CWIEME BERLIN | 14-16 MAY 2024 MESSE BERLIN

By Hyve

Title:
Amorphous Technology-Save The Energy, Secure The Future

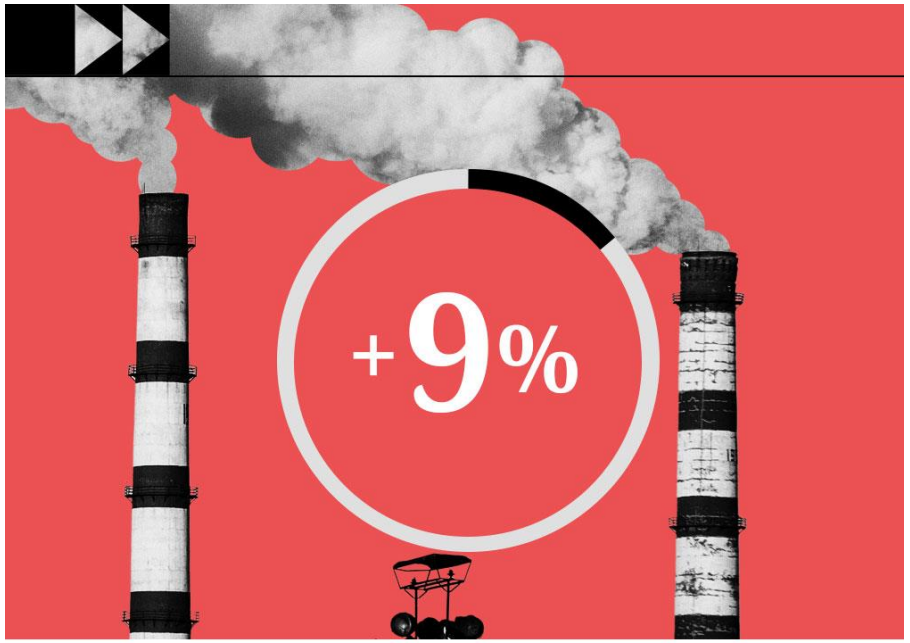
berlin.cwiemeevents.com

AGENDA

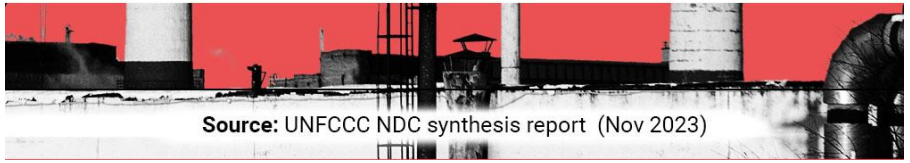
- Global industrialization and carbon control
- Power sector –Amorphous solution
- Present and Tomorrow
- Company

Current actions fall short of what is required

Reduction in global greenhouse gas emissions **needed** by 2030, from 2010 levels, to keep warming to no more than 1.5 degrees Celsius

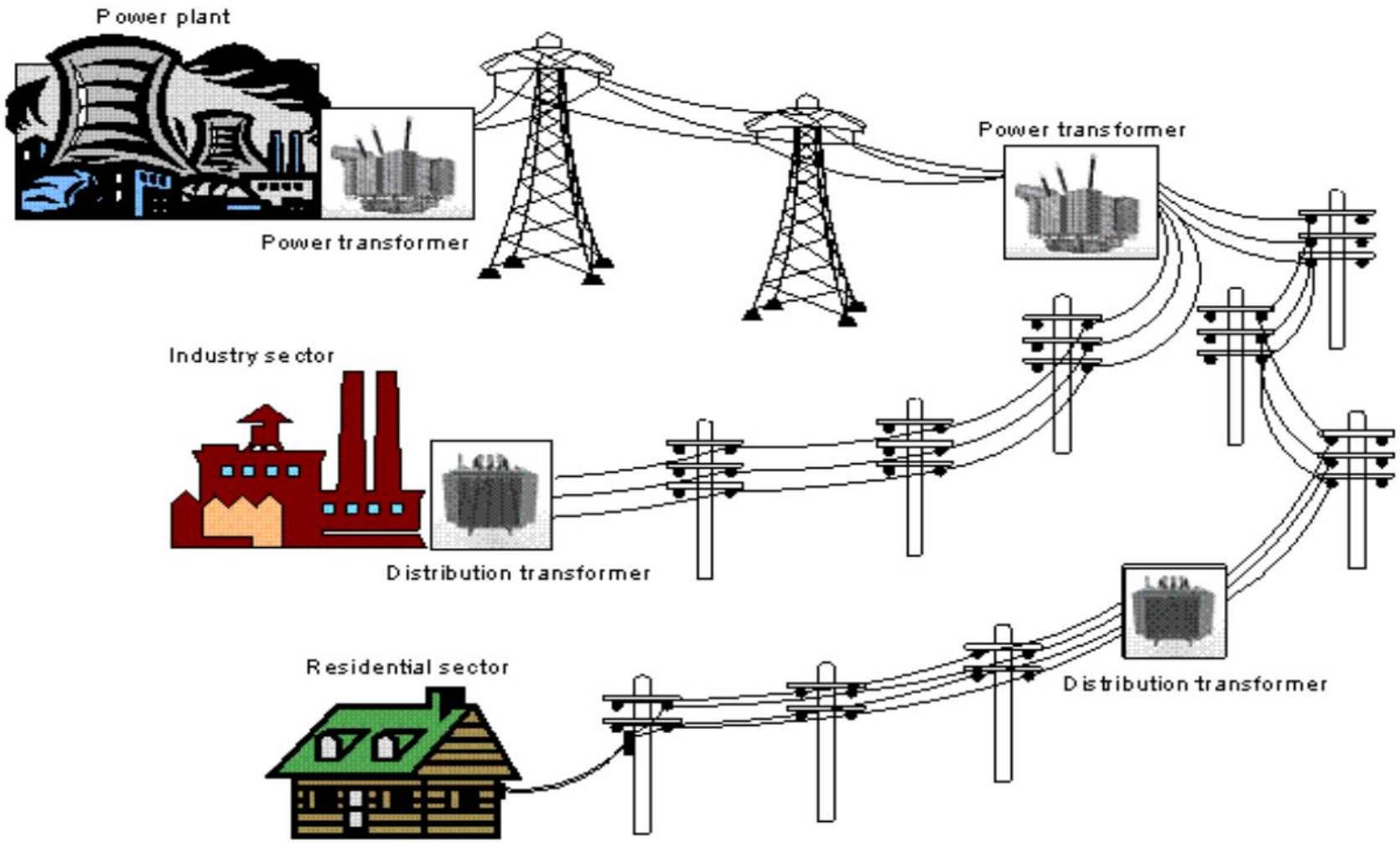


Increase in global greenhouse gas emissions **projected** by 2030, compared to 2010, based on available national action plans

