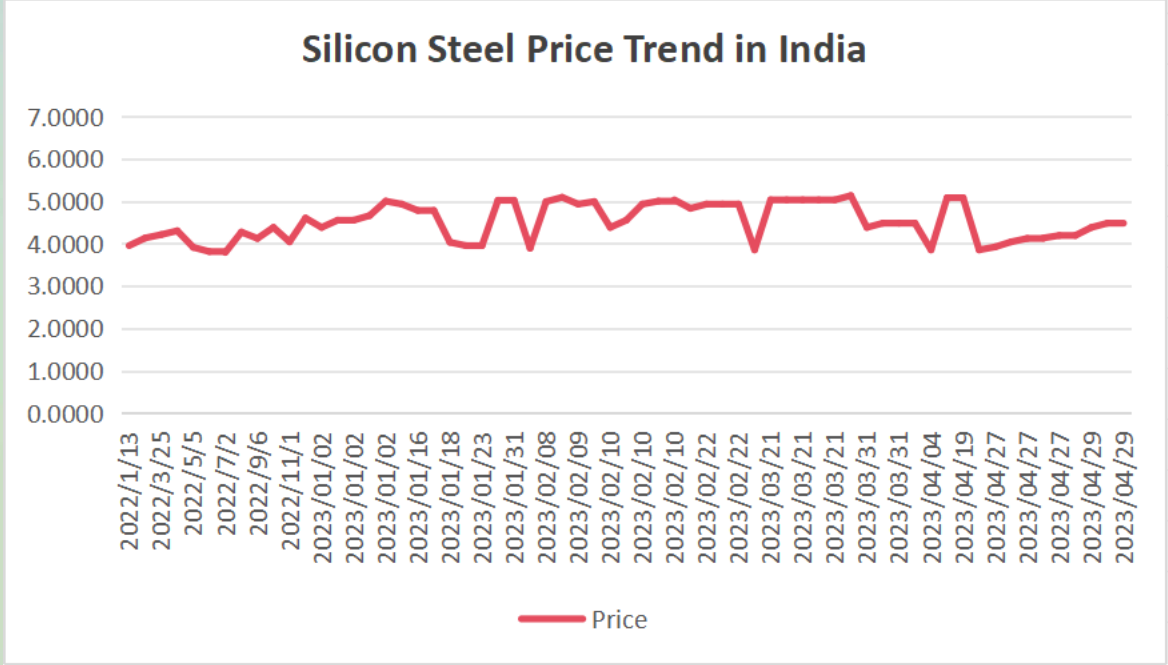
| Transformer type | CRGO | Amorphous alloy |
|---|---|---|
| Capacity | 100 kVA | 100 kVA |
| No-load losses | 130 W | 50 W |
| Load losses | 1750 W | 1750 W |
| Total losses (40% load rate) | 410 W | 330 W |
| Saved power (yearly) | 691.2 kWh | |
| Saved electricity price (yearly) | 221.18 EUR | |
| Saved electricity price (life span) | 6635.4 EUR | |

Under the same load loss, the manufacturing cost of a 100kVA amorphous transformer is usually no more than 15% (about €400) higher than that of a silicon steel transformer.

