



**OVAKO**

**97 %**  
recycled steel

**100 %**  
carbon-neutral  
production

**OVAKO**  
**PRODUCTS**



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# INDUSTRY SOLUTIONS

Ovako has extensive experience in supplying steel for an array of demanding applications across a wide range of industrial segments. We apply the knowledge and expertise derived from direct experience in each field for the benefit of both our customers and their own end-users.

## Agriculture

Ovako supplies different grades of boron steel for agricultural machines, such as plows and many other products where wear resistance is a critical issue.



## Bearings

Ovako provides the world's largest bearing manufacturers with the ultra-clean steel essential to achieve a service life bordering on the infinite. This is a core focus area for Ovako for over a century.



## Chains and lifting devices

For lifting equipment, steel parts need to rise to the occasion with safe and reliable performance around the clock. High wear resistance is also needed.



## Fasteners

Ovako's steel is crucial to the success of a wide variety of advanced fasteners. They include anchor bolts, stud-bolts, bolts for blades and towers in wind turbines and U-Bolts for heavy vehicles.



## Hydraulics

Hydraulic drive systems comprise hydraulic pumps, controls and actuators. Ovako is an industry leading supplier with steels that are ideal for all parts of the system.



## Manufacturing

Our direct manufacturing customers know that our steel helps them add value thanks to its consistently reliable and repeatable performance in forging, machining and heat treatment.



## Rock tools

Rock drilling and processing require steels that can withstand the toughest environments. With a strong tradition in this field, we supply products with superior fatigue and wear resistance.



## Light and heavy vehicles

We provide solutions to design challenges in chassis components and powertrains. Our clean steels support the drive for lighter and stronger high-performance systems.



## Energy

The quest for renewable energy demands reliable, high strength engineering steel for critical applications. Ovako is a key supplier for mission-critical components and climate-smart solutions.



## Transport

Ovako is long-standing steel supplier for demanding transport solutions. Our products are used for safety-critical applications in rail-ways, such as the clips to secure rails.



# GLOBAL COLLABORATION

The collaboration between Nippon Steel, Sanyo Special Steel and Ovako is focused on bringing out the best in each other to achieve one common goal: making our customers more successful than ever. We do this by combining our expertise, products and support in a leading global offering.

Our expanded offering gives customers the added convenience of choosing from the world’s widest range of specialty steel products. Optimized global production and supply also gives them the reliable deliveries they need. And the joint strength of our R&D resources helps accelerate their innovation, boosting competitiveness. Finally, through our environmentally efficient production, strong industrial ownership, global supply and worldwide customer-support capacity, we ensure an unrivalled level of sustainability and availability



### Convenience

The world’s widest range of specialty steel products provides our customers with the exact solution they need for their specific industrial applications. Our experience in meeting demands for product quality means that we can be our customers’ first choice, especially since we are certified to meet most quality and environmental standards, whether from ISO, JIS or IATF.