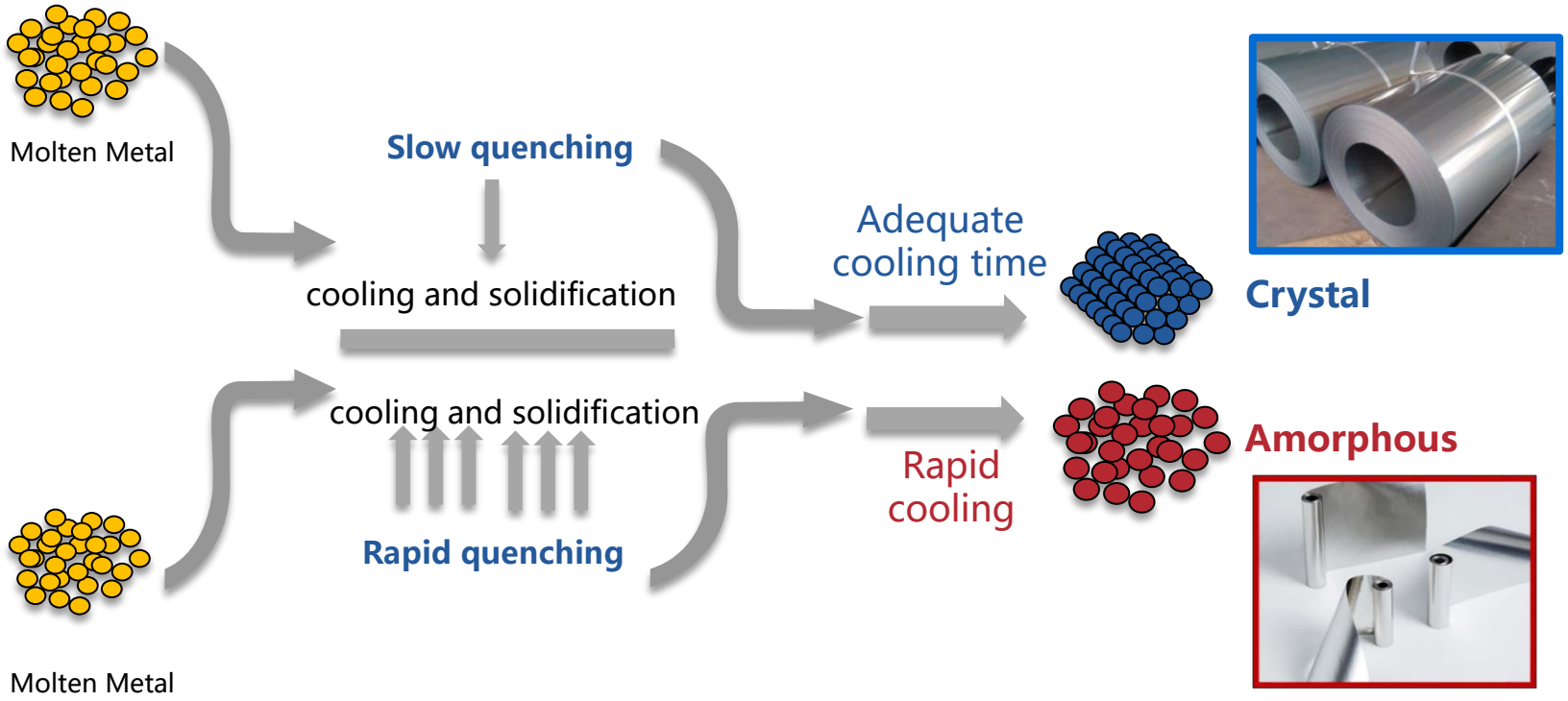


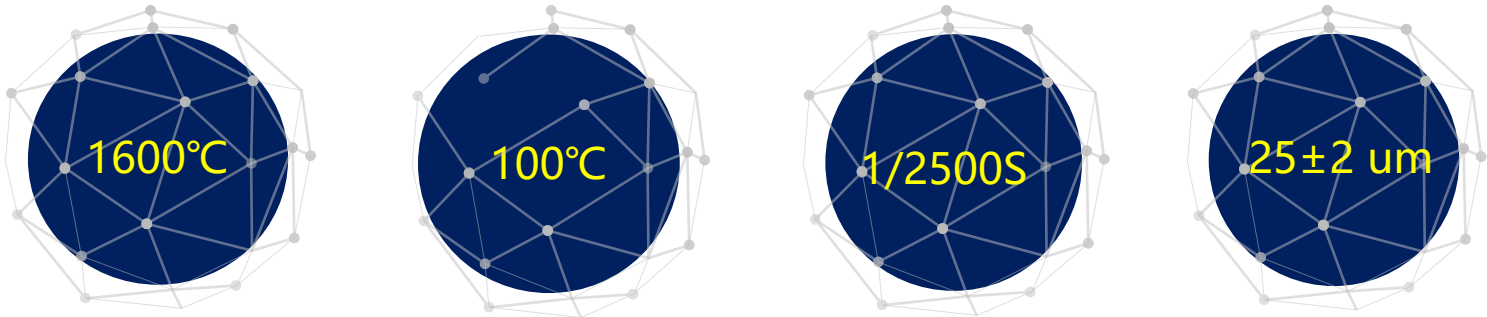
Source: UNFCCC NDC synthesis report (Nov 2023)

Power sector carbon control



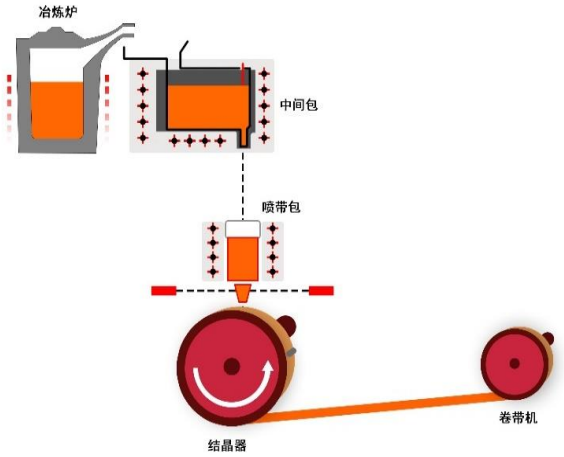
What is Amorphous ?