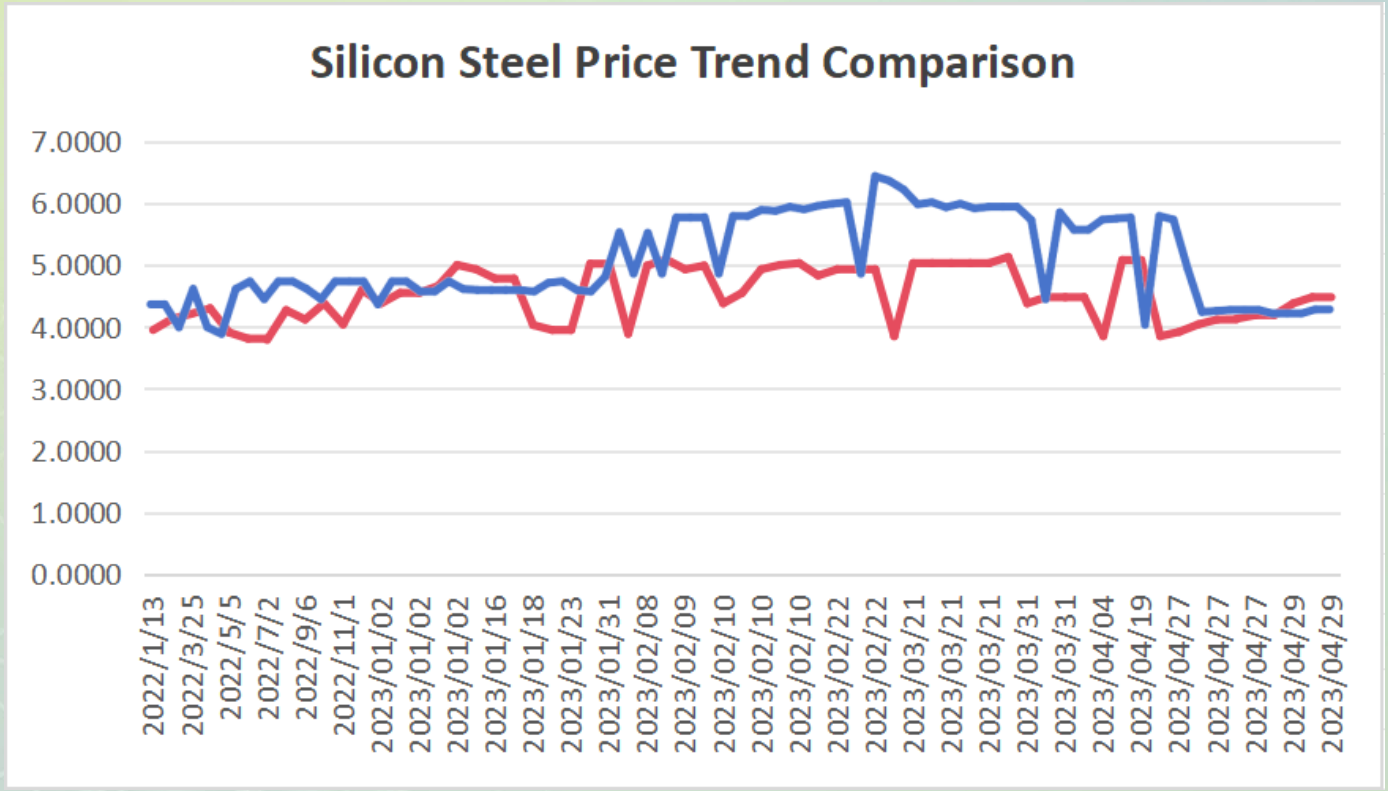
Recycling cycle: 2-5 years (depends on electricity price)

# Advantage of Amorphous alloy: Economical benefit



# Advantage of Amorphous alloy: Economical benefit




When silicon steel price increases, the market which does not have amorphous core as a complementary commodity in the country (Pakistan) will face a more substantial price increase, for transformer manufacturers and power utilities, the supply chain system will be facing a greater impact.

# Clarification and the future of amorphous alloy

## Misconception

Amorphous transformers have lager size, and the cost of amorphous transformers are higher.

## Fact

The cost and volume of amorphous transformers versus CRGO transformers depends on the designing energy conversion efficiency.

It has been proven that amorphous transformers have a cost advantage when energy efficiency requirements are higher. Compared with the low-magnetic density design of the CRGO transformer, its size and weight are almost the same.

The design magnetic density of amorphous transformers is usually 1.4T, and the design magnetic density of CRGO transformers is usually 1.7T. A higher design magnetic density will increase the no-load loss, so when energy efficiency requirements are high, CRGO transformers need to increase the design magnetic density. reduced to meet energy efficiency requirements.
Lower design magnetic density will increase the size of the transformer. Therefore, when the design magnetic density is reduced, the difference in volume between CRGO transformers and amorphous transformers will be reduced.

# Clarification and the future of amorphous alloy

## Misconception

Amorphous transformers cannot be repaired, and as operating time increases, the transformers become unstable.

## Fact

Amorphous transformers can be repaired. Well-designed amorphous transformers have good stability and life cycle.

When repairing amorphous transformers, the core is usually replaced rather than reused. The core of amorphous transformers can be directly recycled as raw material for amorphous ribbon, but CRGO can not.

