Steel

# Non grain oriented electrical steel powercore®

Product range

thyssenkrupp

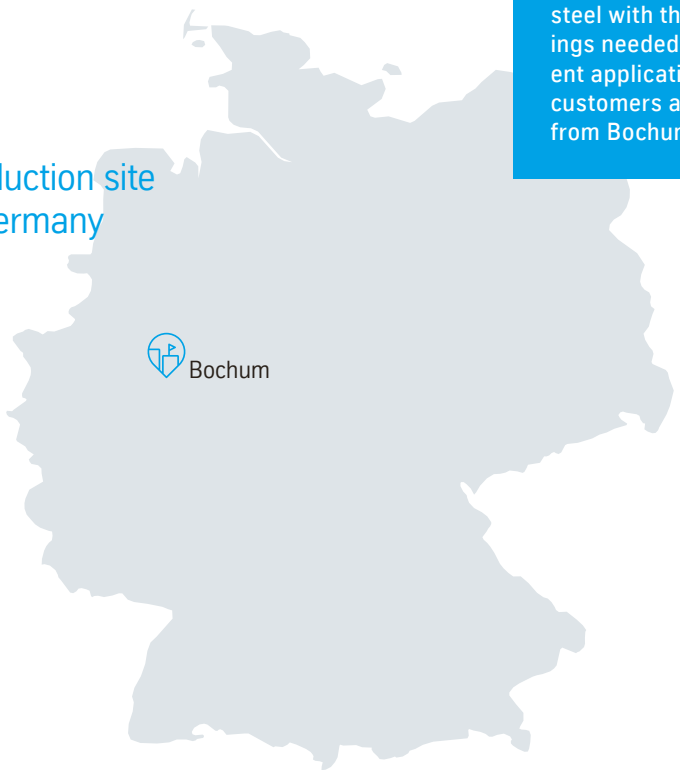
powercore® is a world-leading brand for innovative high-tech electrical steel products. It is used throughout the energy value chain and makes a relevant contribution to meeting ecological requirements in the electrical engineering sector. It is also used to enhance energy efficiency in e-mobility applications. As one of the market leaders for non-oriented electrical steel, we do everything to ensure that our powercore® products make an important contribution to reducing pollution and conserving resources in both the generation and use of energy.

# Contents

# Our quality standards can be summed up easily: very high.

High-quality steel products do not come about by chance; they are the result of a mature, precise, and responsible approach throughout the manufacturing process.

The advanced technology used at our Bochum site and the continuous improvement of our electrical steel at our in-house E-Mobility Center Drives enable us to meet even the most exacting customer requirements. Our high-tech powercore® electrical steel with the insulation coatings needed for its many different applications is delivered to customers around the world from Bochum.




International site

Motta Visconti, Italy

For more information, visit us at:

www.thyssenkrupp-steel.com

**General note**
Information regarding standards refers to the latest version as at the printing date. All statements as to the properties or utilization of materials and products are for the purposes of description only. Guarantees in respect of the existence of certain properties or utilization of materials are only valid if agreed upon in writing.

## Responsible production.

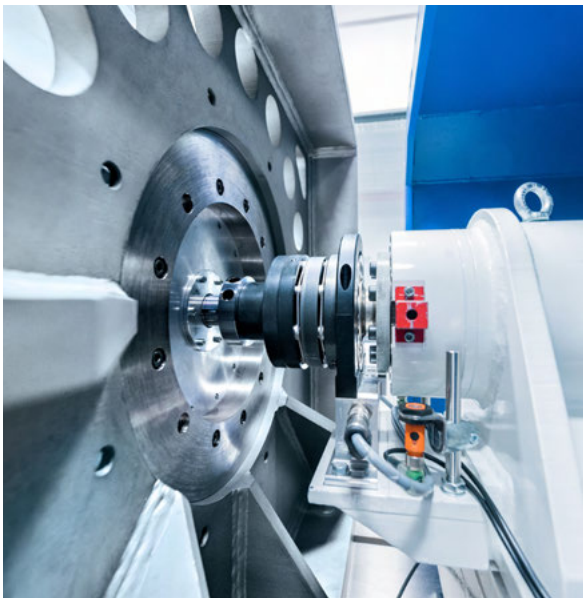
At thyssenkrupp we have the most advanced technologies and processes at our disposal to ensure climate- and resource-efficient production and consistently high product quality at all stages. For example, we have the world's cleanest coke plant, advanced blast furnaces to produce pig iron, and numerous specialty plants to make and process steel.

## Wealth of expertise goes into outstanding products.

We have one particular skill that is invaluable: With our highly qualified employees and expertise accumulated over more than 200 years of steelmaking, our innovative capabilities are second to none. This is ultimately what enables us to produce the high-quality, eco-friendly, cost-efficient materials that frequently give our customers an edge on their markets. Equally important is the fact that all our products can be recycled efficiently.

# Accelerating the advance of e-mobility.

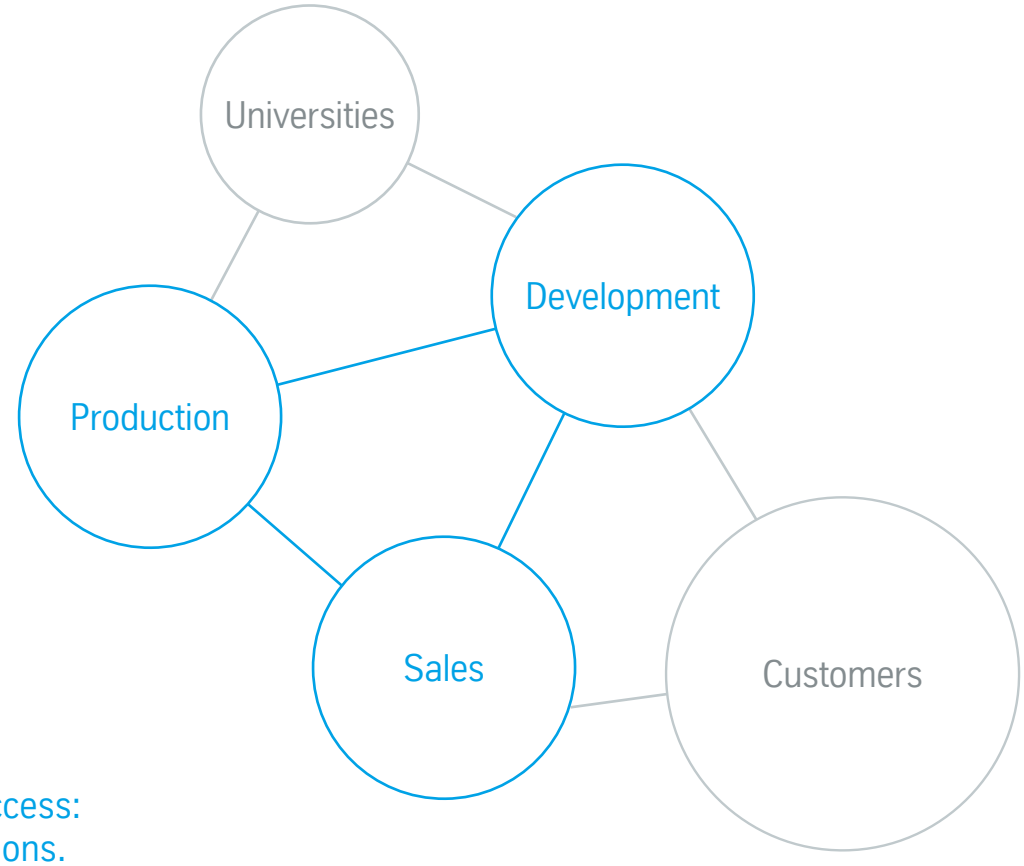
Research and development in all areas using the most advanced methods available is essential when it comes to achieving, maintaining, and extending a technological edge. For example, to develop innovative materials for e-mobility, we have installed an electric motor test rig at our E-Mobility Center Drives in Bochum that enables us to continuously examine the properties of our materials. Our engineers analyze and evaluate the results and then use their findings as the basis for further improvements in the quest for the optimum material for e-mobility.



## Well connected beyond company boundaries.

Key to our innovative strength is the way we combine and connect capabilities and capacities, both within our organization and with external partners. This includes intensive exchanges between our sales, development, and production teams, close partnerships with our customers, and cooperation between our scientists and engineers and selected universities and other research establishments. By combining expertise in this way, we can develop high-tech steels, materials, coatings, and processes in advanced laboratory and pilot facilities to achieve even higher quality.

# Closeness to customers drives quality.




## Firmly focused on success: teamwork in all directions.

In general our technology, innovation, and sales teams are focused as a unit on meeting our customers' standards and requirements. In cases calling for even greater efficiency and speed, we create simultaneous engineering project teams. We have also partnered with the Ruhr University Bochum to set up the Interdisciplinary Center for Advanced Materials Simulation (ICAMS). Researchers there use groundbreaking technology to optimize material properties.

And because you can never do too much to improve efficiency even further, in addition to the customary advice on customer-specific products and applications, we also provide customer and innovation workshops, which have already proved very successful.

Key to constant improvements in product development: Our network combines internal and external expertise.