Green producing

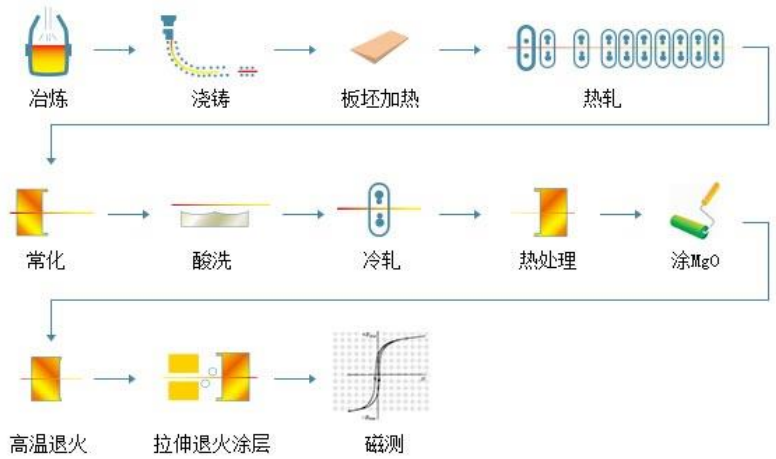
Amorphous ribbon production process



~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

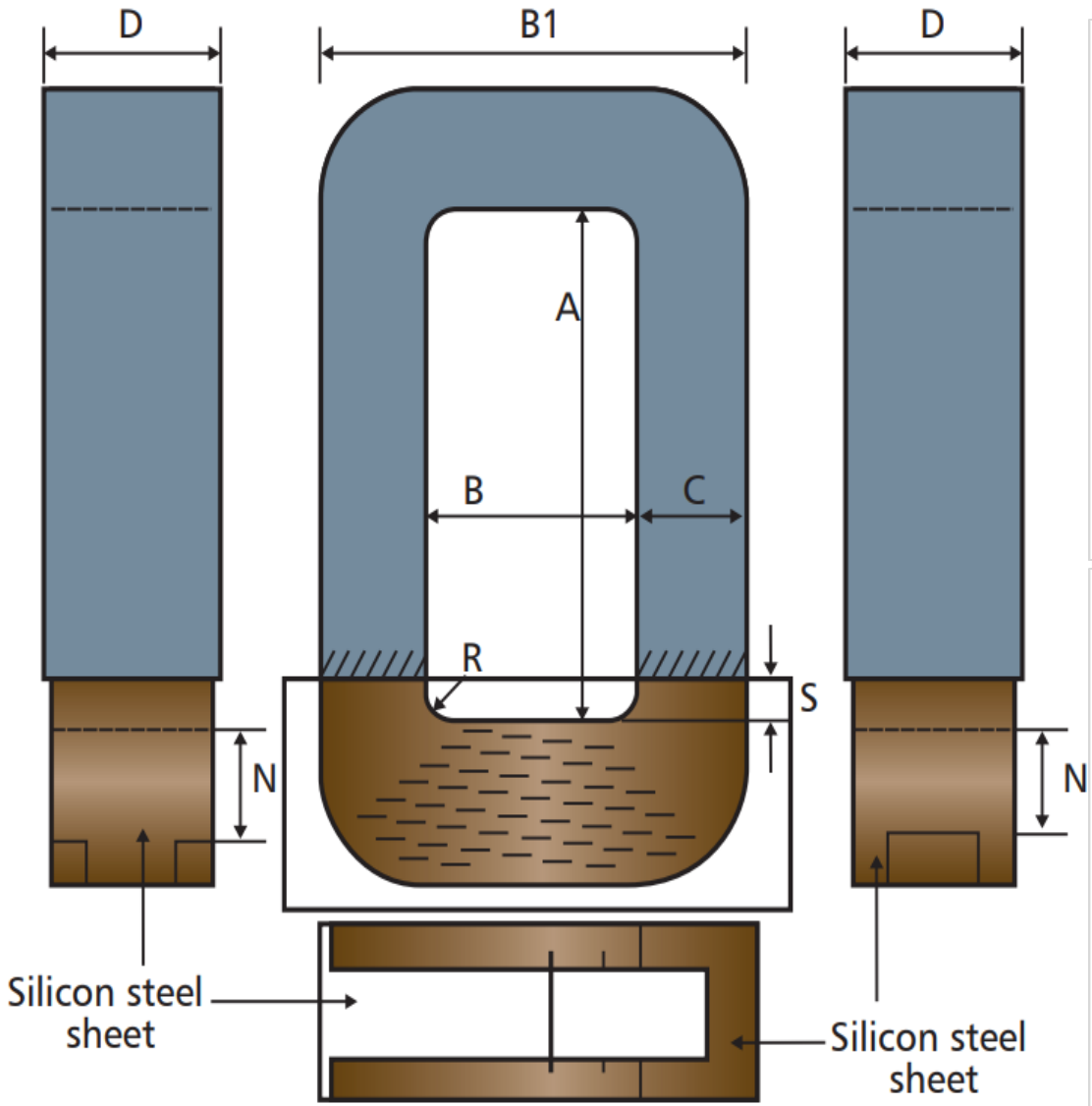