According to existing analysis reports, amorphous transformers still have good performance after 15 years of operation. There is no evidence that amorphous transformers will fail simply because of the amorphous material.

# Clarification and the future of amorphous alloy

Table 1 Retesting of technical parameters of amorphous alloy distribution transformers after grid operation

| Product No. | Capacity/kVA | Testing Time | No-Load loss/kVA |
|---|---|---|---|
| 100706 | 500 | 2010-07-06 | 190 |
| | | 2018-9-26 | 194 |
| 100718 | 200 | 2010-07-18 | 120 |
| | | 2015-07-02 | 117 |
| 100705 | 400 | 2010-07-05 | 170 |
| | | 2019-03-25 | 173 |

Table 2 Retesting of technical parameters of amorphous alloy distribution transformers after grid operation

| Product No. | Capacity/kVA | Testing time | Operation time span | No-load loss/W |
|---|---|---|---|---|
| 060135-10 | 250 | 2006-02-20 | 15 | 127 |
| | | 2021-08-18 | | 136 |
| 070171-4 | 160 | 2007-02-11 | 14 | 80 |
| | | 2021-08-18 | | 85 |

Amorphous transformer core replacement

It can be seen from the data that the no-load loss value of amorphous transformers will not increase by more than 5% after long-term actual operation.

# Clarification and the future of amorphous alloy

## Misconception

Amorphous materials are only suitable for small capacity transformers

## Fact

Amorphous transformers exceeding 1MVA are very common, and amorphous transformers can reach capacities exceeding 5MVA.

5500 kVA wind power step-up amorphous transformer

3300 kVA traction rectifier amorphous transformer

# Clarification and the future of amorphous alloy

CMA 170008221380 · CNAS 中国认可 国际互认 检测 TESTING CNAS L1020

实验室名称：苏州电器科学研究院股份有限公司
国家电器产品质量检验检测中心

Lab Name: Suzhou Electrical Apparatus Science Research Institute Co., Ltd. China National Center for Quality Inspection and Test of Electrical Apparatus Products

№ 22U0104-S

## 型式试验报告
## Type Test Report

委 托 单 位：青岛云路先进材料技术股份有限公司
Client: Qingdao Yunlu Advanced Materials Technology Co., Ltd

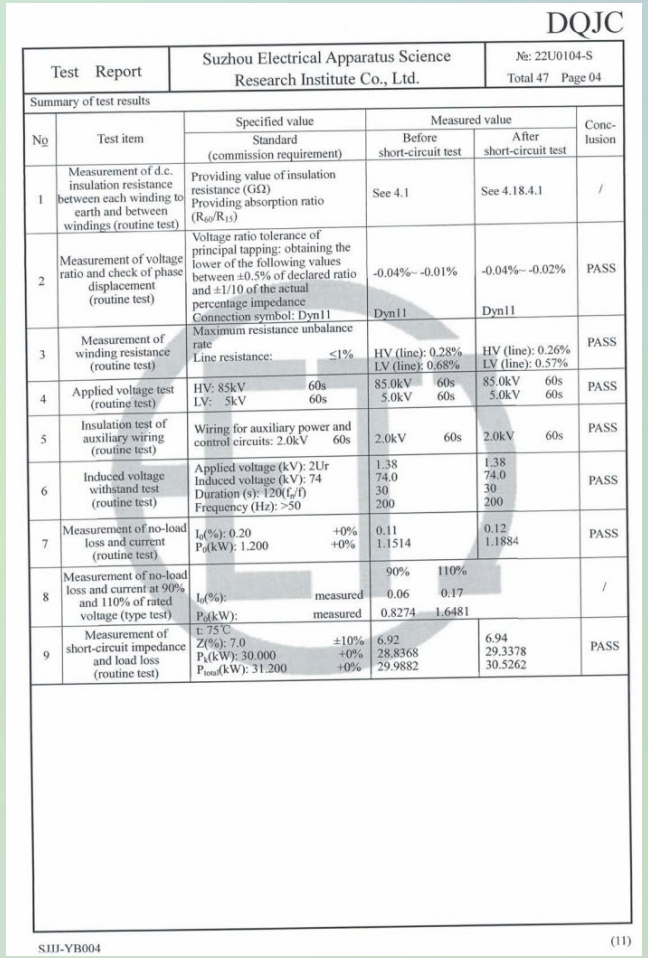
产 品 名 称：非晶合金配电变压器
Name of Product: Amorphous alloy distribution transformer

