

OSAN INDUSTRIAL ELEMENTS

GRAIN-ORIENTED ELECTRICAL STEEL

Low Core Loss Grain-Oriented Electrical Steel
for Transformer Core Systems

Optimized Magnetic Flux Density,
Core Efficiency and Energy Loss Reduction

A Division of

OSAN HOLDING

Global Industrial Materials &
Physical Trade Platform

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GRAIN-ORIENTED ELECTRICAL STEEL

PRODUCT DEFINITION

Electrical steel is a silicon-based alloy material designed to deliver stable magnetic properties under alternating magnetic fields. It is the core material used in transformers and electrical equipment where high magnetic permeability, low core loss and operational reliability are essential.

Grain-oriented electrical steel is produced through a controlled rolling and heat treatment process that develops a sharp $\{100\}\langle 011 \rangle$ crystal texture along the rolling direction. This texture provides high magnetic permeability and low core loss in the specified direction of magnetization.

As global energy systems demand higher efficiency and lower energy loss, premium grain-oriented electrical steel has become a critical material for transformer and electrical infrastructure worldwide.

PRODUCT CLASSIFICATION

Electrical steel is classified into two main categories:

- **Grain-Oriented Electrical Steel (GO)**
Designed for applications requiring high magnetic flux density and low core loss in the rolling direction.
- **Non-Oriented Electrical Steel (NGO)**
Designed for applications where magnetic properties are required in multiple directions.

OSAN Industrial Elements supplies high-specification grain-oriented electrical steel grades that comply with international standards and customer technical requirements.

APPLICATION OVERVIEW

Grain-oriented electrical steel is widely used in:

- Large power transformers
- Voltage transformers
- Small and medium size transformers
- Reactors and magnetic amplifiers
- Distribution transformers
- Rotating electrical machines

These applications require stable magnetic performance, minimized energy loss and long-term operational reliability.

INDUSTRIAL POSITIONING

OSAN Industrial Elements operates under OSAN HOLDING as a global industrial materials and physical trade platform.

Operations are executed through contract-based supply models supported by an integrated global sourcing network, international logistics infrastructure and full compliance with global banking and trade standards (LC / UCP 600).

The platform integrates sourcing capability, technical product alignment and disciplined delivery execution to ensure reliability, traceability and consistency across industrial-scale supply programs.

OSAN HOLDING

Global Industrial Materials & Physical Trade Platform

Contract-Based Supply
Global Logistics
International Banking Compliance
Reliable Execution



MANUFACTURING PROCESS

PROCESS OVERVIEW

Grain-oriented electrical steel is produced through a controlled sequence of rolling, annealing and coating processes to establish precise crystallographic orientation and stable magnetic performance.

Each production stage is tightly controlled to ensure dimensional accuracy, surface integrity and consistent magnetic properties.

The integrated process route delivers material for transformer core applications requiring low core loss, high magnetic permeability and long-term operational reliability.

PROCESS FLOW

Hot Rolling

Hot rolling defines the initial strip geometry and provides a uniform starting structure for subsequent processing.

Pickling and Preliminary Annealing

Surface scale is removed by acid pickling. Preliminary annealing improves ductility and prepares the material for cold rolling.

Cold Rolling

Cold rolling reduces thickness to target range and refines grain structure. Thickness tolerance and flatness are controlled automatically.

Decarburization Annealing

Carbon content is reduced to improve magnetic properties. A base insulation coating is formed during this stage.

High Temperature Annealing

Secondary recrystallization forms a sharp {100}<011> grain structure aligned in the rolling direction, increasing permeability and minimizing core loss.

Heat Flattening and Insulation Coating

Flatness is corrected through heat treatment and skin-pass rolling. Insulation coating is applied to reduce interlaminar eddy current loss.

Inspection and Domain Refining

Final inspection verifies dimensional and magnetic properties. Domain refinement technologies may be applied to further minimize core loss.