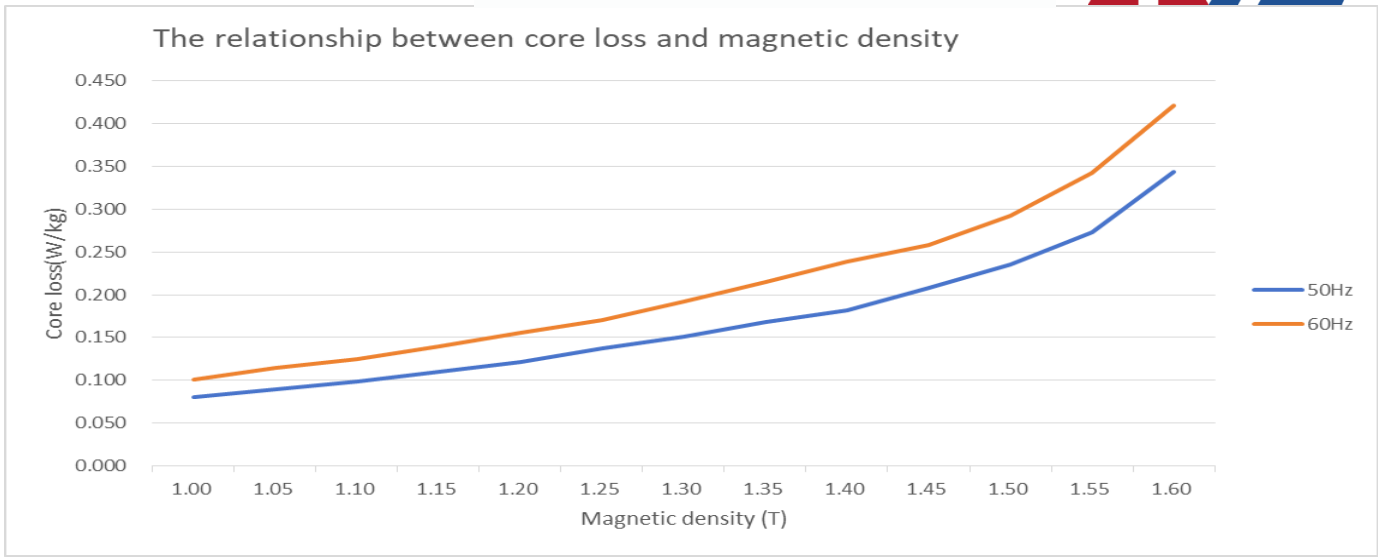
~1000m

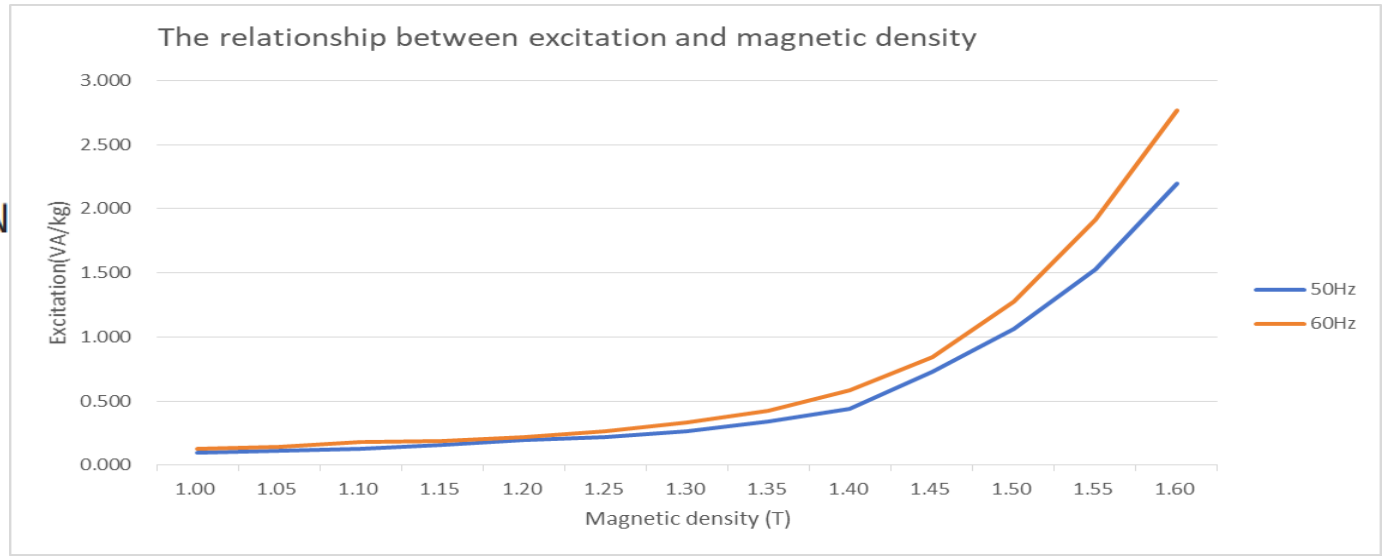
The CO_2 emission per ton of amorphous ribbon production is **730kg** less than that of silicon steel