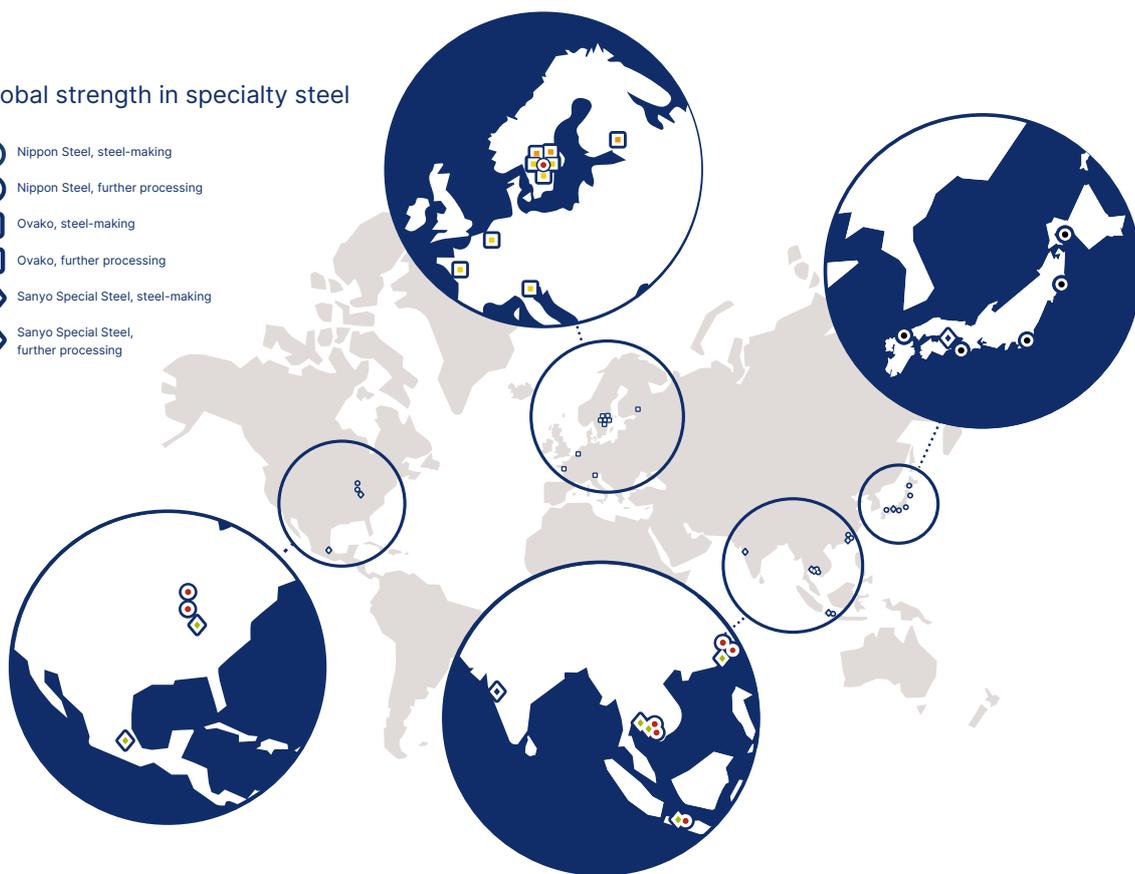
### Availability

The combination of global operations and sales channels means that we can provide even better customer service. Combined sales organizations across the world, in combination with well-established trading channels and value-adding logistics, offers new advantages. This allows us to provide leading-edge technical support as well as tailored logistics for customers wherever they are.



Global strength in specialty steel

-  Nippon Steel, steel-making
-  Nippon Steel, further processing
-  Ovako, steel-making
-  Ovako, further processing
-  Sanyo Special Steel, steel-making
-  Sanyo Special Steel, further processing



**Reliability**

A broad portfolio of steel metallurgies, rolling mills, and many complementary downstream operations means that we can always find several alternative global supply routes for customers. This allows peace of mind, as our customers know they can rely on us for continuity of supply.

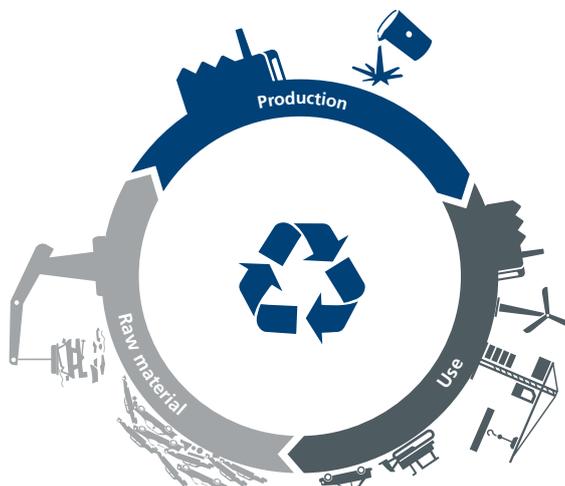
**Innovation**

At each of our R&D locations we have a proud history of having developed advanced products for many types of highly demanding applications. Now that we offer the combined experience of these centers of excellence, we are opening new doors for even better collaboration with customers who are seeking leadership in their specific markets.



**Sustainability**

The collaboration that we now enjoy is based on strong industrial ownerships as well as environmentally efficient steel production, whether scrap, or ore-based. Our focus is long-term, and we are here to stay. This also means that we look at our customer relations from the long-term perspective. We want to build robust and sustainable supply chains, with the aim to develop steel solutions that build a better future.