PROCESS CONTROL PRINCIPLES

- Automated thickness, width and flatness control
- Controlled furnace atmosphere during annealing
- Precise temperature and time regulation for recrystallization
- Surface quality and cleanliness monitoring
- Coating weight and uniformity verification

Strict control of these parameters ensures stable magnetic performance and application reliability.

INDUSTRIAL EXECUTION

OSAN Industrial Elements manages the global supply of grain-oriented electrical steel through structured sourcing and controlled delivery frameworks tailored to project requirements.

Material quality, technical compliance and delivery performance are ensured through contract-based supply models with full adherence to international trade and banking standards.

The platform integrates sourcing capability, technical alignment and logistics execution to support reliable supply for industrial-scale transformer manufacturing.



INSULATION COATING & SURFACE TECHNOLOGY

COATING STRUCTURE

Grain-oriented electrical steel is supplied with a dual-layer coating system designed to ensure electrical insulation, surface protection and operational stability during core assembly.

The coating structure consists of:

- **Base Coating (Forsterite Layer – Mg_2SiO_4)**
Formed during high-temperature annealing, providing a stable inorganic interface layer.
- **Insulation Coating (Phosphate-based Layer)**
Applied as a transparent surface layer to provide electrical insulation and enhance interlaminar resistance.

This multi-layer structure minimizes eddy current losses and ensures consistent magnetic performance in stacked laminations.

COATING SPECIFICATION

Coating System	C-2 (Base Coating) + C-5 (Insulation Coating)
Coating Type	Inorganic, phosphate-based
Coating Thickness	2 – 5 μm

ELECTRICAL & SURFACE PERFORMANCE

Interlaminar Resistance	Before SRA: 15 $\Omega \cdot cm^2/lam.$ After SRA: 5 $\Omega \cdot cm^2/lam.$
Heat Resistance	Stable under stress relief annealing conditions
Adhesion	Maintains integrity during bending and core assembly
Corrosion Resistance	Tested under 35°C / 5% NaCl / 8 hours
Weathering Resistance	65°C / 95% humidity / 72 hours
Weldability (TIG)	Stable under controlled welding parameters

PROCESS COMPATIBILITY

The coating system is designed to maintain performance throughout downstream processing:

- Shearing and punching operations
- Core stacking and assembly
- Stress relief annealing (SRA)
- Handling and transportation

Coating integrity is critical to prevent interlayer electrical contact and ensure low core loss in final applications.

STRESS RELIEF ANNEALING (SRA)

Stress relief annealing is applied after cutting and punching operations to restore magnetic properties.

Temperature	750°C – 840°C
Time	1.5 – 2.5 hours
Atmosphere	Controlled nitrogen-based environment
Cooling	Gradual cooling to prevent deformation

Improper annealing conditions may degrade coating performance and reduce magnetic efficiency.

INDUSTRIAL EXECUTION

OSAN Industrial Elements ensures coating performance and surface integrity through controlled sourcing and strict compliance with technical specifications.

All materials are supplied in alignment with application-specific coating requirements, supported by inspection, documentation and contract-based quality assurance frameworks.

Operations are executed under international trade standards with full banking compliance.



PG-Core

Grain-Oriented Electrical Steel for Transformer Core Applications

PRODUCT OVERVIEW

PG-Core grain-oriented electrical steel is designed for transformer core applications requiring stable magnetic performance, controlled core loss and consistent processing characteristics.

The material is optimized for applications where dimensional stability, permeability and core efficiency are required under standard operating conditions.

PG-Core grades provide reliable performance across large-scale transformer production and general electrical equipment manufacturing.

APPLICATION RANGE

PG-Core is used in:

- Large power transformers
- Medium and small size transformers
- Distribution transformers
- General electrical core applications

The material ensures stable magnetic behavior and repeatable performance during core assembly and operation.

DIMENSIONAL SPECIFICATION

Thickness	0.27 mm	0.30 mm	0.35 mm
Available Width	900 - 1200 mm		
Standard Width	1000 mm	1200 mm	
Inner Diameter	508 mm		

PHYSICAL PROPERTIES

Density	7.65 kg/dm ³
Electrical Resistivity	48 μΩ·cm

MAGNETIC PERFORMANCE

Magnetic Flux Density (B_0) | Minimum 1.80 T

PG-Core grades are designed to provide balanced performance between magnetic flux density and core loss under standard transformer operating conditions.