## Constant dialogue for e-mobility.

Advancing e-mobility is part of our everyday business. That's why the mobility specialists at our dedicated E-Mobility Center Drives are working to design electric motors using non-oriented electrical steel that are even more efficient and powerful – in constant dialogue with our development partners, especially in the auto industry. Our powercore® Explorer helps our partners gain a deeper insight into the properties of our materials so as to find the ideal grade for their applications.

# Our non-oriented electrical steel helps us move forward in many areas.

Electrical energy is an important part of our lives – at work as well as at home. Our non-oriented powercore® electrical steel is used in a wide range of sectors, both in the generation of energy and in products that consume it.

## Cars/trucks

Another application that is growing in importance is e-mobility, where the requirement is for motors that are small yet powerful enough to give vehicles a high range. But powercore® is also an essential ingredient of conventionally powered cars and trucks, where it is increasingly used, for example, in motors for air-conditioning systems, gasoline pumps, and even wing mirrors.

## Energy

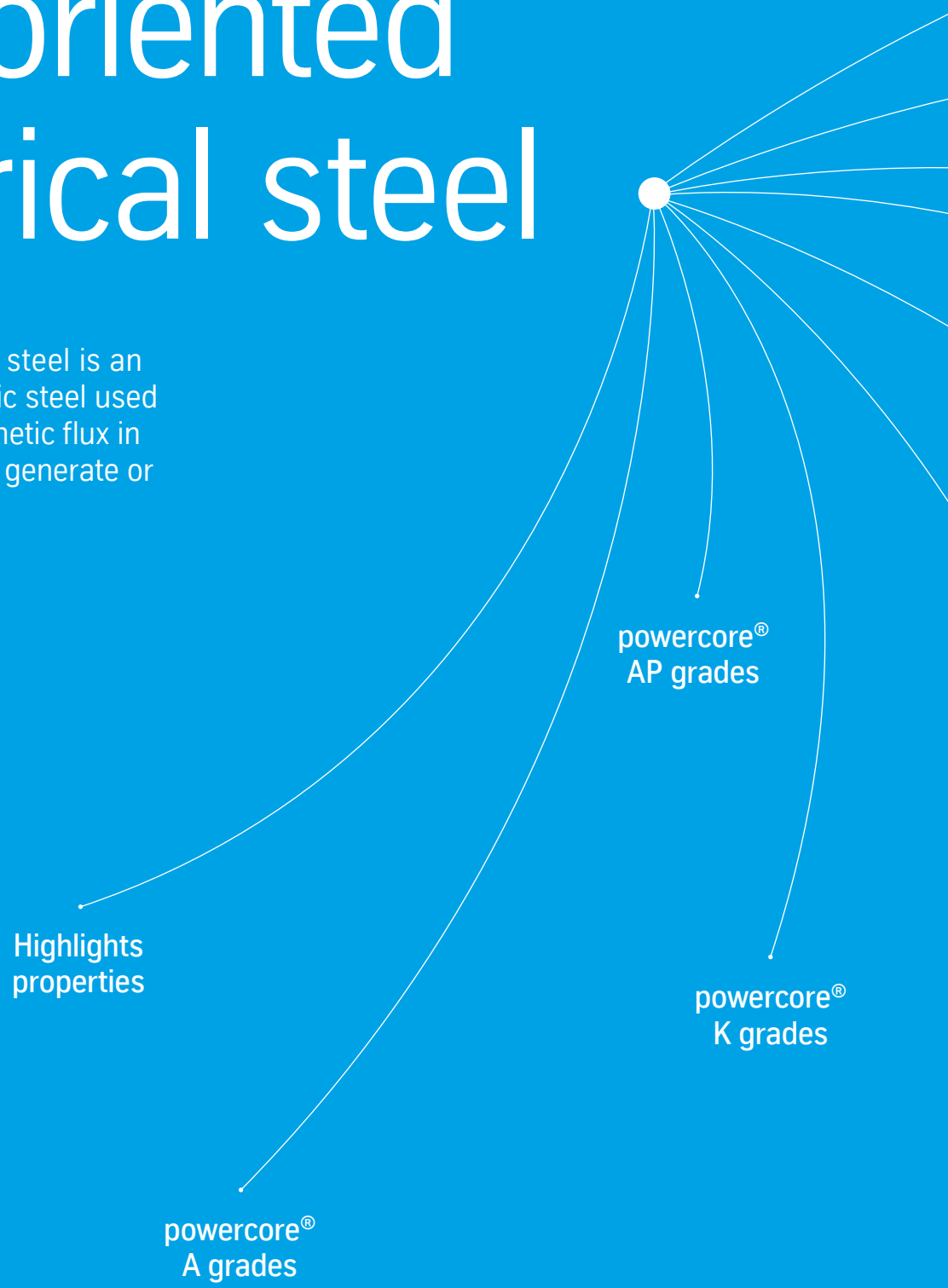
In the energy generation sector, powercore® is mainly used in all kinds of generators to increase performance and efficiency.

## Appliances

Electric motors with powercore® are to be found in virtually all homes: in hairdryers, small kitchen appliances, washing machines, and many other electrical devices.

# Non-oriented electrical steel

Non-oriented electrical steel is an innovative, soft magnetic steel used to concentrate the magnetic flux in electrical machines that generate or use electrical energy.



Electrical steel for e-mobility and high frequencies

Insulation coatings stabolit®

Width / thickness variations, geometric properties

Conversion table

stabosol® – Adhesive system for large-scale automotive production

powercore® PP grades

Your contacts

**Automotive**

Sales NO
P: +49 203 52-24627

thyssenkrupp Steel Europe AG
Kaiser-Wilhelm-Strasse 100
47166 Duisburg, Germany

# Excellent properties.

Our non-oriented powercore® electrical steels are high-efficiency materials that deliver benefits throughout the energy value chain, both in electric motors and appliances and in generators used to convert a wide range of energies.

Magnetic or mechanical: Our powercore® has the properties that make a difference. The fully finished grades for electric drive motors offer ideal magnetic properties even prior to stamping: high magnetic polarization, low eddy current losses, and good thermal conductivity. The semi-finished grades for use in household appliances or hermetic motors gain their properties after stamping and thus offer good magnetic conductivity at very low losses. With a homogeneous microstructure and precisely defined silicon and aluminum contents, the soft magnetic powercore® grades with their very flat strip profile are the ideal solution for electric motors.

## Production sites

Bochum

Motta Visconti

**Higher performance** with the same energy consumption

**Lower consumption** of resources such as copper, oil, and insulation materials

## Concentrated energy

Non-oriented electrical steels are used in the generation and consumption of electrical energy. The efficiency of electric-powered machines is influenced in particular by the magnetic properties of the electrical steel. Our powercore® products allow electric motors with extremely high efficiency – which helps conserve resources and protect the environment. These high-tech electrical steels are characterized by excellent processing properties, outstanding magnetic characteristics, and very high energy efficiency.

# powercore®
# A grades

In fully finished powercore® standard grades, all important quality features are fully developed. In many cases the magnetic properties are better than those specified in the standards.

Thanks to state-of-the-art process technology and reliable process control, all product properties are extremely uniform. The use of our hot strip as a starting material allows low core losses with low silicon and aluminum content. As saturation polarization increases with reduced alloy contents, our grades generally display higher polarization values in the upper magnetization range despite the low core losses.

**Electrical steel (NO) – Standard grades fully finished**

| | | Thickness | Density | Max. Core loss | | | | Min. Polarization | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | [mm] | [kg/dm³] | [W/kg] at | | [W/lb] at | | [T] at | | |
| | | | | 50 Hz | | 60 Hz | | 2,500 | 5,000 | 10,000 |
| | | | | 1.5 T | 1.0 T | 1.5 T | 1.0 T | [A/m] | [A/m] | [A/m] |
| **DIN EN 10106** | | | | | | | | | | |
| Steel grade designation | Standard designation | | | | | | | | | |
| powercore® M235-35A | M235-35A | 0.35 | 7.60 | 2.35 | 0.95 | 1.35 | 0.55 | 1.49 | 1.60 | 1.70 |
| powercore® M250-35A | M250-35A | 0.35 | 7.60 | 2.50 | 1.05 | 1.44 | 0.59 | 1.49 | 1.60 | 1.70 |
| powercore® M270-35A | M270-35A | 0.35 | 7.65 | 2.70 | 1.10 | 1.55 | 0.63 | 1.49 | 1.60 | 1.70 |
| powercore® M300-35A | M300-35A | 0.35 | 7.65 | 3.00 | 1.20 | 1.72 | 0.69 | 1.49 | 1.60 | 1.70 |
| powercore® M330-35A | M330-35A | 0.35 | 7.65 | 3.30 | 1.30 | 1.90 | 0.75 | 1.49 | 1.60 | 1.70 |
| powercore® M250-50A | M250-50A | 0.50 | 7.60 | 2.50 | 1.05 | 1.44 | 0.59 | 1.49 | 1.60 | 1.70 |
| powercore® M270-50A | M270-50A | 0.50 | 7.60 | 2.70 | 1.10 | 1.55 | 0.63 | 1.49 | 1.60 | 1.70 |
| powercore® M290-50A | M290-50A | 0.50 | 7.60 | 2.90 | 1.15 | 1.67 | 0.66 | 1.49 | 1.60 | 1.70 |
| powercore® M310-50A | M310-50A | 0.50 | 7.65 | 3.10 | 1.25 | 1.78 | 0.72 | 1.49 | 1.60 | 1.70 |
| powercore® M330-50A | M330-50A | 0.50 | 7.65 | 3.30 | 1.35 | 1.90 | 0.78 | 1.49 | 1.60 | 1.70 |