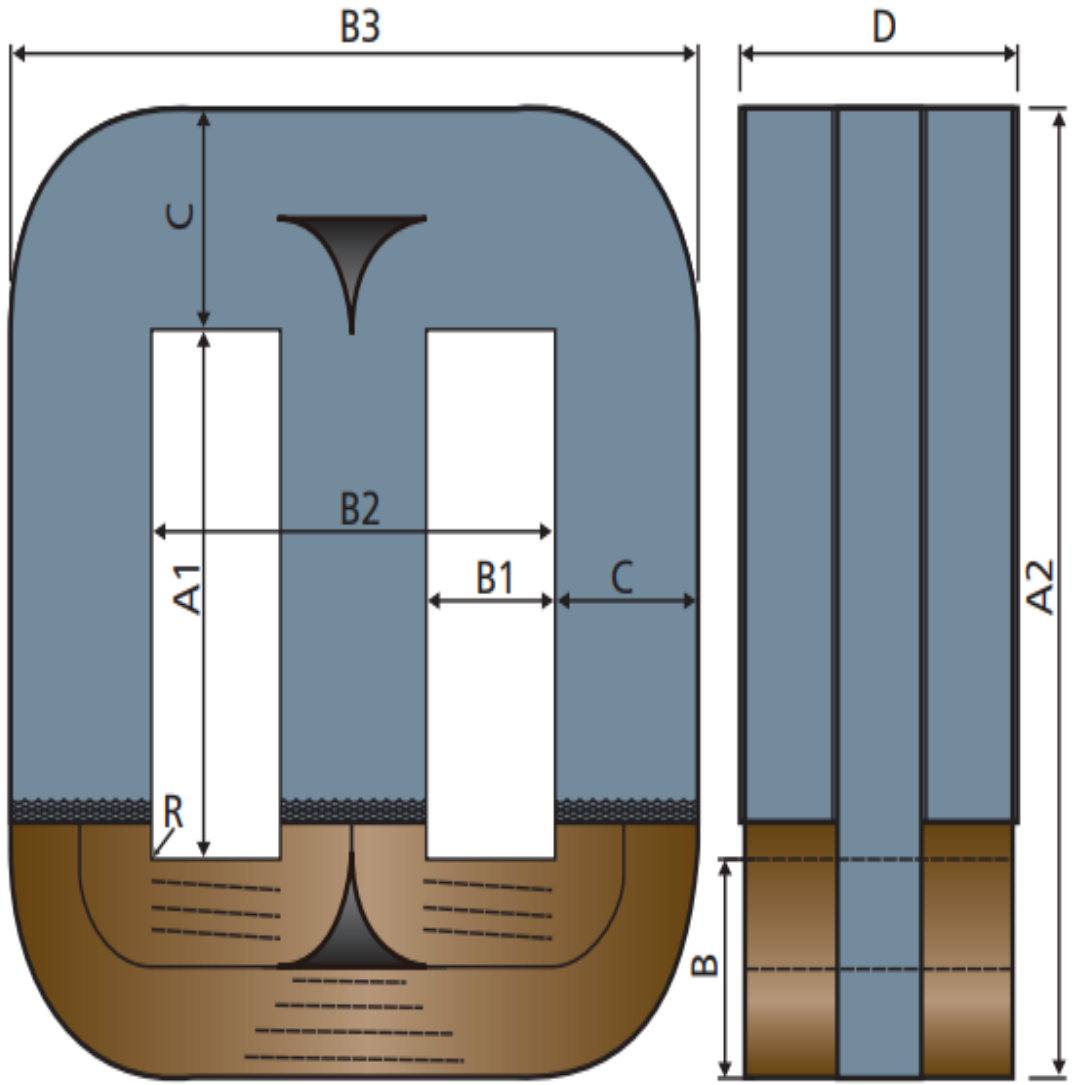
Amorphous Ribbon

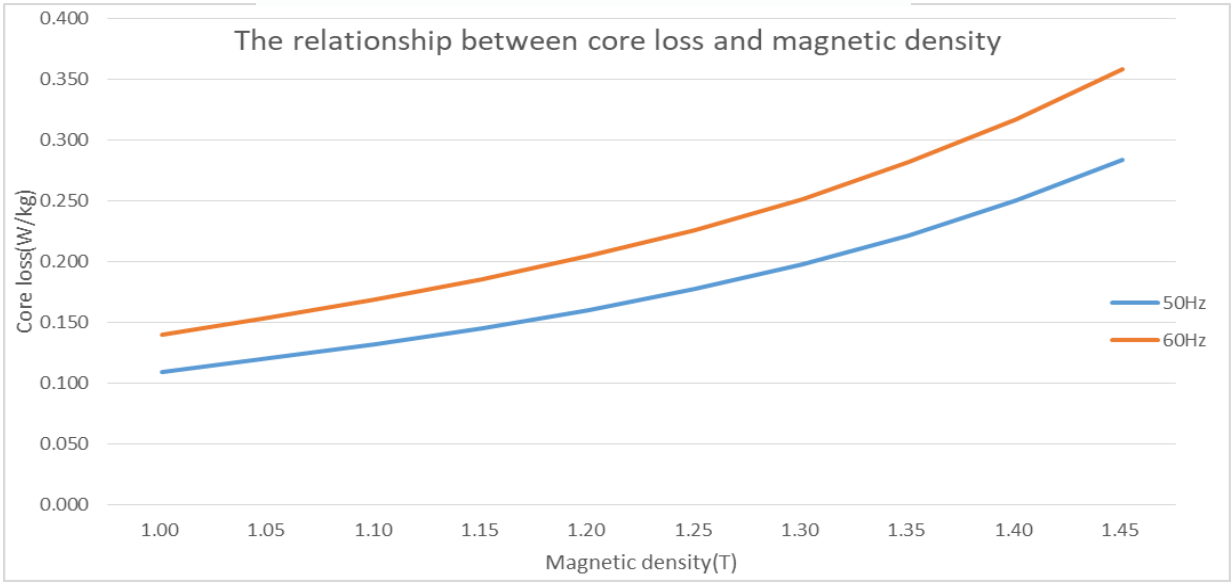
Product Name	Amorphous alloy
Standard Available Widths（mm）	100-280 (120/142/170/213)
Ingredient	Ferrum, Silicon, Boron and other elements
Thickness(um）	25±2
Lamination Factor（%）	≥86

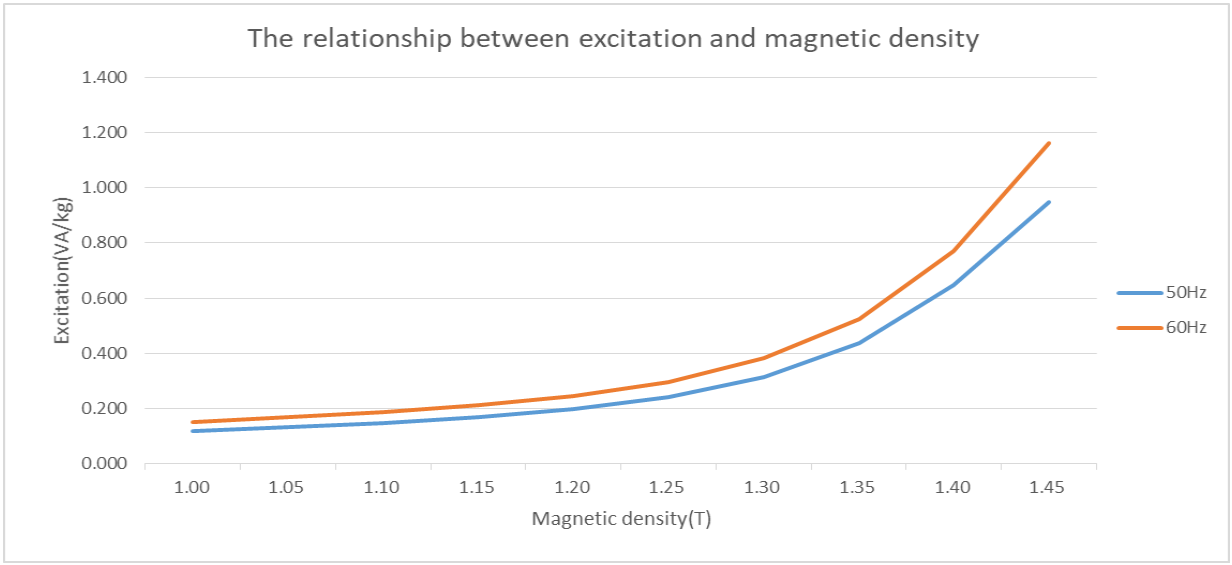

D
B1
D
A
B
C
R
S
N
N
Silicon steel sheet
Silicon steel sheet


The relationship between core loss and magnetic density
Core loss(W/kg)
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
1.00 1.05 1.10 1.15 1.20 1.25 1.30 1.35 1.40 1.45 1.50 1.55 1.60
Magnetic density (T)
50Hz
60Hz