GRADE STRUCTURE

Grade	Thickness (mm)	Core Loss*	Magnetic Flux Density (B_0)
27PG130	0.27	Refer to technical table	≥ 1.80 T
30PG120	0.30	Refer to technical table	≥ 1.80 T
30PG130	0.30	Refer to technical table	≥ 1.80 T
35PG145	0.35	Refer to technical table	≥ 1.80 T
35PG155	0.35	Refer to technical table	≥ 1.80 T

* Core loss values are defined per grade specification and operating conditions.

PROCESS COMPATIBILITY

PG-Core is suitable for:

- Precision cutting and slitting
- Punching operations
- Transformer core stacking
- Stress relief annealing (SRA)

The material maintains coating integrity and dimensional stability during downstream processing.

INDUSTRIAL EXECUTION

OSAN Industrial Elements supplies PG-Core grades through structured sourcing and contract-based delivery models aligned with industrial transformer manufacturing requirements.

Material supply is supported by technical compliance, inspection protocols and international trade execution under LC-based frameworks.



PH-Core

High-Efficiency Grain-Oriented Electrical Steel

PRODUCT OVERVIEW

PH-Core grain-oriented electrical steel is developed for transformer core applications requiring enhanced magnetic performance and reduced core loss.

The material is processed to achieve improved permeability and optimized magnetic flux density, enabling higher efficiency under operational conditions.

PH-Core grades are suitable for applications where energy efficiency and long-term performance stability are critical.

APPLICATION RANGE

PH-Core is used in:

- Energy-efficient power transformers
- High-performance distribution transformers
- Medium and large transformer systems
- Applications requiring reduced core loss

The material supports improved operational efficiency and reduced energy consumption in transformer systems.

DIMENSIONAL SPECIFICATION

Thickness	0.23 mm	0.27 mm	0.30 mm
Available Width	900 - 1200 mm		
Standard Width	1000 mm	1200 mm	
Inner Diameter	508 mm		

PHYSICAL PROPERTIES

Density	7.65 kg/dm ³
Electrical Resistivity	48 μΩ-cm

MAGNETIC PERFORMANCE

Magnetic Flux Density (B₉₀) | Minimum 1.88 T

PH-Core grades are designed to provide higher magnetic flux density compared to standard grades, enabling reduced core loss and improved transformer efficiency.

GRADE STRUCTURE

Grade	Thickness (mm)	Core Loss*	Magnetic Flux Density (B ₉₀)
23PH085	0.23	Refer to technical table	≥ 1.88 T
23PH090	0.23	Refer to technical table	≥ 1.88 T
23PH095	0.23	Refer to technical table	≥ 1.88 T
27PH095	0.27	Refer to technical table	≥ 1.88 T
27PH100	0.27	Refer to technical table	≥ 1.88 T
30PH100	0.30	Refer to technical table	≥ 1.88 T
30PH105	0.30	Refer to technical table	≥ 1.88 T

* Core loss values are defined per grade specification and operating conditions.

PERFORMANCE POSITIONING

Compared to standard grain-oriented grades:

- Higher magnetic flux density
- Lower core loss characteristics
- Improved energy efficiency
- Enhanced performance under load conditions

PH-Core is positioned for applications requiring higher efficiency and reduced operational losses.

PROCESS COMPATIBILITY

PH-Core is suitable for:

- Precision cutting and slitting
- High-accuracy punching operations
- Transformer core stacking
- Stress relief annealing (SRA)

The material maintains coating stability and dimensional consistency during processing.

INDUSTRIAL EXECUTION

OSAN Industrial Elements supplies PH-Core grades through structured sourcing and contract-based delivery frameworks aligned with high-efficiency transformer manufacturing requirements. Material selection, technical compliance and delivery execution are managed under international trade standards, supported by LC-based financial structures.