## Electrical steel (NO) – Standard grades fully finished

| | | Thickness | Density | Max. Core loss | | | | Min. Polarization | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | [mm] | [kg/dm³] | [W/kg] at | | [W/lb] at | | [T] at | | |
| | | | | 50 Hz | | 60 Hz | | 2,500 | 5,000 | 10,000 |
| | | | | 1.5 T | 1.0 T | 1.5 T | 1.0 T | [A/m] | [A/m] | [A/m] |
| **DIN EN 10106** | | | | | | | | | | |
| Steel grade designation | Standard designation | | | | | | | | | |
| powercore® M350-50A | M350-50A | 0.50 | 7.65 | 3.50 | 1.50 | 2.01 | 0.86 | 1.50 | 1.60 | 1.70 |
| powercore® M400-50A | M400-50A | 0.50 | 7.70 | 4.00 | 1.70 | 2.30 | 0.98 | 1.53 | 1.63 | 1.73 |
| powercore® M470-50A | M470-50A | 0.50 | 7.70 | 4.70 | 2.00 | 2.70 | 1.15 | 1.54 | 1.64 | 1.74 |
| powercore® M530-50A | M530-50A | 0.50 | 7.70 | 5.30 | 2.30 | 3.05 | 1.32 | 1.56 | 1.65 | 1.75 |
| powercore® M600-50A | M600-50A | 0.50 | 7.75 | 6.00 | 2.60 | 3.45 | 1.49 | 1.57 | 1.66 | 1.76 |
| powercore® M700-50A | M700-50A | 0.50 | 7.80 | 7.00 | 3.00 | 4.02 | 1.72 | 1.60 | 1.69 | 1.77 |
| powercore® M800-50A | M800-50A | 0.50 | 7.80 | 8.00 | 3.60 | 4.60 | 2.07 | 1.60 | 1.70 | 1.78 |
| powercore® M940-50A | M940-50A | 0.50 | 7.85 | 9.40 | 4.20 | 5.40 | 2.41 | 1.62 | 1.72 | 1.81 |
| powercore® M310-65A | M310-65A | 0.65 | 7.60 | 3.10 | 1.25 | 1.78 | 0.72 | 1.49 | 1.60 | 1.70 |
| powercore® M330-65A | M330-65A | 0.65 | 7.60 | 3.30 | 1.35 | 1.90 | 0.78 | 1.49 | 1.60 | 1.70 |
| powercore® M350-65A | M350-65A | 0.65 | 7.60 | 3.50 | 1.50 | 2.01 | 0.86 | 1.49 | 1.60 | 1.70 |
| powercore® M400-65A | M400-65A | 0.65 | 7.65 | 4.00 | 1.70 | 2.30 | 0.98 | 1.52 | 1.62 | 1.72 |
| powercore® M470-65A | M470-65A | 0.65 | 7.65 | 4.70 | 2.00 | 2.70 | 1.15 | 1.53 | 1.63 | 1.73 |
| powercore® M530-65A | M530-65A | 0.65 | 7.70 | 5.30 | 2.30 | 3.05 | 1.32 | 1.54 | 1.64 | 1.74 |
| powercore® M600-65A | M600-65A | 0.65 | 7.75 | 6.00 | 2.60 | 3.45 | 1.49 | 1.56 | 1.66 | 1.76 |
| powercore® M700-65A | M700-65A | 0.65 | 7.75 | 7.00 | 3.00 | 4.02 | 1.72 | 1.57 | 1.67 | 1.76 |
| powercore® M800-65A | M800-65A | 0.65 | 7.80 | 8.00 | 3.60 | 4.60 | 2.07 | 1.60 | 1.70 | 1.78 |
| powercore® M1000-65A | M1000-65A | 0.65 | 7.80 | 10.00 | 4.40 | 5.75 | 2.53 | 1.61 | 1.71 | 1.80 |
| powercore® M600-100A | M600-100A | 1.00 | 7.60 | 6.00 | 2.60 | 3.45 | 1.49 | 1.53 | 1.63 | 1.72 |
| powercore® M700-100A | M700-100A | 1.00 | 7.65 | 7.00 | 3.00 | 4.02 | 1.72 | 1.54 | 1.64 | 1.73 |
| powercore® M800-100A | M800-100A | 1.00 | 7.70 | 8.00 | 3.60 | 4.60 | 2.07 | 1.56 | 1.66 | 1.75 |
| powercore® 940-100A | Special mill grade | 1.00 | 7.80 | 9.40 | 4.20 | 5.40 | 2.41 | 1.58 | 1.68 | 1.78 |
| powercore® M1000-100A | M1000-100A | 1.00 | 7.80 | 10.00 | 4.40 | 5.75 | 2.53 | 1.58 | 1.68 | 1.76 |
| powercore® M1300-100A | M1300-100A | 1.00 | 7.80 | 13.00 | 5.80 | 7.47 | 3.33 | 1.60 | 1.70 | 1.78 |

## Electrical steel (NO) – Standard grades fully finished, according to standards

| Thickness | powercore® grade | Grade as per | Grade as per | Grade as per | Grade as per | Grade as per | Grade as per |
|---|---|---|---|---|---|---|---|
| [mm] | | DIN EN 10106 | IEC 60404-8-4 | JIS C 2552 | ASTM A 677 M | ASTM A 677 | former |
| | | 1996 | 1988 | 1986 | 1989 | 1989 | AISI designation |
| 0.35 | M235-35A | M235-35A | – | 35-A-230 | – | – | – |
| | M250-35A | M250-35A | 250-35-A5 | 35-A-250 | 36F 320M | 36F 145 | M-15 |
| | M270-35A | M270-35A | 270-35-A5 | 35-A-270 | 36F 348M | 36F 158 | M-19 |
| | M300-35A | M300-35A | 300-35-A5 | 35-A-300 | 36F 370M/397M | 36F 168/180 | M-22/M-27 |
| | M330-35A | M330-35A | 330-35-A5 | – | 36F 419M | 36F 190 | M-36 |
| 0.50 | M250-50A | M250-50A | – | – | – | – | – |
| | M270-50A | M270-50A | 270-50-A 5 | 50-A-270 | 47F 370M | 47F 168 | M-15 |
| | M290-50A | M290-50A | 290-50-A 5 | 50-A-290 | 47F 384M | 47F 174 | M-19 |
| | M310-50A | M310-50A | 310-50-A 5 | 50-A-310 | 47F 408M/419M | 47F 185/190 | M-22/M-27 |
| | M330-50A | M330-50A | 330-50-A 5 | 50-A-330 | 47F 452M | 47F 205 | M-36 |
| | M350-50A | M350-50A | 350-50-A 5 | 50-A-350 | 47F 507M | 47F 230 | M-43 |
| | M400-50A | M400-50A | 400-50-A 5 | 50-A-400 | 47F 617M | 47F 280 | – |
| | M470-50A | M470-50A | 470-50-A 5 | 50-A-470 | 47F 672M | 47F 305 | M-45 |
| | M530-50A | M530-50A | 530-50-A 5 | – | – | – | – |
| | M600-50A | M600-50A | 600-50-A 5 | 50-A-600 | 47F 882M | 47F 400 | M-47 |
| | M700-50A | M700-50A | 700-50-A 5 | 50-A-700 | 47F 992M | 47F 450 | – |
| | M800-50A | M800-50A | 800-50-A 5 | 50-A-800 | – | – | – |
| | M940-50A | M940-50A | – | 50-A-1000 | – | – | – |
| 0.65 | M310-65A | M310-65A | – | – | – | – | – |
| | M330-65A | M330-65A | – | – | – | – | – |
| | M350-65A | M350-65A | 350-65-A 5 | – | 64F 459M/480M | 64F 208/218 | M-19/M-22 |
| | M400-65A | M400-65A | 400-65-A 5 | – | 64F 496M/529M | 64F 225/240 | M-27/M-36 |
| | M470-65A | M470-65A | 470-65-A 5 | – | 64F 595M | 64F 270 | M-43 |
| | M530-65A | M530-65A | 530-65-A 5 | – | 64F 705M | 64F 320 | – |
| | M600-65A | M600-65A | 600-65-A 5 | – | 64F 792M | 64F 360 | M-45 |
| | M700-65A | M700-65A | 700-65-A 5 | – | 64F 882 | 64F 400 | – |
| | M800-65A | M800-65A | 800-65-A 5 | 65-A-800 | 64F 1078M | 64F 490 | M-47 |
| | M1000-65A | – | 1000-65-A 5 | 65-A-1000 | – | – | – |
| 1.00 | M600-100A | M600-100A | – | – | – | – | – |
| | M700-100A | M700-100A | – | – | – | – | – |
| | M800-100A | M800-100A | – | – | – | – | – |
| | 940-100A | – | – | – | – | – | – |
| | M1000-100A | M1000-100A | – | – | – | – | – |
| | M1300-100A | M1300-100A | – | – | – | – | – |

# Electrical steel for e-mobility and high frequencies

The grades for e-mobility and high frequencies are ideal for use in highly efficient automotive drive systems. The steel grade features very good processing properties, providing advantages in final application regardless of whether it is used in hybrid or electric vehicles.