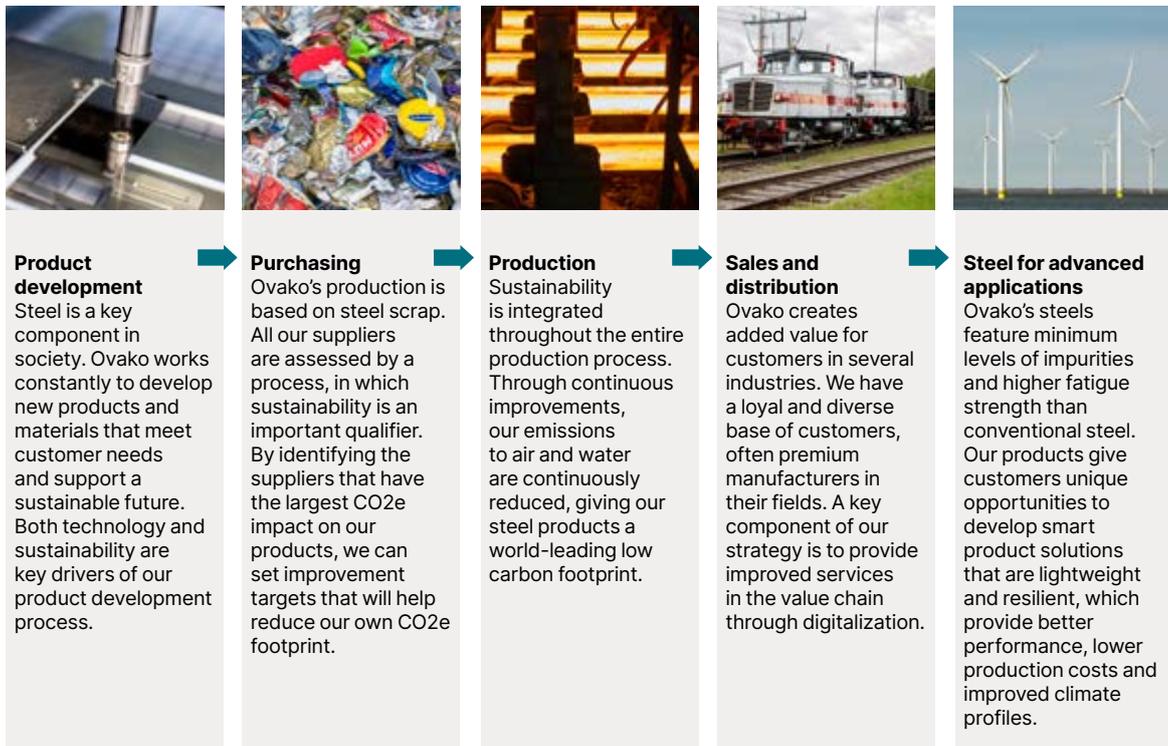


# SUSTAINABILITY

Ovako is a world-leader in low carbon dioxide emissions, yet our ambition is to improve even further, at a higher pace than our peers. Therefore we have set a target for 2030 to reduce our CO2 emissions by 80 % from the base year of 2015. This puts us well on the journey towards zero carbon emissions, but already from 2022 our total operations are carbon-neutral thanks to voluntary carbon offsets.

Ovako strives for a sustainable value chain and a business that generates value at all stages, from product development to end products. A sustainable value chain is about ensuring that all aspects of sustainability are

integrated within the entire chain, from materials and design all the way to production. Our value chain can be divided into the following stages:



## The product life cycle

The steel industry represents more than 8 % of the world's carbon dioxide emissions and even more when taking in the complete "cradle-to-gate" perspective. This creates an opportunity for climate-conscious producers like Ovako to make a difference by supplying steel that is more sustainable.

We work continuously to improve our performance. Our production is based on melting recycled steel scrap in electric arc furnaces (EAF) that are powered by low carbon energy. This differs from many steel producers who use the basic oxygen furnace (BOF) method to process iron ore using fossil fuels.

Ovako's steel is part of a cycle in which scrap becomes steel products which again, becomes scrap. Once a product that uses steel has reached the end of its life, it can be recycled. Steel is the world's most recycled material and can be remelted again and again to produce the highest quality products in a sustainable cycle. Ovako is the largest recycler in the Nordics, with products based on an average scrap content of 97 %.

We also re-use or recycle 94 % of all our residual products with the goal of contributing to the best possible societal benefits. Ovako therefore conducts ongoing development to identify areas of use for the residual products that arise in the production process of our high-quality steel products.