PHD-Core

Advanced Domain-Refined Grain-Oriented Electrical Steel

PRODUCT OVERVIEW

PHD-Core grain-oriented electrical steel is produced using domain refinement technology to achieve reduced core loss and enhanced magnetic efficiency.

The material is engineered to improve magnetic domain structure, minimizing energy loss during magnetization and enabling higher operational efficiency in transformer applications.

PHD-Core grades are used in advanced transformer systems where energy performance and efficiency optimization are critical.

APPLICATION RANGE

PHD-Core is used in:

- High-efficiency power transformers
- Ultra-low loss transformer systems
- Advanced energy infrastructure applications
- Applications requiring minimized energy loss

The material supports improved efficiency and reduced operational energy consumption.

DIMENSIONAL SPECIFICATION

Thickness	0.23 mm	0.27 mm	0.30 mm
Available Width	900 - 1200 mm		
Standard Width	1000 mm	1200 mm	
Inner Diameter	508 mm		

PHYSICAL PROPERTIES

Density	7.65 kg/dm ³
Electrical Resistivity	48 μΩ·cm

MAGNETIC PERFORMANCE

Magnetic Flux Density (B₉₀) | Defined per grade specification

PHD-Core grades are characterized by reduced core loss compared to standard and high-efficiency grades, achieved through domain refinement processing.

This structure enables improved energy efficiency and reduced losses during transformer operation.

DOMAIN REFINEMENT TECHNOLOGY

Domain refinement is applied to control magnetic domain structure within the steel.

This process reduces domain wall movement resistance and lowers hysteresis loss, resulting in improved magnetic efficiency.

However, domain refinement effects may be partially reduced during stress relief annealing (SRA) depending on processing conditions.

GRADE STRUCTURE

Grade	Thickness (mm)	Core Loss*	Magnetic Flux Density
23PHDxxx	0.23	Refer to technical table	Refer to specification
27PHDxxx	0.27	Refer to technical table	Refer to specification
30PHDxxx	0.30	Refer to technical table	Refer to specification

* Core loss values depend on domain refinement condition and operating parameters.

PERFORMANCE POSITIONING

Compared to PG-Core and PH-Core:

- Lower core loss characteristics
- Improved energy efficiency
- Enhanced magnetic domain control
- Advanced transformer performance

PHD-Core is positioned for applications requiring optimized efficiency and reduced energy loss.

PROCESS COMPATIBILITY

PHD-Core is suitable for:

- Precision cutting and slitting
- Controlled punching operations
- Transformer core stacking
- Stress relief annealing (SRA)

Processing conditions must be controlled to maintain domain refinement effects.

INDUSTRIAL EXECUTION

OSAN Industrial Elements supplies PHD-Core grades through structured sourcing and controlled delivery frameworks. Material selection, technical compliance and inspection protocols are in strict accordance with international trade standards, supported by LC-based terms and inspection protocols.



PHE-Core

Ultra Low-Loss Grain-Oriented Electrical Steel

PRODUCT OVERVIEW

PHE-Core grain-oriented electrical steel represents the ultra low-loss segment within the product range, developed for transformer core applications requiring maximum efficiency and minimized energy loss.

The material is processed through advanced control of crystallographic orientation and domain refinement techniques to achieve reduced hysteresis and eddy current losses under operating conditions.

PHE-Core grades are applied in high-efficiency transformer systems where performance optimization and long-term operational stability are critical.

APPLICATION RANGE

PHE-Core is used in:

- Ultra high-efficiency power transformers
- Low-loss transformer systems
- Advanced energy infrastructure applications
- Grid-level efficiency optimization projects

The material supports minimized energy loss and improved system efficiency in high-performance transformer applications.

DIMENSIONAL SPECIFICATION

Thickness	0.23 mm	0.27 mm
Available Width	900 – 1200 mm	
Standard Width	1000 mm	1200 mm
Inner Diameter	508 mm	

PHYSICAL PROPERTIES

Density	7.65 kg/dm ³
Electrical Resistivity	48 μΩ·cm

MAGNETIC PERFORMANCE

Magnetic Flux Density (B₉₀) | Defined per grade specification

PHE-Core grades are characterized by ultra low core loss levels achieved through precise control of material structure and processing conditions.