**Electrical steel (NO) – For e-mobility and high frequencies**

| | | Thick-ness | Density | Max. Core loss | Min. Polarization | | | Min. yield strength as per DIN EN ISO 6892-1 |
|---|---|---|---|---|---|---|---|---|
| | | [mm] | [kg/dm³] | [W/kg] at | [T] at | | | $R_{p0.2}$ in the rolling direction at room temperature |
| | | | | 400 Hz | 2,500 | 5,000 | 10,000 | |
| | | | | 1.0 T | [A/m] | [A/m] | [A/m] | [MPa] |
| **According to EN 10303** | | | | | | | | |
| Steel grade designation | Standard designation | | | | | | | |
| powercore® traction 020-130Y320 | NO20-13 | 0.20 | 7.60 | 13 | 1.48 | 1.59 | 1.69 | 320 |
| powercore® traction 020-130Y350 | NO20-13 | 0.20 | 7.60 | 13 | 1.48 | 1.59 | 1.69 | 350 |
| powercore® traction 020-150Y320 | NO20-15 | 0.20 | 7.60 | 15 | 1.48 | 1.59 | 1.69 | 320 |
| powercore® traction 025-140Y400 | NO25-14 | 0.25 | 7.60 | 14 | 1.52 | 1.61 | 1.71 | 400 |
| powercore® traction 027-140Y420 | NO27-15 | 0.27 | 7.60 | 14 | 1.51 | 1.61 | 1.73 | 420 |
| powercore® traction 027-150Y370* | NO27-15 | 0.27 | 7.60 | 15 | 1.52 | 1.61 | 1.73 | 370 |
| powercore® traction 027-150Y420* | NO27-15 | 0.27 | 7.60 | 15 | 1.52 | 1.61 | 1.73 | 420 |
| powercore® traction 027-180Y370* | NO27-18 | 0.27 | 7.60 | 18 | 1.52 | 1.61 | 1.73 | 370 |
| powercore® traction 030-150Y420* | NO30-16 | 0.30 | 7.60 | 15 | 1.52 | 1.61 | 1.73 | 420 |
| powercore® traction 030-160Y420* | NO30-16 | 0.30 | 7.60 | 16 | 1.52 | 1.61 | 1.73 | 420 |
| powercore® traction 032-190Y330* | NO35-19 | 0.32 | 7.65 | 19 | 1.52 | 1.62 | 1.74 | 330 |
| powercore® traction 035-170Y420* | NO35-19 | 0.35 | 7.60 | 17 | 1.52 | 1.61 | 1.73 | 420 |
| powercore® traction 035-180Y400 | NO35-19 | 0.35 | 7.60 | 18 | 1.52 | 1.61 | 1.73 | 400 |
| powercore® traction 035-190Y390 | NO35-22 | 0.35 | 7.60 | 19 | 1.52 | 1.61 | 1.73 | 390 |
| powercore® traction 035-220Y330 | NO35-22 | 0.35 | 7.65 | 22 | 1.52 | 1.62 | 1.74 | 330 |
| powercore® traction 035-220Y300 | NO35-22 | 0.35 | 7.65 | 22 | 1.55 | 1.64 | 1.76 | 300 |

*Steel grades stand out on account of their excellent further processing properties and advantages with regard to their final applications.

More detailed information on properties and processing can be found in our production information brochures at www.thyssenkrupp-steel.com.

# powercore®
# AP grades

powercore® AP grades display a more favorable texture in the sheet plane thanks to the use of special production technology.

This texture results in higher polarization values. AP grades can be magnetized more easily at medium field strengths. Their special chemical composition also provides improved thermal conductivity.

**Electrical steel (NO) – Highly permeable grades fully finished**

| | | Thickness | Density | Max. Core loss | | | | Min. Polarization | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | [mm] | [kg/dm³] | [W/kg] at | | [W/lb] at | | [T] at | | |
| | | | | 50 Hz | | 60 Hz | | 2,500 | 5,000 | 10,000 |
| | | | | 1.5 T | 1.0 T | 1.5 T | 1.0 T | [A/m] | [A/m] | [A/m] |
| Steel grade designation | Standard designation | | | | | | | | | |
| powercore® 330-35AP | Special mill grade | 0.35 | 7.65 | 3.30 | 1.30 | 1.90 | 0.75 | 1.55 | 1.64 | 1.76 |
| powercore® 440-35AP | Special mill grade | 0.35 | 7.80 | 4.40 | 2.10 | 2.53 | 1.21 | 1.62 | 1.71 | 1.82 |
| powercore® 330-50AP | Special mill grade | 0.50 | 7.65 | 3.30 | 1.35 | 1.90 | 0.78 | 1.57 | 1.67 | 1.79 |
| powercore® 400-50AP | Special mill grade | 0.50 | 7.70 | 4.00 | 1.70 | 2.30 | 0.98 | 1.61 | 1.70 | 1.81 |
| powercore® 530-50AP | Special mill grade | 0.50 | 7.80 | 5.30 | 2.30 | 3.05 | 1.32 | 1.65 | 1.74 | 1.84 |
| powercore® 700-50AP | Special mill grade | 0.50 | 7.85 | 7.00 | 3.00 | 4.02 | 1.72 | 1.68 | 1.76 | 1.87 |
| powercore® 350-65AP | Special mill grade | 0.65 | 7.60 | 3.50 | 1.50 | 2.01 | 0.86 | 1.57 | 1.67 | 1.79 |
| powercore® 470-65AP | Special mill grade | 0.65 | 7.75 | 4.70 | 2.20 | 2.70 | 1.26 | 1.61 | 1.70 | 1.81 |
| powercore® 600-65AP | Special mill grade | 0.65 | 7.80 | 6.00 | 2.60 | 3.45 | 1.49 | 1.64 | 1.73 | 1.83 |
| powercore® 800-65AP | Special mill grade | 0.65 | 7.85 | 8.00 | 3.60 | 4.60 | 2.07 | 1.68 | 1.76 | 1.87 |
| powercore® 1400-100AP | Special mill grade | 1.00 | 7.85 | 14.00 | 5.50 | 8.05 | 3.16 | 1.68 | 1.76 | 1.87 |

# powercore® PP grades

powercore® PP grades display a favorable isotropic texture in the sheet plane thanks to the use of special production technology.

This texture results in higher polarization values. PP grades can be magnetized more easily at medium and high field strengths. Their special chemical composition also provides improved thermal conductivity. The magnetic properties are controlled by annealing individual laminations or complete stacks at the customer's plant – resulting in very high magnetic conductivity at very low losses.

## Electrical steel (NO) – Highly permeable grades non-fully finished

| | | Thickness | Density | Max. Core loss* | | | | Min. Polarization* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | [mm] | [kg/dm³] | [W/kg] at | | [W/lb] at | | [T] at | | |
| | | | | 50 Hz | | 60 Hz | | 2,500 | 5,000 | 10,000 |
| | | | | 1.5 T | 1.0 T | 1.5 T | 1.0 T | [A/m] | [A/m] | [A/m] |
| Steel grade designation | Standard designation | | | | | | | | | |
| powercore® 235-35PP | Special mill grade | 0.35 | 7.60 | 2.35 | 0.95 | 1.35 | 0.55 | 1.49 | 1.60 | 1.70 |
| powercore® 280-35PP | Special mill grade | 0.35 | 7.60 | 2.80 | 1.10 | 1.61 | 0.63 | 1.49 | 1.60 | 1.70 |
| powercore® 330-35PP | Special mill grade | 0.35 | 7.65 | 3.30 | 1.30 | 1.90 | 0.75 | 1.49 | 1.60 | 1.70 |
| powercore® 270-50PP | Special mill grade | 0.50 | 7.70 | 2.70 | 1.16 | 1.55 | 0.67 | 1.61 | 1.70 | 1.81 |
| powercore® 330-50PP | Special mill grade | 0.50 | 7.75 | 3.30 | 1.60 | 1.90 | 0.92 | 1.61 | 1.70 | 1.81 |
| powercore® 390-50PP | Special mill grade | 0.50 | 7.80 | 3.90 | 1.70 | 2.24 | 0.98 | 1.60 | 1.68 | 1.78 |
| powercore® 450-50PP | Special mill grade | 0.50 | 7.80 | 4.50 | 2.00 | 2.58 | 1.15 | 1.60 | 1.68 | 1.78 |
| powercore® 660-50PP | Special mill grade | 0.50 | 7.85 | 6.60 | 3.00 | 3.79 | 1.72 | 1.68 | 1.76 | 1.86 |
| powercore® 800-65PP | Special mill grade | 0.65 | 7.85 | 8.00 | 3.50 | 4.60 | 2.01 | 1.68 | 1.75 | 1.87 |

*Following reference annealing on the lines of DIN EN 10341.