产 品 型 号：SBH25-M-5500/35-NX1
Product Type: SBH25-M-5500/35-NX1

检 验 类 别：型式试验
Test Category: Type test

本实验室对出具的检验（试验）结果负责，未经实验室书面同意，不得部分地复制本报告。

The laboratory is responsible for the inspection (Test) results. The report shall not be reproduced except in full, written approval of the laboratory.



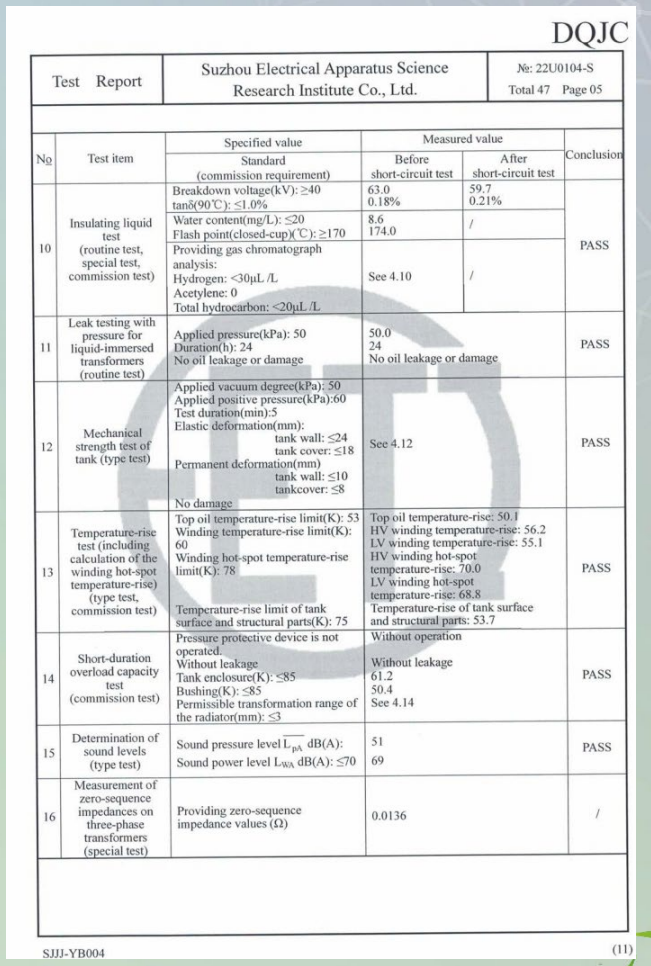
DQJC

| Test Report | Suzhou Electrical Apparatus Science Research Institute Co., Ltd. | №: 22U0104-S Total 47 Page 04 |
|---|---|---|