The material enables reduced energy dissipation and improved efficiency in transformer core operation.

ADVANCED MATERIAL CONTROL

PHE-Core production involves strict control of:

- Crystallographic orientation
- Domain structure refinement
- Surface and coating uniformity
- Thickness and flatness precision

These parameters are critical to achieving consistent ultra low-loss performance.

GRADE STRUCTURE

Grade	Thickness (mm)	Core Loss*	Magnetic Flux Density
23PHExxx	0.23	Refer to technical table	Refer to specification
27PHExxx	0.27	Refer to technical table	Refer to specification

* Core loss values are defined per grade specification and operating conditions.

PERFORMANCE POSITIONING

Compared to PG-Core, PH-Core and PHD-Core:

- Lowest core loss characteristics
- Maximum energy efficiency
- Advanced magnetic domain control
- High-performance transformer optimization

PHE-Core is positioned for applications requiring the highest level of efficiency and minimal operational losses.

PROCESS COMPATIBILITY

PHE-Core is suitable for:

- Precision slitting and cutting
- Controlled punching operations
- Transformer core stacking
- Stress relief annealing (SRA)

Processing conditions must be strictly controlled to preserve ultra low-loss characteristics.

INDUSTRIAL EXECUTION

OSAN Industrial Elements supplies PHE-Core grades through structured sourcing and controlled delivery frameworks aligned with ultra high-efficiency transformer manufacturing requirements. Material selection, technical compliance and execution are managed under international trade standards, supported by LC-based financial structures, inspection protocols and contract-based quality assurance.



Technical Data Tables

Grain-Oriented Electrical Steel Performance Data

1. INTRODUCTION

The following tables present reference performance data for grain-oriented electrical steel grades. Values are defined under standard testing conditions and may vary depending on processing, handling and operating parameters.

All data should be evaluated in relation to specific application requirements.

2. PG-CORE DATA

Grade	Thickness (mm)	Core Loss (W/kg @ 1.7T / 50Hz)	Magnetic Flux Density (B_0)
27PG130	0.27	≤ 1.30	≥ 1.80 T
30PG120	0.30	≤ 1.20	≥ 1.80 T
30PG130	0.30	≤ 1.30	≥ 1.80 T
35PG145	0.35	≤ 1.45	≥ 1.80 T
35PG155	0.35	≤ 1.55	≥ 1.80 T

3. PH-CORE DATA

Grade	Thickness (mm)	Core Loss (W/kg @ 1.7T / 50Hz)	Magnetic Flux Density (B_0)
23PH085	0.23	≤ 0.85	≥ 1.88 T
23PH090	0.23	≤ 0.90	≥ 1.88 T
23PH095	0.23	≤ 0.95	≥ 1.88 T
27PH095	0.27	≤ 0.95	≥ 1.88 T
27PH100	0.27	≤ 1.00	≥ 1.88 T
30PH100	0.30	≤ 1.00	≥ 1.88 T
30PH105	0.30	≤ 1.05	≥ 1.88 T

4. PHD-CORE DATA

Grade	Thickness (mm)	Core Loss Reduction	Magnetic Flux Density
23PHDxxx	0.23	Improved vs PH-Core	Defined per specification
27PHDxxx	0.27	Improved vs PH-Core	Defined per specification
30PHDxxx	0.30	Improved vs PH-Core	Defined per specification

5. PHE-CORE DATA

Grade	Thickness (mm)	Core Loss Reduction	Magnetic Flux Density
23PHExxx	0.23	Ultra low-loss	Defined per specification
27PHExxx	0.27	Ultra low-loss	Defined per specification

6. TEST CONDITIONS

- Magnetic flux density measured under standard laboratory conditions
- Core loss values measured at 50 Hz frequency
- Reference flux density: 1.7 Tesla
- Values may vary depending on processing conditions

7. TOLERANCE INFORMATION

- Thickness tolerance: as per grade specification
- Width tolerance: standard industrial tolerance
- Flatness: controlled within processing limits
- Coating thickness: 2–5 μm

8. TECHNICAL DISCLAIMER

All values presented are reference data based on standard production and testing conditions. Actual performance may vary depending on processing methods, transformer design, operating conditions and stress relief annealing parameters.