# powercore®
# K grades

Semi-processed powercore® grades display good processing properties in the as-delivered condition.

The magnetic properties are controlled by annealing the individual laminations or complete stacks at the customer's plant. In many cases, core losses are lower and polarization values higher than specified in the standards.

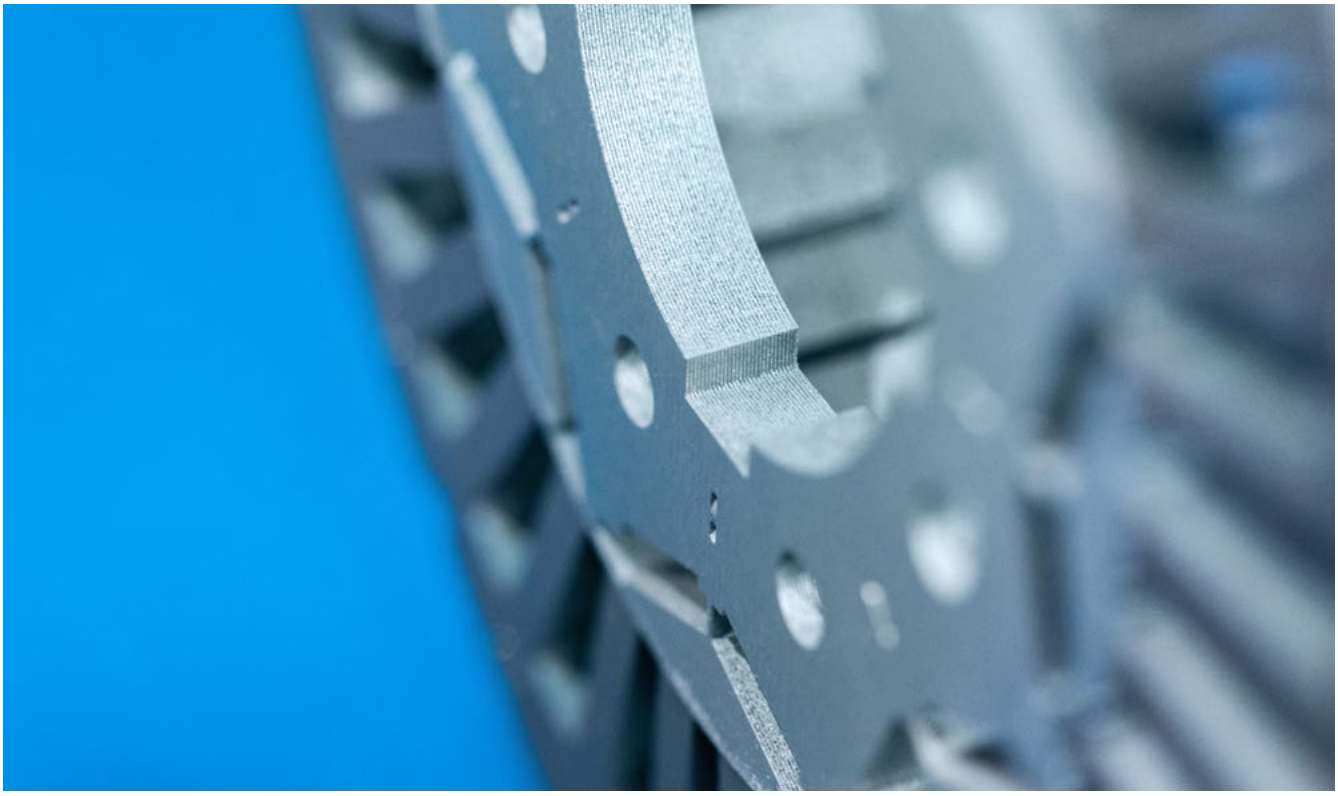
**Electrical steel (NO) – Standard grades semi-finished**

| | | Thickness | Density | Max. Core loss* | | | | Min. Polarization* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | [mm] | [kg/dm³] | [W/kg] at | | [W/lb] at | | [T] at | | |
| | | | | 50 Hz | | 60 Hz | | 2,500 | 5,000 | 10,000 |
| | | | | 1.5 T | 1.0 T | 1.5 T | 1.0 T | [A/m] | [A/m] | [A/m] |
| **DIN EN 10341** | | | | | | | | | | |
| Steel grade designation | Standard designation | | | | | | | | | |
| powercore® M890-50K | M890-50K | 0.50 | 7.85 | 8.90 | 3.70 | 5.12 | 2.13 | 1.60 | 1.68 | 1.78 |
| powercore® M1050-50K | M1050-50K | 0.50 | 7.85 | 10.50 | 4.30 | 6.04 | 2.47 | 1.57 | 1.65 | 1.77 |
| powercore® M800-65K | M800-65K | 0.65 | 7.85 | 8.00 | 3.30 | 4.60 | 1.90 | 1.62 | 1.70 | 1.79 |
| powercore® M1000-65K | M1000-65K | 0.65 | 7.85 | 10.00 | 4.20 | 5.75 | 2.41 | 1.60 | 1.68 | 1.78 |

* Following reference annealing on the lines of DIN EN 10341.

## Electrical steel (NO) – Standard grades semi-finished, according to standards

| Thickness | powercore® grade | Grade as per | Grade as per | Grade as per | Grade as per | Grade as per | Grade as per |
|---|---|---|---|---|---|---|---|
| [mm] | | DIN EN 10341 | DIN EN 10126<br>DIN EN 10165 | IEC 60404-8 2/3 | ASTM A 683 M | ASTM A 683 | former |
| | | 2006 | 1996 | 1988 | 1984 | 1984 | AISI designation |
| 0.50 | – | – | – | – | 47S392M | 47S178 | M-27 |
| | M340-50K | M340-50K | M340-50E | M340-50E5 | 47S414M/441M | 47S188/200 | M-36/M-43 |
| | M390-50K | M390-50K | M390-50E | M390-50E5 | 47S507M | 47S230 | – |
| | M450-50K | M450-50K | M450-50E | M450-50E5 | 47S551M | 47S250 | M-45 |
| | M560-50K | M560-50K | M560-50E | M560-50E5 | 47S661M | 47S300 | – |
| | M660-50K | M660-50K | M660-50D | M660-50D5 | – | – | – |
| | M890-50K | M890-50K | M890-50D | M890-50D5 | – | – | – |
| | M1050-50K | M1050-50K | M1050-50D | M1050-50D5 | – | – | – |
| 0.65 | M390-65K | M390-65K | M390-65E | M390-65E5 | 64S470M/507M | 64S213/230 | M-36/M-43 |
| | M450-65K | M450-65K | M450-65E | M450-65E5 | 64S573M | 64S260 | – |
| | M520-65K | M520-65K | M520-65E | M520-65E5 | 64S617M | 64S280 | M-45 |
| | M630-65K | M630-65K | M630-65E | M630-65E5 | 64S772M | 64S350 | – |
| | M800-65K | M800-65K | M800-65D | M800-65D5 | – | – | – |
| | M1000-65K | M1000-65K | M1000-65D | M1000-65D5 | – | – | – |
| | M1200-65K | M1200-65K | M1200-65D | M1200-65D5 | – | – | – |



# Insulation coatings

**Electrical steel (NO) – Insulation coatings**

| | Insulation type | Coating | Color[1] | Improvement in punchability[2] | Suitability for the annealing of laminations as per DIN EN 10341 | Corrosion resistance as per DIN EN ISO 6270-2 AHT[3] |
|---|---|---|---|---|---|---|
| **IEC 60 404-1-1** | | | | | | |
| Designation | | | | | | |
| stabolit® 10 | organic | both sides | yellow-green | very good | – | good |
| stabolit® 20 | inorganic with organic components | both sides | colorless | very good | yes | satisfactory |
| stabolit® 30 | inorganic | both sides | light gray | good | yes | satisfactory |
| stabolit® 60 | inorganic with organic components, pigmented | one and both sides | gray | good | yes | satisfactory |
| stabolit® 70 | organic bonding lacquer | one and both sides | colorless | – | – | – |

1) Color deviations are possible without affecting the properties.
2) In comparison to uncoated material.
3) AHT = condensation atmosphere with alternating humidity and air temperature.
4) SEP = Stahl-Eisen-Prüfblatt (steel-iron test sheet).
5) At room temperature as per ASTM A717.
6) To avoid premature corrosion, the oil content of water-dilutable lubrication must be higher than 5% (max. time in stock for lamination five days).
7) Depending on steel surface and coating thickness.
8) Resistant to annealing according to DIN EN 10126

## stabolit® 10

offers high surface insulation resistance, and is therefore ideal for small transformers with cores that are assembled by clamping, riveting, or similar. Significantly improved stampability (up to three times longer die life) compared with uncoated dry-stamped electrical steel.

## stabolit® 20

has high elevated-temperature strength and very good weldability and is ideal for small and medium-size machines as well as miniature transformers, also with welded cores. It provides significantly improved punchability and adequate insulation resistance despite its low coating thickness.

## stabolit® 30

is a classic anti-stick coating. Its high elevated-temperature strength and very good weldability make it ideal for small and medium-size motors as well as miniature transformers, also with welded cores. It provides adequate insulation resistance despite its low coating thickness.