Summary of test results

| № | Test item | Specified value: Standard (commission requirement) | Measured value: Before short-circuit test | Measured value: After short-circuit test | Conclusion |
|---|---|---|---|---|---|
| 1 | Measurement of d.c. insulation resistance between each winding to earth and between windings (routine test) | Providing value of insulation resistance (GΩ)<br>Providing absorption ratio ($R_{60}/R_{15}$) | See 4.1 | See 4.18.4.1 | / |
| 2 | Measurement of voltage ratio and check of phase displacement (routine test) | Voltage ratio tolerance of principal tapping: obtaining the lower of the following values between ±0.5% of declared ratio and ±1/10 of the actual percentage impedance<br>Connection symbol: Dyn11 | -0.04%~ -0.01%<br>Dyn11 | -0.04%~ -0.02%<br>Dyn11 | PASS |
| 3 | Measurement of winding resistance (routine test) | Maximum resistance unbalance rate<br>Line resistance: ≤1% | HV (line): 0.28%<br>LV (line): 0.68% | HV (line): 0.26%<br>LV (line): 0.57% | PASS |
| 4 | Applied voltage test (routine test) | HV: 85kV 60s<br>LV: 5kV 60s | 85.0kV 60s<br>5.0kV 60s | 85.0kV 60s<br>5.0kV 60s | PASS |
| 5 | Insulation test of auxiliary wiring (routine test) | Wiring for auxiliary power and control circuits: 2.0kV 60s | 2.0kV 60s | 2.0kV 60s | PASS |
| 6 | Induced voltage withstand test (routine test) | Applied voltage (kV): 2Ur<br>Induced voltage (kV): 74<br>Duration (s): 120($f_r$/f)<br>Frequency (Hz): >50 | 1.38<br>74.0<br>30<br>200 | 1.38<br>74.0<br>30<br>200 | PASS |
| 7 | Measurement of no-load loss and current (routine test) | $I_0$(%): 0.20 +0%<br>$P_0$(kW): 1.200 +0% | 0.11<br>1.1514 | 0.12<br>1.1884 | PASS |
| 8 | Measurement of no-load loss and current at 90% and 110% of rated voltage (type test) | | 90% 110%<br>$I_0$(%): measured 0.06 0.17<br>$P_0$(kW): measured 0.8274 1.6481 | | / |
| 9 | Measurement of short-circuit impedance and load loss (routine test) | t: 75℃<br>Z(%): 7.0 ±10%<br>$P_k$(kW): 30.000 +0%<br>$P_{total}$(kW): 31.200 +0% | 6.92<br>28.8368<br>29.9882 | 6.94<br>29.3378<br>30.5262 | PASS |

SJJ-YB004 (11)



DQJC

| Test Report | Suzhou Electrical Apparatus Science Research Institute Co., Ltd. | №: 22U0104-S Total 47 Page 05 |
|---|---|---|

| № | Test item | Specified value: Standard (commission requirement) | Measured value: Before short-circuit test | Measured value: After short-circuit test | Conclusion |
|---|---|---|---|---|---|
| 10 | Insulating liquid test (routine test, special test, commission test) | Breakdown voltage(kV): ≥40<br>tanδ(90℃): ≤1.0%<br>Water content(mg/L): ≤20<br>Flash point(closed-cup)(℃): ≥170<br>Providing gas chromatograph analysis:<br>Hydrogen: <30μL /L<br>Acetylene: 0<br>Total hydrocarbon: <20μL /L | 63.0<br>0.18%<br>8.6<br>174.0<br>See 4.10 | 59.7<br>0.21%<br>/<br>/ | PASS |
| 11 | Leak testing with pressure for liquid-immersed transformers (routine test) | Applied pressure(kPa): 50<br>Duration(h): 24<br>No oil leakage or damage | 50.0<br>24<br>No oil leakage or damage | | PASS |
| 12 | Mechanical strength test of tank (type test) | Applied vacuum degree(kPa): 50<br>Applied positive pressure(kPa):60<br>Test duration(min):5<br>Elastic deformation(mm):<br>tank wall: ≤24<br>tank cover: ≤18<br>Permanent deformation(mm)<br>tank wall: ≤10<br>tankcover: ≤8<br>No damage | See 4.12 | | PASS |
| 13 | Temperature-rise test (including calculation of the winding hot-spot temperature-rise) (type test, commission test) | Top oil temperature-rise limit(K): 53<br>Winding temperature-rise limit(K): 60<br>Winding hot-spot temperature-rise limit(K): 78<br>Temperature-rise limit of tank surface and structural parts(K): 75 | Top oil temperature-rise: 50.1<br>HV winding temperature-rise: 56.2<br>LV winding temperature-rise: 55.1<br>HV winding hot-spot temperature-rise: 70.0<br>LV winding hot-spot temperature-rise: 68.8<br>Temperature-rise of tank surface and structural parts: 53.7 | | PASS |
| 14 | Short-duration overload capacity test (commission test) | Pressure protective device is not operated.<br>Without leakage<br>Tank enclosure(K): ≤85<br>Bushing(K): ≤85<br>Permissible transformation range of the radiator(mm): ≤3 | Without operation<br>Without leakage<br>61.2<br>50.4<br>See 4.14 | | PASS |
| 15 | Determination of sound levels (type test) | Sound pressure level $\overline{L_{pA}}$ dB(A):<br>Sound power level $L_{WA}$ dB(A): ≤70 | 51<br>69 | | PASS |
| 16 | Measurement of zero-sequence impedances on three-phase transformers (special test) | Providing zero-sequence impedance values (Ω) | 0.0136 | | / |