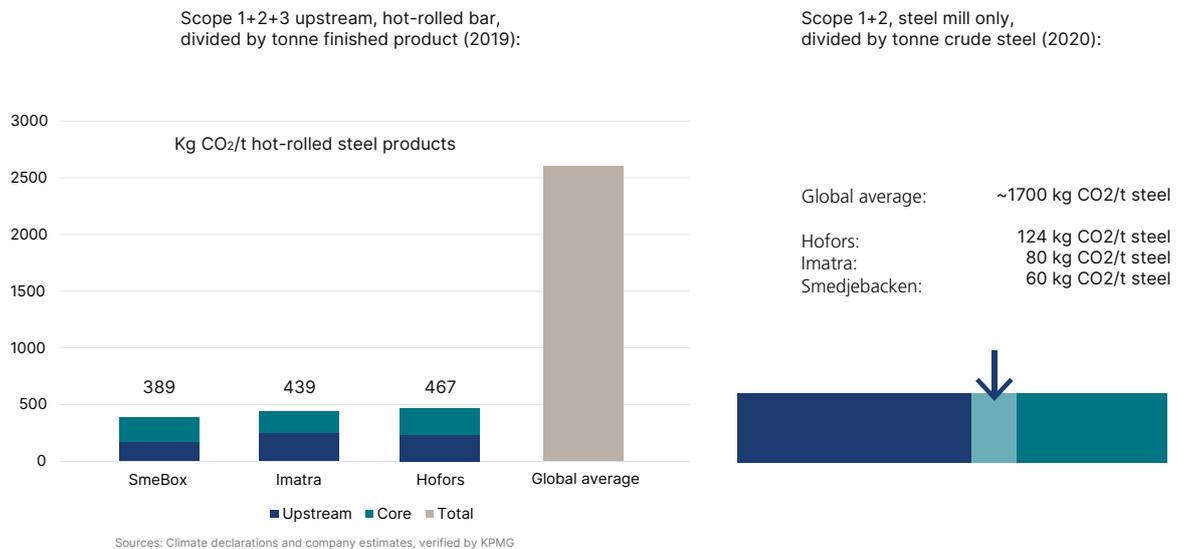
**Carbon neutral steel**

Since 2015, Ovako has reduced its scope 1 and 2 emission of CO<sub>2</sub>e by more than 50 %. This achievement shows how we are responding to the climate challenge and our targets are in line with limiting the global temperature rise to below 1.5°C under the United Nations’ Paris Climate Agreement.

Our cradle-to-gate footprint is second to none and some two tonnes per tonne of product below global average.

We believe our customer can make a difference by choosing steel with the right performance. In fact, our vision statement reads “innovative steel for a better engineered future”. With a more careful selection process the best performing steels with the lowest carbon footprint can enable large environmental contributions.

In this way, our sustainability ambitions stretch from raw materials, through our own production to final use of the products based on the steel we provide.



**Contributing to the circular economy**

Ovako’s production is based on using recycled steel as input material instead of iron ore. Steel can be recycled an infinite number of times while maintaining its properties. By basing 97 % of our production on steel scrap, we can create high-quality steel with a lower climate impact without compromising on quality.

However, not all scrap is the same. We sort our incoming scrap material into multiple categories based on its alloy content, size and shape. By closely matching the quality of the scrap with the steel grade we are planning to produce, we reduce the amount of virgin alloys needed. That is one reason why we achieve a “cradle-to-gate” carbon footprint that is 80 % lower than the global average.

**Carbon Neutral Now**

Starting in 2022, to bring our already very low carbon footprint to zero, we will buy voluntary carbon credits, aligned with UN Sustainable Development Goals. This carbon credits measure should be seen as only an interim step along our path towards zero carbon emissions.



# PRODUCT FORMS

We offer a wide range of grades combined with a very wide range of shapes and sizes. All to provide our customers with a real competitive edge.

## Hot-rolled bar

We have established a long-standing leading reputation for products ideal for applications where fatigue strength, toughness and wear resistance are critical. As well as meeting specified requirements, our bar products offer good formability, machinability and weldability, making them a cost-saving solution.

## Flat bar and special profiles

We have the ability to supply bar steel in flat shapes as well as in many hundreds of variants of Special profiles, helping customers reduce their machining operations and increase productivity.

## Further processed bar

Available in a wide range of shapes, our bright bar grades eliminate processing steps and unnecessary stock build-up.

## Wire and bar-in-coil

Ovako's SR-100 Wire is a surface removed and inspected wire that increases the quality of the finished product.

## Seamless tube and hollow bar

Ovako's tube and hollow bar is used when there are stringent demands on the material, such as within the rolling bearing, automotive, hydraulic and manufacturing industries.

## Rolled and forged rings

As a producer of rolled and forged rings for almost a century, Ovako has a proven track record in this product niche. We strictly control the whole production chain, from melt to the rolling of the rings.

## Pre-components

Near net shape products are supplied by profiling bar or rings. We can also supply many variants of cut tube or bar to allow our customers to focus on their core production steps. This typically makes the complete production chain more efficient. Machined flat and round bar components can be produced on a large scale and in-line with our other production. We can also supply machined rings.