More detailed information on insulation coatings can be found in our production information brochures at www.thyssenkrupp-steel.com.

| Degree of rusting as per DIN EN ISO 4628-3 | Weldability (TIG) as per SEP[4] 1210 | Temperature resistance in air as per DIN IEC 60404-12 | Classification as per international standards | Coating thickness per side [µm] | Insulation resistance[5] [Ω cm²/lamination] |
|---|---|---|---|---|---|
| Ri 0 | – | permanently 180 °C | EC-3 | 0.50 – 1.50 | > 5 |
| | | | | 2.50 – 4.50 | > 20 |
| | | | | 3.00 – 5.00 | > 50 |
| Ri 0[6] | Up to 1,000 mm/min at 125 A | permanently 210 °C short time 30 min at 600 °C | EC-5-P chrome-free C-5 | max. 1.00 | > 2 |
| | | | | 0.50 – 1.50 | > 5 |
| | | | | 1.50 – 2.50 | > 50 |
| Ri 0 to Ri 3[7] | > 1,000 mm/min | permanently 300 °C[8] | EC-4 C-4 or C-4-AS | 0.50 – 1.00 | > 5 |
| Ri 0 to Ri 3[7] | Up to 1,000 mm/min (at 1.5 µm thickness) | permanently 270 °C 2,500 h at 300 °C or 30 min at 600 °C | EC-5 C-5 | 1.00 – 3.00 | > 15 |
| – | – | – | – | 3.00 – 5.00 (water soluble) | |
| | | | | 4.00 – 6.00 (water soluble) | |

With stabolit® 70, it must be ensured that the max. storage temperature of 40 °C and also the max. processing time fo 6 months are not exceeded. The adhesive properties decrease with increasing storage time.

## stabolit® 60

is a pigmented organic-inorganic insulation coating. It displays very good weldability and punchability at low coating thicknesses. Other properties of note include corrosion protection and high elevated-temperature strength. This insulation coating is therefore ideal for all processing operations in which the material is exposed to thermal stresses, e. g. welding, die casting, or stress relief annealing. It can also be used as an anti-stick coating.

## stabolit® 70

was developed to adhesively bond laminations into stacks and is therefore the ideal solution in cases where other assembly methods would cause unacceptable magnetic disturbances (for example in stepping motors, linear motors, or large magnets). Stacks bonded with stabolit® 70 can also be used as “active end plates” in medium-size and large machines and in large deflection systems. Please note that bonding strength may be reduced at temperatures over 100 °C. In addition, roller peel values depend on the silicon content of the substrate. Processing information is available on request.

# stabosol® – Adhesive system for large-scale automotive production

Highly reactive adhesive system for joining and insulating the laminations without damage: Reduction of motor loss up to 16 %

Inline bonding directly in the die is possible

Compared to baking varnish, faster curing at lower temperature with shorter process: approx. 75 % time saving

## Advantages for the OEM

- Higher motor efficiency; more vehicle range
- Increased mechanical load capacity in handling
- Higher stacking factor
- Better thermal management
- Interlamellar corrosion protection

## Advantages for the stamper

- Continuous, high-volume punching and stacking process
- No additional oven required
- Tooling costs comparable with punching
- Tool and press line space requirements as for die stacking
- Tool contamination at the level of baking varnish
- With existing oven capacities: capacity increase and cost reduction without investment

## Areas of application

stabosol® denominates a special highly reactive adhesive and insulating varnish for the coating of electrical steel intended for the manufacture of rotor and stator packets in large-scale electric motor production. The product has the ability to stably bond the full surface of laminations punched for stack assembly in a short and energetically advantageous series production process. In contrast to the processes commonly used in large-scale production, such as interlocking and welding, the material properties of the electrical steel strip are optimally maintained for the final motor product.

With stabosol®, the disadvantageous effects of joining the laminations in the form of material damage and short circuits are avoided. In this way, eddy current losses and disturbances in the magnetic flux can be minimized, and thus electric motors with significantly higher efficiency and power density can be built. In contrast to other established bonding solutions, e.g. with baking varnishes, stack assembly with the highly reactive stabosol® bonding system is also characterized by a particularly short cycle time suitable for large-scale production as well as for a continuous process that is not interrupted by oven storage.

| Coating thickness and application method as delivered (both sides) | | | |
|---|---|---|---|
| Coating thickness | Application | State of delivery | Storage capability (without reduction of adhesion and processing properties) |
| 2.5 µm | Outer side | dry | Sheets stackable, coils rewindable, 6 months at room temperature |
| 4.0 µm | Inner side | dry | Sheets stackable, coils rewindable, 6 months at room temperature |

## Process sequence and variants

### Variant 1: Today's standard process (Discontinuous process with oven storage)

Punched parts can be produced from an electrical steel strip coated with stabosol® in the same way as a classic adhesive stacking process.

After punching and stacking, the sheets are bonded together in a separate oven process by applying pressure and temperature to form the stack. During this process, the previously dry adhesive layer softens, bonds the laminations together and finally hardens.

Compared to baking varnishes, the special chemical formulation of stabosol® enables a significant reduction in the required activation energy and reaction time until the lamella stack has reached handling strength. Overall, the cycle time can be reduced by up to 75% when compared to conventional baking varnishes due to the lower temperature required and the associated reduction in oven dwell time.

The risk of the coating being squeezed out at the side and subsequent reworking effort is also significantly reduced due to the high reactivity when compared to standard baking varnishes – even at excessive process temperatures.

At the same time, stabosol® is characterized by an extended process window in terms of temperature and processing time in contrast to baking varnishes.

### Variant 2: New inline process (Continuous process with integrated activation in the punching tool)

A particularly advantageous second process variant is the continuous, layer-by-layer bonding of the lamellae already in the die-cutting sequence process in the area of the stacking unit. For this purpose, each subsequent lamella is irradiated by a short high-energy infrared light pulse and thus activated. Immediately after activation, it is placed on the stack being built up and joined with contact pressure.

The stack of sheets is bonded layer by layer in the cycle of the punching tool, thus dispensing with any subsequent separate oven exposure. In a subsequent second processing step, which has no negative effect on the cycle time, the stack must be re-compacted for full retention of the handling strength. Optionally, additional heat can be introduced during compaction.

In this process variant, cycle times of approx. 160 strokes/min can be achieved, proving that adhesive packaging using stabosol® is competitive with established processes in large-series production such as interlocking or welding, but without adopting their disadvantages.

Thanks to the special product properties of stabosol®, it is thus possible to achieve optimal end product properties, significantly reduced process costs and capacity increases compared to today's standard process. This means that stabosol® is not limited to the production of small machines and/or series, but is ideally suited for large quantities in electromobility.

# stabosol® properties

## Adhesion of the joint

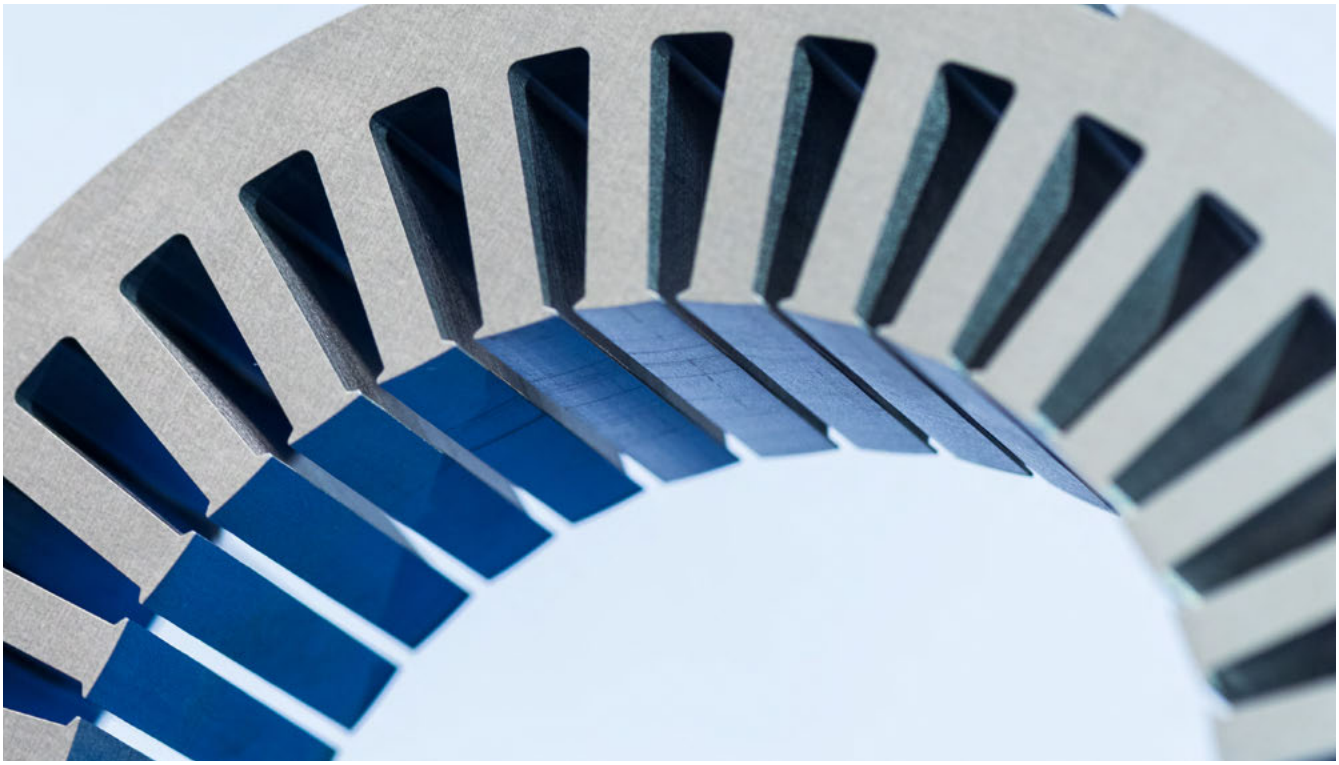
When bonding two sheet metal strips with stabosol® in accordance with the requirements, the tensile shear test shows that separation is generally only triggered by the plastic flow of the substrate material starting in the yield point range.Depending on the Si content and taking into account that stabosol® sheets are coated on both sides, the shear values are as follows:

- 027-150Y420 with > 4 N/mm²
- 032-190Y330 with > 4 N/mm²
- M800-65A with > 6 N/mm²

The shear values are reference values determined according to DIN EN 1465.