SJJ-YB004 (11)

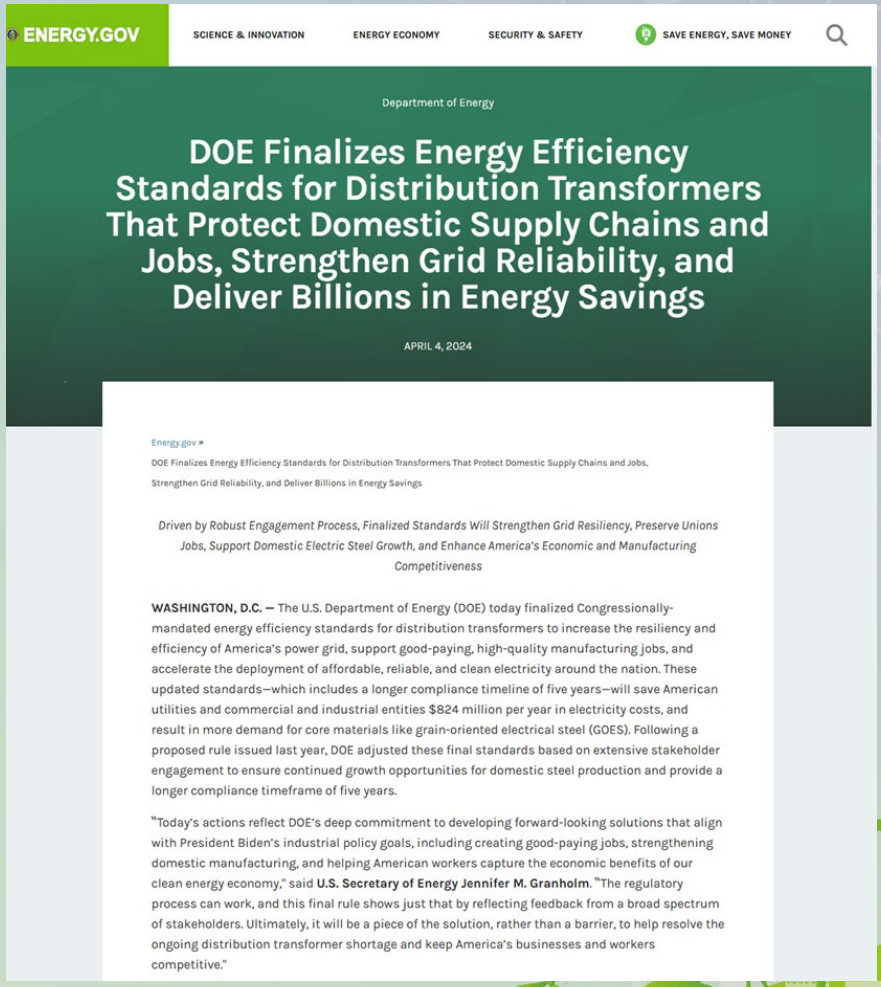
# The answer to the global carbon neutralization trend in USA

**4th April. 2024, DOE (Department of energy, America) finalized new energy-efficiency standards for three categories of distribution transformers to improve the resiliency of America's power grid, lower utility bills, and significantly reduce domestic carbon-dioxide ($CO_2$) emissions. The new law will be officially implemented in 2029.**

**New energy efficiency standards for three categories of distribution transformers to improve the resiliency of America's power grid, lower utility bills, and significantly reduce domestic carbon-dioxide ($CO_2$) emissions.**

**U.S.: Amorphous Transformer adoption will increase from Less than 5% to at least 25% before 2029.**

**Source:** DOE Finalizes Energy Efficiency Standards for Distribution Transformers That Protect Domestic Supply Chains and Jobs, Strengthen Grid Reliability, and Deliver Billions in Energy Savings | Department of Energy



ENERGY.GOV SCIENCE & INNOVATION ENERGY ECONOMY SECURITY & SAFETY SAVE ENERGY, SAVE MONEY

Department of Energy

DOE Finalizes Energy Efficiency Standards for Distribution Transformers That Protect Domestic Supply Chains and Jobs, Strengthen Grid Reliability, and Deliver Billions in Energy Savings