## Hard-chrome plated bar and tube

Ovako Cromax is the pioneer and the technology leader in its field. The unique capability of in-house production from steel mill to plating, facilitates unmatched quality and consistency of the base materials and surface.

## Other product forms from Nippon Steel Group

### Pipe and Tube

- Seamless
- Butt-welded
- Electric-resistance welded
- Electric-arc welded
- Cold-drawn
- Coated pipes and tubes

### Powder metallurgy

- Metal powder
- PM products
- Sputtering targets

### Sheet and Plate

- Heavy plates
- Medium plates
- Hot-rolled sheets
- Cold-rolled sheets
- Tin-free steel
- Hot-dipped galvanized sheets
- Other metallic coated sheets
- Pre-coated sheets
- Cold-rolled electrical sheets
- Rolled titanium products

### Formed and Fabricated Parts



# HOT-ROLLED BAR

Ovako delivers hot-rolled bar in many shapes: round, square, flat and as special profiles. We also hot-roll bar under very controlled condition for a range of Special Properties bar, SP-bar for short.

## Hot-rolled round bar

We have an excellent track record in delivering products for applications where fatigue strength, toughness and wear resistance are critical. As well as meeting the specified requirements, our bar products offer good formability, machinability and weldability, making them a cost-saving solution for our customers.

Our hot-rolled bar can be further processed by heat treatment, machining and chrome plating. A major proportion of our round bar is supplied as peeled, ground or drawn bright bar. The Ovako hot-rolled bar offering also contains round bar, flat bar, round corner squared bar, special properties bar, special profiles and pre-components plus our SR-100 Wire and the Cromax product family. All are available in a variety of sizes. Our hot-rolled bar is characterised by close tolerances, excellent straightness as well as roundness, good surfaces and low decarburization. This makes them ideally suited for forging and machining.

### Size range

Standard hot-rolled round bar is delivered in diameters from 14 mm to 230 mm, and in many different sizes. They can typically be delivered at 1 mm intervals up to Ø 75 mm. Larger dimensions are available at 5 mm intervals

### Tolerances on dimensions and shape

The tolerances on dimensions and shape for round bar according to EN 10060 meet the European standards. Our rolling mills have excellent capability to produce tighter tolerances, including half the standard tolerance. Please contact our sales organisation when enquiring about hot-rolled bar if tighter tolerances are needed.

### Lengths

The most common bar length is 6 meters, but can also range between 2.8 and 21 meters, depending on the producing rolling mill. Heat treatments and operations may restrict the maximum length.

If not otherwise specified, the manufacturing length is 6,000 mm. Bar diameter, heat treatment and yield optimisation may result in a deviation from this common length. Ten per cent of the bar may be below the minimum of the ordered range, but not less than 3 meters.

At the time of the order, bar can be delivered sawn to exact lengths.

### Roundness

Out of roundness is measured as the difference between the maximum and minimum diameters. Out of roundness is typically at most two-thirds of the diameter tolerance.

### Straightness

Straightness is measured as the deviation from a straight line. Depending on the particular mill, we measure straightness over a test length of 1.0 meter with a maximum acceptable deviation of 2 mm.

### Surface quality

Standard surface crack depth is a maximum 1 % of the diameter. When an order is made the bar can be inspected, for example, by magnetic flux leakage or the magnetic particle method. Normally, surface quality class D can be achieved for diameters up to Ø 80 mm and C for diameters up to Ø 120 mm that comply with EN ISO 9443.

From Nippon Steel and Sanyo Special Steel in Japan we can source products to expand the range of hot-rolled bar up to 400 mm in round and up to 550 mm for round corner square bar. In addition the range for forged bar is 150–880 mm.

### Round corner square bar

Square bar, or billets, are mainly used for drop-forged components in the automotive industry. Ovako's round corner square bar has a uniform internal structure and a very good surface quality – absolute requirements when producing drop-forged parts.

Round corner squared bar has a suitable shape for forging operations. Its shape also provides higher size flexibility in rolling processes.

Round corner square bar from Ovako has a uniform weight distribution over the bar length due to its high consistent quality. This makes it possible to produce forging blanks with a small variation in weight.

Round corner square bar has no sharp edges which could cause the formation of laps and surface defects during forging operations.

#### Advantages of Round corner square bar

- Offers a uniform weight distribution over the bar due to high consistent quality
- No sharp edges that could cause laps or surface defects when forged
- No overheating of corners in induction heating compared to sharp corner bar
- Easier handling in rotary hearth furnaces since it does not require rolling like round bar
- Safer handling since it does not require rolling

### Forged/Rolled Bar

The range of bars that Ovako can supply has historically been split into fine, medium and heavy bars. All depending on size.