## Thermal behavior in the bonded stack

To test the stability of bonded sheet packages, individually bonded two sheets were bonded to form a sandwich sheet and subjected to a continuous temperature load at 180 °C for a period of 5,000 hours. Subsequently, the adhesion properties of bonded joints made from these sheets were investigated in a tensile shear test according to DIN EN 1465 at 20 °C (RT). This showed that there was no loss of strength when compared to the initial state. In contrast to stabolit® 70, stabosol® is characterized by a significantly higher residual tensile shear strength in the bonded joint, even at high temperatures. The reduction in strength at 180 °C is only approx. 30 % when compared to RT. Application-specific loading temperatures above 180 °C must be ensured by testing.



## Resistance to aggressive media

stabosol® is resistant to common types of oil.
The not yet bonded coating is not solvent resistant.

## Surface condition

The coated surface must be free from grease. In cases of contamination, the cleanability must be checked in each individual case.

## Insulation resistance

During bonding, individual contact areas between the lamellae may occur – depending on the amount of pressure exerted. It is not possible to determine the surface resistance for the as-delivered condition, as stabosol® has not yet been finally chemically cross-linked. If the process is carried out correctly, stabosol® is characterized by a familiar insulating effect known in common insulating varnishes.

## Shelf life

At temperatures below 20 °C and in dry storage, the shelf life is at least 6 months. At temperatures below 30 °C and in dry storage, the shelf life is at least 4 months. The prerequisite for this is that direct sunlight or UV radiation as well as temperatures falling below the dew point are avoided. Temperatures above 30 °C should be avoided as the shelf life decreases. Temperatures up to 60 °C are possible in the short term.

# Width / thickness variations and geometric properties

## Width variations

| Strip width | Narrow strip | Wide strip | |
|---|---|---|---|
| [mm] | 30 * to 500 | Edge trimmed | Mill edge |
| | | 500 to 1,250 | 700 to 1,250 |
| ≤ 300 | 0 / + 0.2 | – | – |
| > 300 – 500 | 0 / + 0.3 | – | – |
| > 500 – 600 | – | 0 / + 0.5 | – |
| > 600 – 1,000 | – | 0 / + 1.0 | 0 / + 10.0 |
| > 1,000 – 1,250 | – | 0 / + 1.5 | 0 / + 10.0 |

* Narrower on request.

## Thickness variations

| | Nominal thickness [mm] | | | |
|---|---|---|---|---|
| | 0.35 | 0.50 | 0.65 | 1.00 |
| Max. variation from thickness | ± 8% | ± 6% | ± 5% | ± 5% |
| Max. thickness variation parallel to rolling direction over a gauge length of 1 m | 6% | 4% | 4% | 4% |
| Max. thickness variation perpendicular to rolling direction, measured at least 30 mm from edge | 0.02 mm | 0.02 mm | 0.03 mm | 0.03 mm |

Electrical steel for e-mobility and high frequencies according to DIN EN 10303.

## Geometric properties

| | Guaranteed value | |
|---|---|---|
| | Fully finished | Semi-finished |
| Max. burr height | 0.03 mm | 0.03 mm |
| Max. waviness for product width > 100 mm with | | |
| trimmed edges | 1.5% | 1.5% |
| mill edges | 2.0% | 2.0% |
| Max. camber for products > 100 mm and nominal thickness ≤ 0.65 mm to DIN EN 10251 | 35 mm | – |
| Max. edge camber to DIN EN 10251 over 1 m gauge length for strip widths | | |
| > 30 – 150 mm | 1.0 mm | – |
| > 150 mm | 0.5 mm | – |
| On 1 m gauge length for products with | | |
| trimmed edges | – | 4.0 mm |
| mill edges | – | 6.0 mm |
| Max. deviation from shearing line per 1 m gauge length for products > 150 mm | 2.0 mm | – |

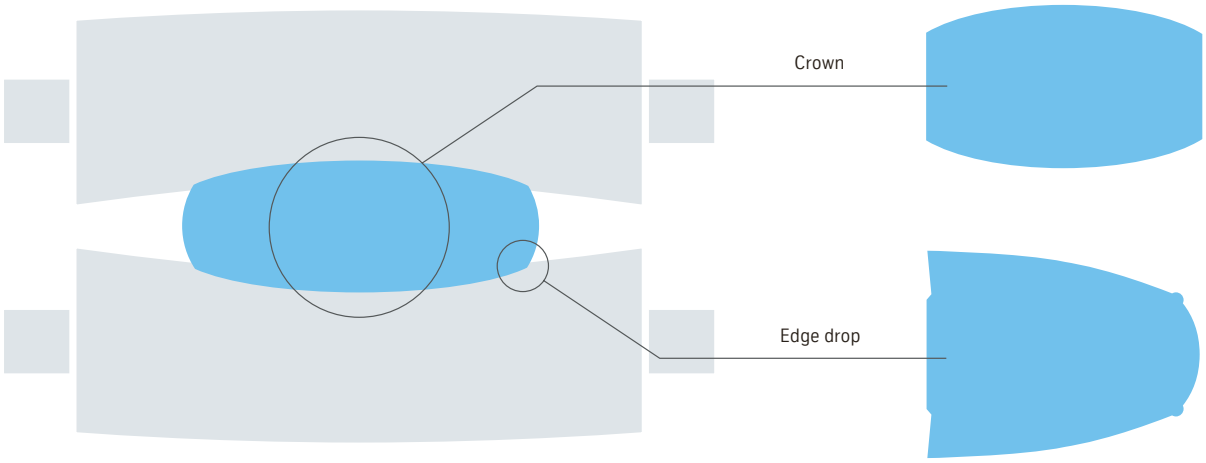
## Electrical steel (NO) – Dimensions

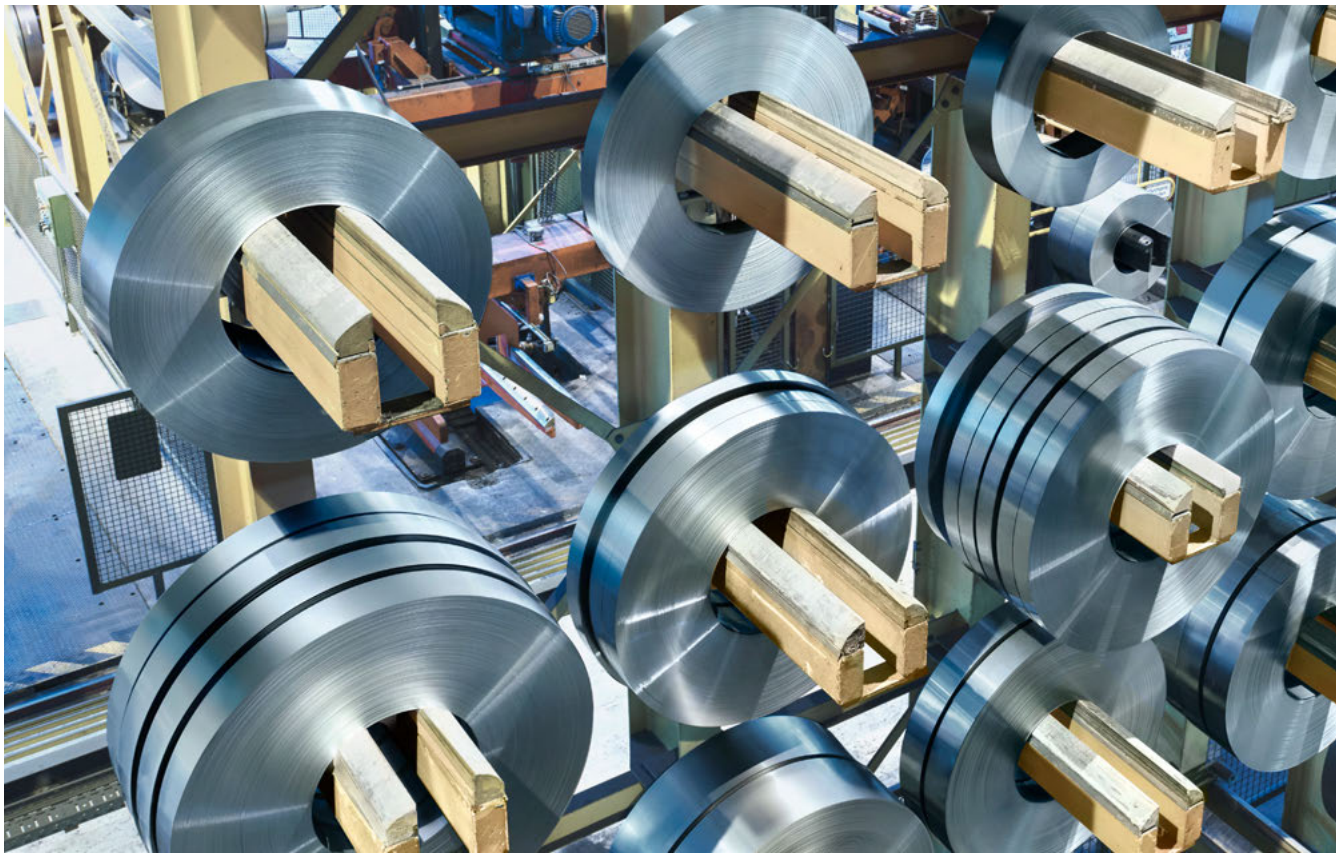
| | Width [mm] |
|---|---|
| **Narrow strip** | |
| Inside diameter 508 mm | 30 – 500* |
| **Wide strip** | |
| Inside diameter 508 mm and 610 mm | 500 – 1,250 |