Material selection should be validated based on specific project requirements.

9. INDUSTRIAL EXECUTION (OSAN LANGUAGE)

OSAN Industrial Elements provides technical data transparency supported by structured sourcing, inspection protocols and contract-based supply execution. All materials are delivered in alignment with agreed specifications and international trade standards under LC-based frameworks.



Applications & Use Cases

Grain-Oriented Electrical Steel in Industrial Energy Systems

APPLICATION OVERVIEW

Grain-oriented electrical steel is a critical material in electrical energy systems where magnetic efficiency, energy loss control and long-term operational reliability are required.

The material is primarily used in transformer core manufacturing and related electrical equipment, supporting stable performance under continuous load conditions.

POWER TRANSFORMERS

Grain-oriented electrical steel is widely used in power transformers for transmission and distribution networks.

Key requirements in these applications include:

- Low core loss
- Stable magnetic flux density
- Long-term thermal stability
- Reliable performance under continuous operation

GO electrical steel enables efficient energy transfer and reduced losses in high-capacity transformer systems.

DISTRIBUTION TRANSFORMERS

In distribution transformers, material efficiency directly impacts energy consumption across large-scale grid systems.

Applications require:

- Consistent magnetic performance
- Controlled energy loss
- High-volume manufacturing compatibility

The use of high-grade GO steel contributes to improved system efficiency and reduced operational losses.

HIGH-EFFICIENCY TRANSFORMER SYSTEMS

Advanced transformer systems require materials with optimized magnetic properties and reduced loss characteristics.

Applications include:

- Energy-efficient transformer design
- Low-loss transformer cores
- High-performance electrical systems

PHD-Core and PHE-Core grades are typically used in these applications.

VOLTAGE TRANSFORMERS & REACTORS

Grain-oriented electrical steel is also used in:

- Voltage transformers
- Magnetic reactors
- Power conditioning equipment

These applications require precise magnetic behavior and stable performance under varying electrical loads.

INDUSTRIAL ELECTRICAL EQUIPMENT

GO electrical steel is applied in various industrial electrical systems where magnetic performance is critical.

Typical uses include:

- Electrical core components
- Industrial energy systems
- Specialized electromagnetic applications

APPLICATION POSITIONING BY GRADE

Application Type	Recommended Grade
Standard transformers	PG-Core
Energy-efficient transformers	PH-Core
Low-loss transformer systems	PHD-Core
Ultra high-efficiency systems	PHE-Core

PERFORMANCE IMPACT

Material selection directly affects:

- Core loss levels
- Energy efficiency
- Thermal performance
- Operational cost

Optimized grade selection ensures improved system performance and reduced long-term energy consumption.

INDUSTRIAL EXECUTION (OSAN LANGUAGE)

OSAN Industrial Elements supports application-specific material selection through structured sourcing and technical alignment.

Supply programs are executed based on project requirements, supported by inspection protocols and contract-based delivery under international trade standards.



OSAN INDUSTRIAL ELEMENTS

Global Industrial Materials & Structured Supply Platform

CORPORATE STATEMENT

OSAN Industrial Elements operates under OSAN HOLDING as a structured industrial materials and global supply platform.

Operations are conducted through contract-based execution models, supported by international logistics infrastructure, technical compliance frameworks and financial discipline under global banking standards.

The organization integrates sourcing capability, technical alignment and controlled delivery execution across industrial-scale supply programs.

GLOBAL PRESENCE

OSAN HOLDING operates across multiple international locations, supporting manufacturing, sourcing and distribution activities.

Operations are aligned with industrial requirements and executed through coordinated global infrastructure.

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