The relationship between excitation and magnetic density
Excitation(VA/kg)
3.000
2.500
2.000
1.500
1.000
0.500
0.000
1.00 1.05 1.10 1.15 1.20 1.25 1.30 1.35 1.40 1.45 1.50 1.55 1.60
Magnetic density (T)
50Hz
60Hz


B3
D
C
B2
A1
B1
C
R
A2
B


The relationship between core loss and magnetic density
Core loss(W/kg)
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
1.00
1.05
1.10
1.15
1.20
1.25
1.30
1.35
1.40
1.45
Magnetic density(T)
50Hz
60Hz


The relationship between excitation and magnetic density
Excitation(VA/kg)
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
1.00
1.05
1.10
1.15
1.20
1.25
1.30
1.35
1.40
1.45
Magnetic density(T)
50Hz
60Hz

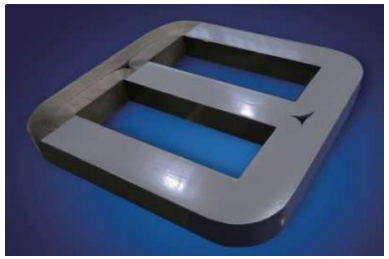
Typical Amorphous Transformer

35kV and below

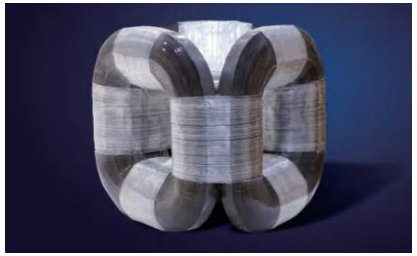
10MVA and below

Flat core

E-vans core



3D core



Application of amorphous transformer

Power Grid

Public buildings

Rail transit

New energy generation

Data center

Green operation

Take transformer capacity of 630kVA as an example:

Terms	No-load Loss（W)	Load Loss（W)
CRGO TR	**540（Tier2）**	4600
AMT	**185**	4600
Annual Saving（kW·h)	**3109.80**	30% of load rate
30 years Saving(kW·h)	**93294.00**	30% of load rate

Calculated using average electricity prices in Germany(0.35USD/kWh), 1088.43$ will be saved yearly, 32652.90$ will be saved through the whole transformer life.