The range of rolled bars is restricted in size due to several parameters relating to the size range of our rolling mills as well as reduction rates and center homogeneity.

In our heavy rolling from ingots we currently offer bars up to 160 mm outer diameter, mainly due to the internal issues.

We do however also roll larger sizes, which then are billets for further processing as in ring or tube rolling. For our largest rings we even make forged bars from Ingots.

To expand the external offering of heavy bars, we are now developing our routes for forging and heavy rolling. This new product will combine the center homogeneity of forged bars with the surface and outer tolerance of rolled bars.

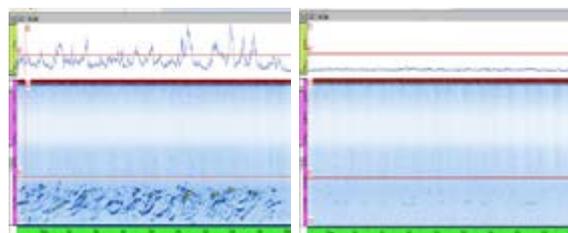
We will stepwise expand our size range. At first up to 230 mm outer diameter round bar.

Please check in with us to see what we currently offer.

#### Advantages Forged/Rolled bar

Combining both processes can give a product with:

- Improved centre soundness compared to rolled only
- Improved dimension tolerances compared to forging only
- Improved surface quality compared to forged only



Rolled-only

Forged/rolled

## SP-bar

As a hot-rolled bar with enhanced properties, our Special Properties bar is offered in a variety of grades that provide added value and substantial cost savings due to the SP-Bar treatment's effect on mechanical properties.

Special Properties round bar, commonly known as SP-Bar, is the result of Ovako's continuous product development. By optimising the properties of the bar material, customers can benefit from increased added value and substantial cost savings in manufacturing operations.

Size range: 14 to 52 mm

Lengths: 4 to 12 m

### Mechanical properties

SP-Bar offers improved mechanical properties compared to regular bar. The result is a longer fatigue life and a greater impact strength.

### Tolerances

SP-Bar offer extremely tight tolerances. Consequently SP-Bar can often replace peeled or drawn bar. Customers can decrease the nominal size and get more manufactured pieces per tonne of purchased SP-Bar.

### Surface quality

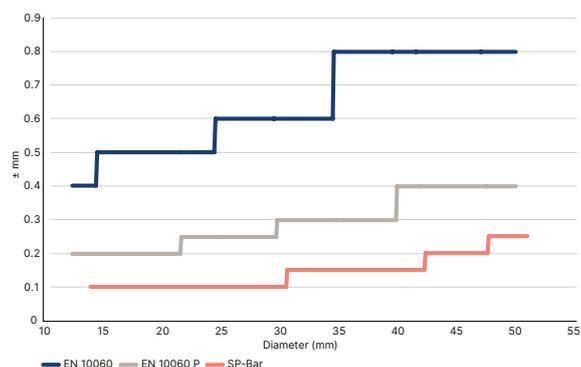
Scale thickness is generally reduced on SP-Bar. The reduction can be up to 50 % compared to conventionally hot-rolled products. The reduced scale thickness gives a cleaner environment in subsequent operations such as cold-forming or heat treatment.



### Advantages of SP-Bar

- Tighter tolerances that deliver increased yields and repeatability as well as material savings
- Improved mechanical properties that provide longer fatigue life and greater impact strength
- Better surface quality that reduces scale and results in cleaner quenching tanks and an improved process environment.

### Dimensional tolerances SP-Bar





# FLAT BAR AND SPECIAL PROFILES

We have the ability to supply bar steel in flat shapes, characterized by excellent straightness and shape as well as good surfaces and low decarburization. We can also supply bar steel in many hundred variants of profiles, helping customers reduce their machining operations and increase productivity.

## Hot-rolled flat bar

Flat bar by Ovako is produced by a combination of precisely controlled manufacturing processes that provide superior impact toughness, good surfaces and high yield strength across a range of applications.

Ovako delivers hot-rolled flat bar in a broad range of dimensions. The bar is characterised by excellent straightness and shape as well as good surfaces and low decarburization.