APRIL 4, 2024

Energy.gov »

DOE Finalizes Energy Efficiency Standards for Distribution Transformers That Protect Domestic Supply Chains and Jobs, Strengthen Grid Reliability, and Deliver Billions in Energy Savings

*Driven by Robust Engagement Process, Finalized Standards Will Strengthen Grid Resiliency, Preserve Unions Jobs, Support Domestic Electric Steel Growth, and Enhance America's Economic and Manufacturing Competitiveness*

**WASHINGTON, D.C. –** The U.S. Department of Energy (DOE) today finalized Congressionally-mandated energy efficiency standards for distribution transformers to increase the resiliency and efficiency of America's power grid, support good-paying, high-quality manufacturing jobs, and accelerate the deployment of affordable, reliable, and clean electricity around the nation. These updated standards—which includes a longer compliance timeline of five years—will save American utilities and commercial and industrial entities $824 million per year in electricity costs, and result in more demand for core materials like grain-oriented electrical steel (GOES). Following a proposed rule issued last year, DOE adjusted these final standards based on extensive stakeholder engagement to ensure continued growth opportunities for domestic steel production and provide a longer compliance timeframe of five years.

"Today's actions reflect DOE's deep commitment to developing forward-looking solutions that align with President Biden's industrial policy goals, including creating good-paying jobs, strengthening domestic manufacturing, and helping American workers capture the economic benefits of our clean energy economy," said **U.S. Secretary of Energy Jennifer M. Granholm.** "The regulatory process can work, and this final rule shows just that by reflecting feedback from a broad spectrum of stakeholders. Ultimately, it will be a piece of the solution, rather than a barrier, to help resolve the ongoing distribution transformer shortage and keep America's businesses and workers competitive."

# The answer to the global carbon neutralization trend in China

**On December 22nd, 2020, MIIT, The State Administration for Market Regulation and the NEA jointly issued the "Transformer Energy Efficiency Improvement Plan (2021-2023)", which calls for increasing the promotion of high-efficiency and energy-saving transformers. From June 2021, new transformers must meet the requirements of national energy efficiency standards, and the use of energy-efficient transformers is encouraged.**