Green recycling

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

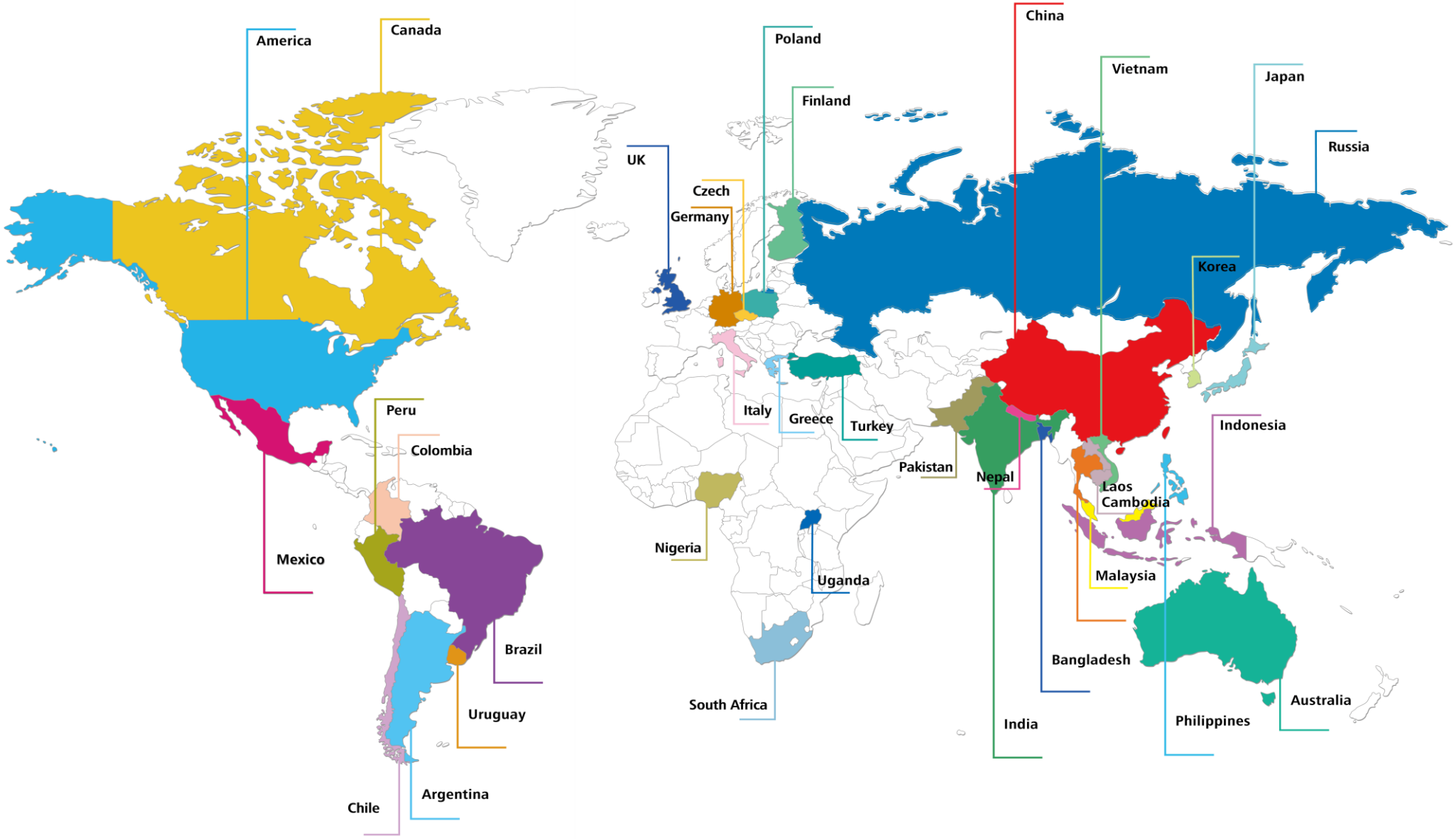
Pack the cleand amorphous ribbon

⑥ As amorphous raw material, remelting in the furnace

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

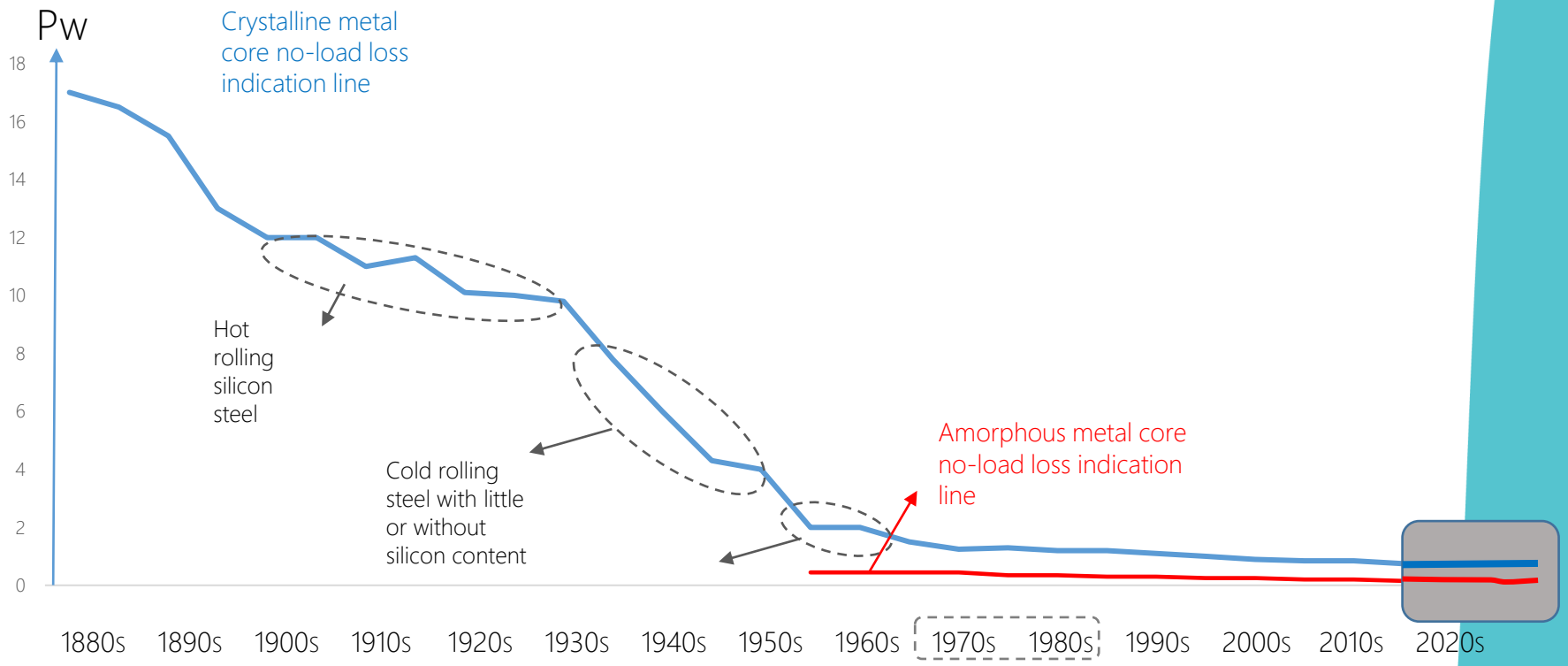
Global AMT footprint

CWIEME BERLIN | 14-16 MAY 2024 MESSE BERLIN



Price comparison

The develop history of transformer core material



Tier1&Tier2 transformer efficiency Standards

Rated Power(kVA)	Tier 1 (from July 1, 2015)		Tier 2 (from July 1, 2021)	
	Max. no-load losses P0 (W)*	Max. load losses PK (W)*	Max. no-load losses P0 (W)*	Max. load losses PK (W)*
≤ 25	70	900	63	600
50	90	1100	81	750
100	145	1750	130	1250
160	210	2350	189	1750
250	300	3250	270	2350
315	360	3900	324	2800
400	430	4600	387	3250
500	510	5500	459	3900
630	600	6500	540	4600
800	650	8400	585	6000
1,000	770	10500	693	7600
1,250	950	11000	855	9500
1,600	1200	14000	1080	12000
2,000	1450	18000	1305	15000
2,500	1750	22000	1575	18500
3,150	2200	27500	1980	23000

Energy Efficiency Distribution Transformer Policies set out the MEPs for three-phase, liquid-filled and dry-type, medium power 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 1st July 2021.

Source: https://ec.europa.eu/energy/en/topics/energy efficiency/energy-efficient-products.

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."

- America DOE energy standard will be implemented from 2029. To meet energy efficiency standards, **25%** of distribution transformers demanded is requested to shift to Amorphous technology.
- U.S. amorphous material demand will gradually increase to **80,000 tons** within 5 years.
    - https://www.energy.gov/articles/doe-finalizes-energy-efficiency-standards-distribution-transformers-protect-domestic

Misconception& Clarifications

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 reduce the design magnetic density 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.

Misconception& Clarifications

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 cannot.

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.

Misconception& Clarifications

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

picture: 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.