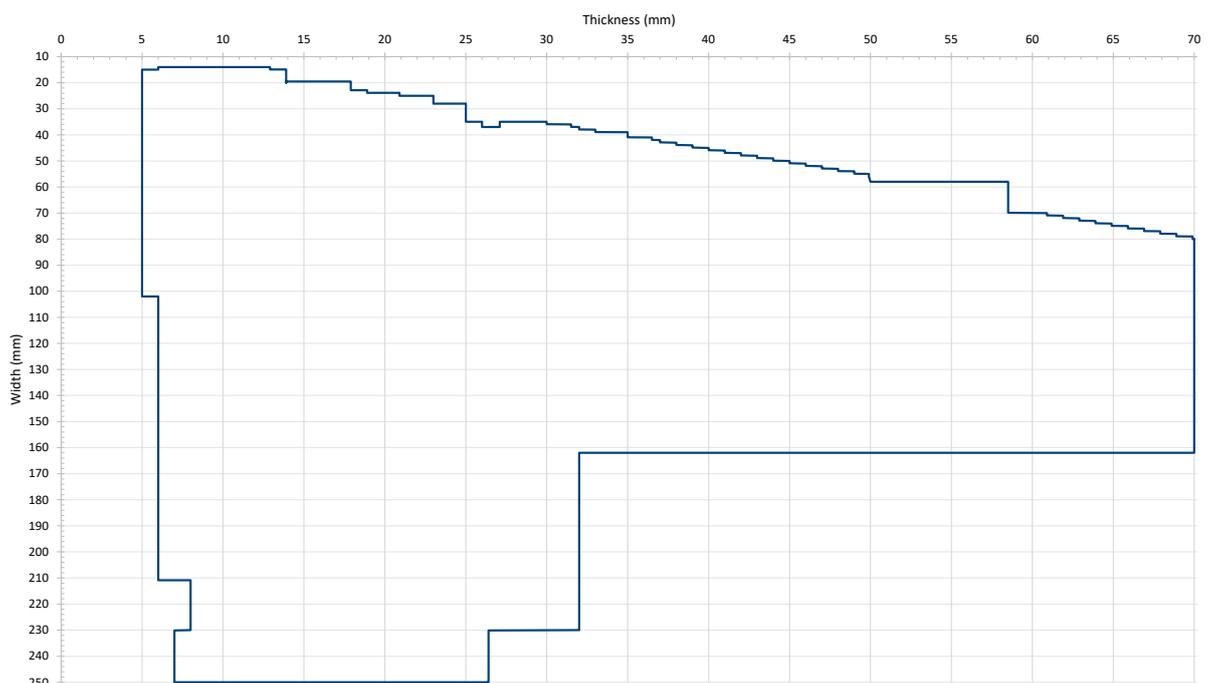
### Straightness

The out of straightness is measured and our flat bar complies with European Standard EN 10058 as-rolled, but can also be delivered in the as-straightened condition.

## Shape and dimensions

The rolled shape is generally flat bar with square corner edges. It can on request also be rolled as flat bar with different corner radii. The tolerances on dimensions for flat bar fulfil the European standard EN 10058. Our rolling mills have excellent capability to produce even tighter tolerances. The most common bar length is 6 meters, but can also range from 2.8 to 21 meters, depending on size and the producing rolling mill. Heat treatment may restrict the maximum length available. Bar can be delivered sawn to the exact length required.

## Dimensions, hot-rolled flat bar





**Hot-rolled spring steel flat bar**

Ovako delivers hot-rolled spring steel flat bar according to European Standard EN-10092-1 (Profile A, B, C). The steel used in Ovako's flat bar for spring manufacturing has very low levels of non-metallic inclusions and optimal hardenability. These contribute to a favorable yield-to-tensile strength ratio in the quenched and tempered condition – a combination of properties that provides exactly the right qualities for the end product.

Profile A

Profile A  
Hot-rolled flat bar with half-rounded edges.  
(EN 10092-1)

Profile B

Profile B  
Hot-rolled flat bar with semi-rounded edges.  
(EN 10092-1)

Profile C

Profile C  
Hot-rolled flat bar with straight edges and rounded corners.  
(EN 10092-1)



## Special profiles

By using hot-rolled special profile bar tailored to your exact needs, some manufacturing steps may be eliminated, lowering your costs. Our capability to hot-roll special profiles as required for a specific application may enable you to skip several steps in your production process. Ovako manufactures special profiles both in symmetrical and asymmetrical shapes.

### Size range

Our special profiles are rolled in widths ranging from 15 mm to 300 mm and thicknesses from 5 mm to 60 mm.