**Time being:**

**China state grid: Amorphous oil-immersed distribution transformer accounts for 58% tender volume;**

**China Southern power grid: Amorphous oil-immersed distribution transformer accounts for 53% tender volume.**

**Level 1** **Level 2** **Level 3**

SST AMT SST AMT SST AMT

| 额定容量 kVA | 1级 | | | | | | 2级 | | | | | | 3级 | | | | | | 短路阻抗 % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 电工钢带 | | | 非晶合金 | | | 电工钢带 | | | 非晶合金 | | | 电工钢带 | | | 非晶合金 | | | |
| | 空载损耗 W | 负载损耗 W | | 空载损耗 W | 负载损耗 W | | 空载损耗 W | 负载损耗 W | | 空载损耗 W | 负载损耗 W | | 空载损耗 W | 负载损耗 W | | 空载损耗 W | 负载损耗 W | | |
| | | Dyn11/Yzn11 | Yyn0 | | Dyn11/Yzn11 | Yyn0 | | Dyn11/Yzn11 | Yyn0 | | Dyn11/Yzn11 | Yyn0 | | Dyn11/Yzn11 | Yyn0 | | Dyn11/Yzn11 | Yyn0 | |
| 30 | 65 | 455 | 430 | 25 | 510 | 480 | 70 | 505 | 480 | 33 | 535 | 510 | 80 | 630 | 600 | 33 | 630 | 600 | 4.0 |
| 50 | 80 | 655 | 625 | 35 | 735 | 700 | 90 | 730 | 695 | 43 | 780 | 745 | 100 | 910 | 870 | 43 | 910 | 870 | |
| 63 | 90 | 785 | 745 | 40 | 880 | 840 | 100 | 870 | 830 | 50 | 930 | 890 | 110 | 1 090 | 1 040 | 50 | 1 090 | 1 040 | |
| 80 | 105 | 945 | 900 | 50 | 1 060 | 1 010 | 115 | 1 050 | 1 000 | 60 | 1 120 | 1 070 | 130 | 1 310 | 1 250 | 60 | 1 310 | 1 250 | |
| 100 | 120 | 1 140 | 1 080 | 60 | 1 270 | 1 215 | 135 | 1 265 | 1 200 | 75 | 1 350 | 1 285 | 150 | 1 580 | 1 500 | 75 | 1 580 | 1 500 | |
| 125 | 135 | 1 360 | 1 295 | 70 | 1 530 | 1 450 | 150 | 1 510 | 1 440 | 85 | 1 615 | 1 540 | 170 | 1 890 | 1 800 | 85 | 1 890 | 1 800 | |
| 160 | 160 | 1 665 | 1 585 | 80 | 1 870 | 1 780 | 180 | 1 850 | 1 760 | 100 | 1 975 | 1 880 | 200 | 2 310 | 2 200 | 100 | 2 310 | 2 200 | |
| 200 | 190 | 1 970 | 1 870 | 95 | 2 210 | 2 100 | 215 | 2 185 | 2 080 | 120 | 2 330 | 2 225 | 240 | 2 730 | 2 600 | 120 | 2 730 | 2 600 | |
| 250 | 230 | 2 300 | 2 195 | 110 | 2 590 | 2 470 | 260 | 2 560 | 2 440 | 140 | 2 735 | 2 610 | 290 | 3 200 | 3 050 | 140 | 3 200 | 3 050 | |
| 315 | 270 | 2 760 | 2 630 | 135 | 3 100 | 2 950 | 305 | 3 065 | 2 920 | 170 | 3 275 | 3 120 | 340 | 3 830 | 3 650 | 170 | 3 830 | 3 650 | |
| 400 | 330 | 3 250 | 3 095 | 160 | 3 660 | 3 480 | 370 | 3 615 | 3 440 | 200 | 3 865 | 3 675 | 410 | 4 520 | 4 300 | 200 | 4 520 | 4 300 | |

**Source**: https://openstd.samr.gov.cn/

# The answer to the global carbon neutralization trend in Europe

**Energy Efficient Distribution Transformer Policies set out by the MEPs for three-phase, liquid-filled and dry-type, medium powel transformers in Europe (EC, 2014). The first set of requirements took effect on 1 July 2015 and the second (more stringent) tier 2 took effect on 1 July 2021.**

**When will Tier 3 come?**

| 24 kV | Tier 1 (from 1 July 2015) | | Tier 2 (from 1 July 2021) | |
|---|---|---|---|---|
| kVA | Maximum no-load losses (W) | Maximum load losses (W) | Maximum no-load losses (W) | Maximum load losses (W) |
| ≤25 | 70 | 900 | 63 | 600 |
| 50 | 90 | 1,100 | 81 | 750 |
| 100 | 145 | 1,750 | 130 | 1,250 |
| 160 | 210 | 2,350 | 189 | 1,750 |
| 250 | 300 | 3,250 | 270 | 2,350 |
| 315 | 360 | 3,900 | 324 | 2,800 |
| 400 | 430 | 4,600 | 387 | 3,250 |
| 500 | 510 | 5,500 | 459 | 3,900 |
| 630 | 600 | 6,500 | 540 | 4,600 |
| 630 | 650 | 8,400 | 585 | 6,000 |
| 800 | 770 | 10,500 | 693 | 7,600 |
| 1,000 | 950 | 11,000 | 855 | 9,500 |
| 1,250 | 1,200 | 14,000 | 1,080 | 12,000 |
| 1,600 | 1,450 | 18,000 | 1,305 | 15,000 |
| 2,000 | 1,750 | 22,000 | 1,575 | 18,500 |
| 2,500 | 2,200 | 27,500 | 1,980 | 23,000 |

# Our company:

## Qingdao Yunlu Advanced Material Technology Co., Ltd

## 3 MAJOR PRODUCT LINES

The company's three major products are the
latest soft magnetic materials known to mankind in the past 40 years

# The world's foremost leader in Amorphous industry

## The world's largest amorphous material producer

Amorphous Ribbon: 130,000 Ton/Year

Amorphous core: 30,000 Ton/Year

**Global market share: 60%**

**China domestic market share: 70%**