Misconception& Clarifications

Misconception

Amorphous materials are only suitable for small capacity transformers

5500kVA wind power step-up amorphous transformer

Fact

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

3300kVA traction rectifier amorphous transformer

Misconception& Clarifications

CNAS 中国认可 国际互认 检测 TESTING CNAS L1020

170008221380

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

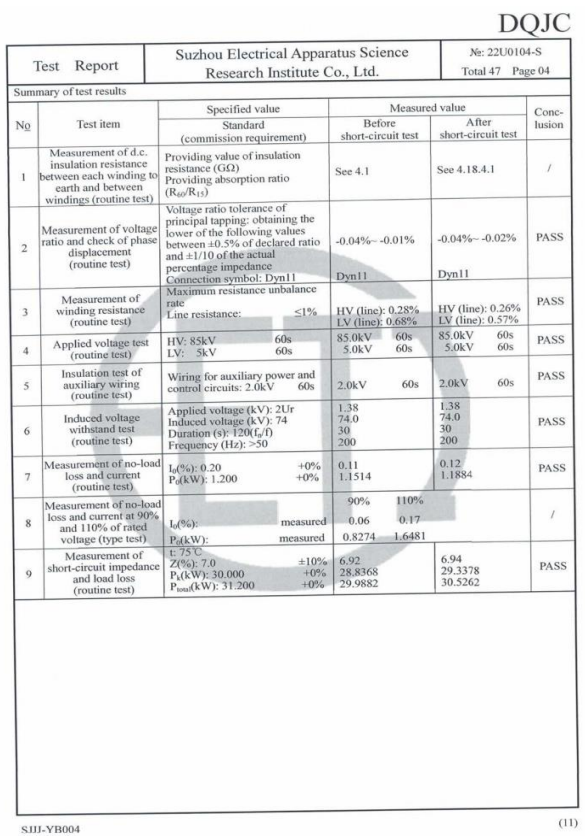
产 品 名 称：非晶合金配电变压器
Name of Product: Amorphous alloy distribution transformer

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.



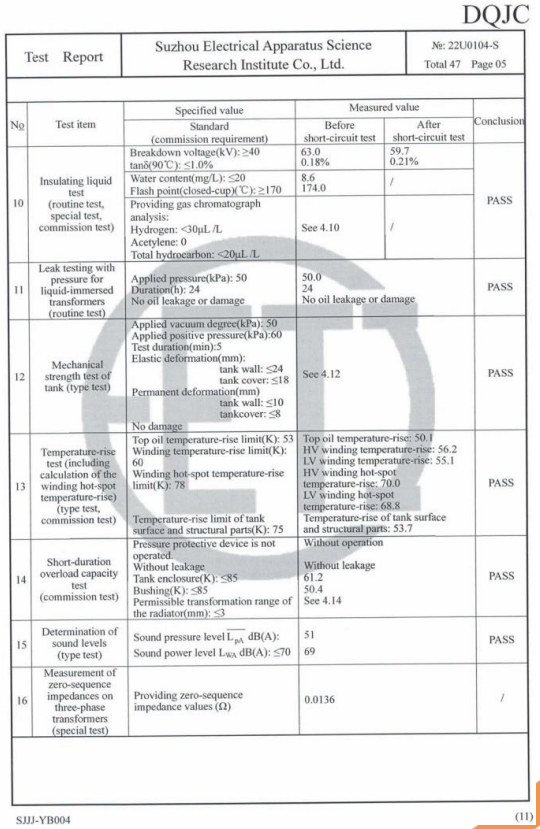
DQJC

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

Summary of test results

No	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) 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 Connection symbol: Dyn11	-0.04%~ -0.01% Dyn11	-0.04%~ -0.02% Dyn11	PASS
3	Measurement of winding resistance (routine test)	Maximum resistance unbalance rate Line resistance: ≤1%	HV (line): 0.28% LV (line): 0.68%	HV (line): 0.26% LV (line): 0.57%	PASS
4	Applied voltage test (routine test)	HV: 85kV 60s LV: 5kV 60s	85.0kV 60s 5.0kV 60s	85.0kV 60s 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 Induced voltage (kV): 74 Duration (s): 120(f_r/f) Frequency (Hz): >50	1.38 74.0 30 200	1.38 74.0 30 200	PASS
7	Measurement of no-load loss and current (routine test)	I_0(%): 0.20 +0% P_0(kW): 1.200 +0%	0.11 1.1514	0.12 1.1884	PASS
8	Measurement of no-load loss and current at 90% and 110% of rated voltage (type test)	I_0(%): measured P_0(kW): measured	90% 110% 0.06 0.17 0.8274 1.6481		/
9	Measurement of short-circuit impedance and load loss (routine test)	t: 75℃ Z(%): 7.0 ±10% P_k(kW): 30.000 +0% P_{load}(kW): 31.200 +0%	6.92 28.8368 29.9882	6.94 29.3378 30.5262	PASS

SJJ-YB004 (11)



DQJC

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

No	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 tanδ(90℃): ≤1.0% Water content(mg/L): ≤20 Flash point(closed-cup)(℃): ≥170 Providing gas chromatograph analysis: Hydrogen: <30μL /L Acetylene: 0 Total hydrocarbon: <20μL /L	63.0 0.18% 8.6 174.0 See 4.10	59.7 0.21% / /	PASS
11	Leak testing with pressure for liquid-immersed transformers (routine test)	Applied pressure(kPa): 50 Duration(h): 24 No oil leakage or damage	50.0 24 No oil leakage or damage		PASS
12	Mechanical strength test of tank (type test)	Applied vacuum degree(kPa): 50 Applied positive pressure(kPa):60 Test duration(min):5 Elastic deformation(mm): tank wall: ≤24 tank cover: ≤18 Permanent deformation(mm) tank wall: ≤10 tankcover: ≤8 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 Winding temperature-rise limit(K): 60 Winding hot-spot temperature-rise limit(K): 78 Temperature-rise limit of tank surface and structural parts(K): 75	Top oil temperature-rise: 50.1 HV winding temperature-rise: 56.2 LV winding temperature-rise: 55.1 HV winding hot-spot temperature-rise: 70.0 LV winding hot-spot temperature-rise: 68.8 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. Without leakage Tank enclosure(K): ≤85 Bushing(K): ≤85 Permissible transformation range of the radiator(mm): ≤3	Without operation Without leakage 61.2 50.4 See 4.14		PASS
15	Determination of sound levels (type test)	Sound pressure level $\overline{L_{pA}}$ dB(A): Sound power level L_{WA} dB(A): ≤70	51 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)

Company-Qingdao Yunlu

Amorphous Ribbon
130,000Ton/Year

Amorphous Transformer Core
30,000Ton/Year

500,000T Amorphous Ribbon

1 year: 1.34 billion kW·h saved

Yunlu Advanced Materials

Active practitioner of carbon neutrality solutions

12E20

Western Europe Marketing Manager：
Carter Wang
TEL: +86 15043757989
Email：wangshuo@yunlu.com.cn

Global Marketing Director：
Harvey Zheng
TEL: +86 18853816962
Email：zhenghui@yunlu.com.cn

Overseas Marketing Manager：
Eden T
TEL: +86 19147003731
Email：tangqi@yunluamt.com

CWIEME BERLIN | 14-16 MAY 2024 MESSE BERLIN

Please feel free to contact us in 12E20