*Narrower on request.

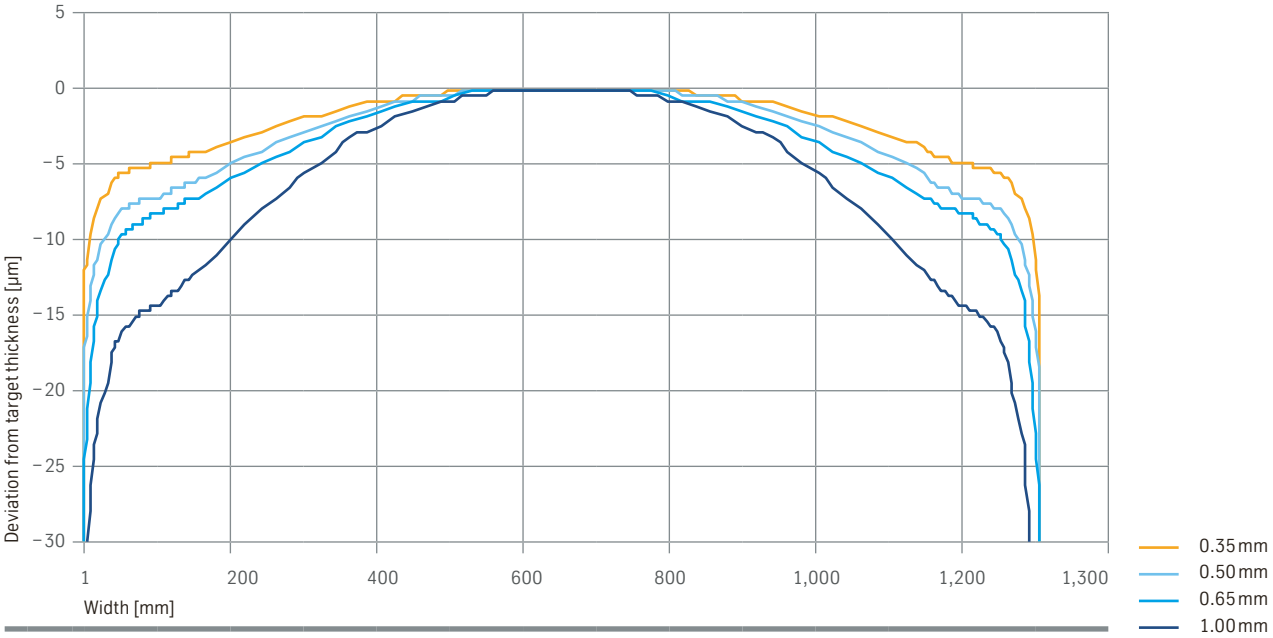
## Development of crown and edge drop at hot rolling and cold rolling

Work roll bending and embedding of the strip

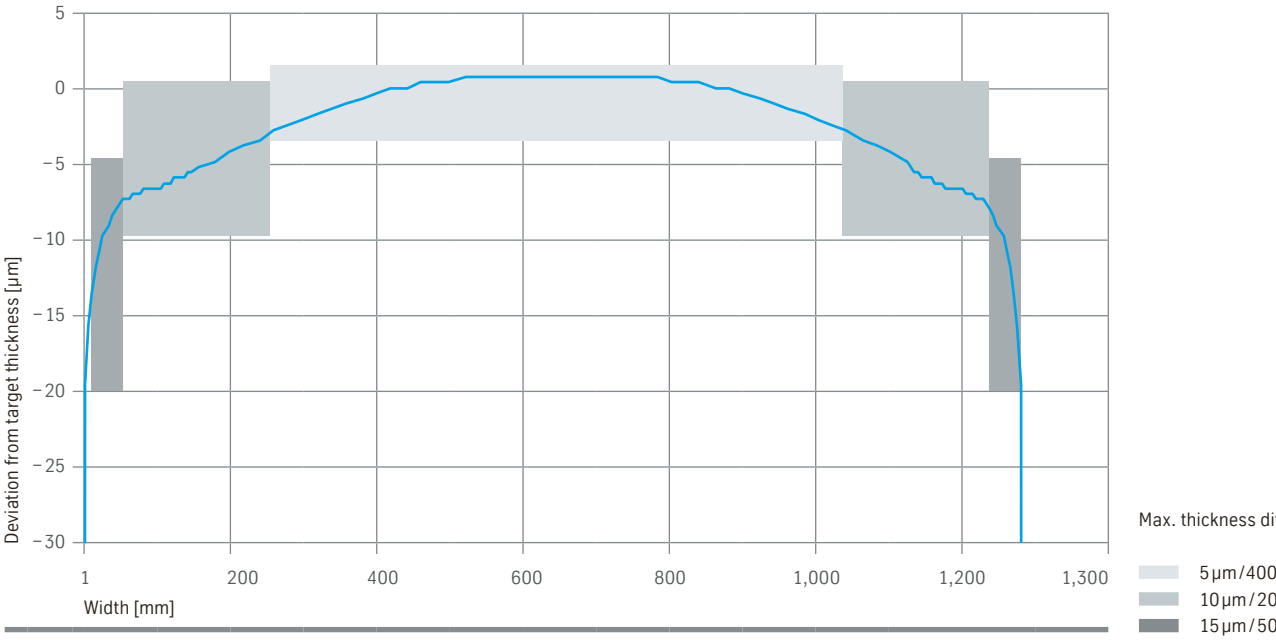


## Cold strip shape depending on the final thickness




## Optimized slitting schedule (nominal thickness 0.5 mm)



# Conversion table

## Conversion of units of measure

| | in | to be multiplied by | to obtain |
|---|---|---|---|
| Size | | | |
| Magnetic flux density B/ magnetic polarization J | T = Wb/m² = Vs/m² | $10^{-4}$ | Wb/cm² = Vs/cm² |
| | T | $10^{4}$ | G |
| | T | $6.45 \times 10^{4}$ | lines/square inch |
| | Vs/cm² | $10^{4}$ | T |
| | G | $10^{-4}$ | T |
| | lines/square inch | $1.55 \times 10^{-5}$ | T |
| Magnetic field strength H | A/m | 0.01 | A/cm |
| | A/m | 0.01257 | Oe |
| | A/m | 0.0254 | Ampere-turns/inch |
| | A/cm | 100 | A/m |
| | Oe | 79.6 | A/m |
| | Ampere-turns/inch | 39.37 | A/m |
| Core loss | W/kg | 0.4536 | W/lb |
| | W/lb | 2.20462 | W/kg |
| | W/kg (50 Hz) | 1.266 | W/kg (60 Hz) |
| | W/kg (60 Hz) | 0.79 | W/kg (50 Hz) |
| Length L | cm | 0.3937 | inch |
| | inch | 2.54 | cm |
| Area A | cm² | 0.155 | square inch |
| | square inch | 6.45 | cm² |
| Volume V | cm³ | 0.061 | cubic inch |
| | cubic inch | 16.4 | cm³ |
| Mass m | g | 0.0353 | ounce |
| | kg | 2.20462 | pound |
| | ounce | 28.35 | g |
| | pound | 0.4536 | kg |
| Force F | N = kgm/s² | 0.102 | kp |
| | kp | 9.81 | N = kgm/s² |
| Stress σ | N/mm² | 0.102 | kp/mm² |
| | N/mm² | 145 | psi |
| | kp/mm² | 9.81 | N/mm² |
| | psi | $6.90 \times 10^{-3}$ | N/mm² |
| Temperature T | °C | ×1.8+32 | °F |
| | °F | ×0.556−17.8 | °C |

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