### Lower production costs

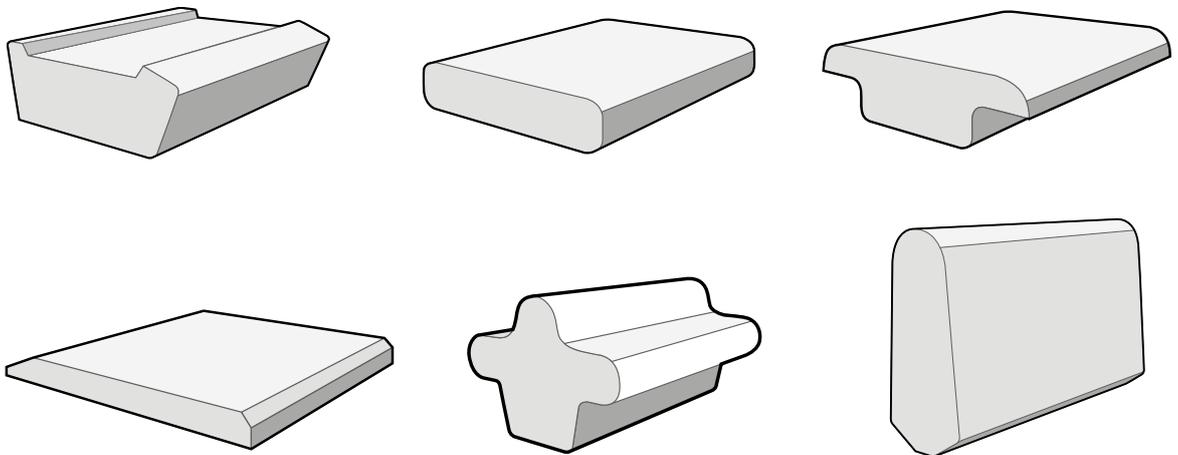
Being able to produce hot-rolled special profile bar often allows us to find a solution that allows more efficient manufacturing and lower production costs. Even basic simple profiles, such as flats with welding chamfers and rounded corners, often deliver high cost savings compared to machining or gas cutting.

### Marking

Special profile bar can be marked with a customer logo or other information.

### Advantages of special profiles

- Manufacturing steps may be eliminated, lowering costs
- Tailored to customer needs
- Highly intensive process steps such as machining can be eliminated for increased productivity
- Lower raw material costs due to lower weight usage
- Ovako helps customer design their unique profile
- Profiles can be produced from the whole range of Ovako steel grades



Within the Nippon steel group profiled bar is also offered in a wide range of shapes, sizes and grades from Oji Steel and Nihon Steel.

# FURTHER PROCESSED BAR

Available in a wide range of shapes, our further processed bar products eliminate processing steps and unnecessary stock build-up. This creates additional floor space in operations and/or warehouses and reduces capital tied up in raw material.

Bright bar, as it also is named, is a substantial part of our further processed bar offering. It contains peeled bar, drawn bar, ground bar and finally pre-components. With outer diameter tolerances of ground bar down to IT 6 or cut bar length tolerances of only +/- 0.05 mm we can help you to rationalize your production by eliminating some of your operations. That enables you to focus on the more critical value-added processes.

Besides the obvious product parameters there are a number of additional advantages you can gain using bright bar from Ovako, such as cleaner production with lower maintenance by avoiding black bar surfaces. Or minimized risk of shocks and vibrations by using a consistent product.

Our advanced logistics also means you can run a lean operation with JIT supplies. This minimizes the need to hold stock that both takes up space and ties up capital.

Finally you will also help the world by cutting down the transportation of material that only will end up as chips. And the chips we produce at Ovako are recycled in our own steel mills.

## Advantages of Further Processed Bar

- Environmental benefit from minimizing transport weight
- Rationalized production from further processed bar closer to end product
- Avoid spending CAPEX on non-core processes
- Just-in-time (JIT) contract for deliveries according to specific needs
- Reduce capital tied up in raw material

As an alternative to further processing we offer Special properties (SP-bar), hot-rolled bar with enhanced properties. SP-bar is the result of Ovako's continuous product development. By optimizing the properties of the hot-rolled bar material, customers can benefit from increased added value and substantial cost savings in manufacturing operations.

[Read more on page 15](#)

Pre-components from bar open up new possibilities to simplify production and to cut production costs, especially by not converting fixed costs to variable costs.

[Read more on page 36](#)

## Cold-drawn bar

Cold-drawn bar from Ovako is produced using special steel from our own steelworks. We are able to tailor steel properties such as strength, machinability, formability and hardenability for the most common customer requirements.

The size of the drawn bar can also be tailored to specific needs. The result is that our customers receive a material that supports consistently high-quality production and contributes to cost-effective manufacturing.

Due to its availability and the possibility to tailor the bar to customer requirements, this product is well suited for a wide range of applications. Rolling bearings, transmission components, shafts in automotive water pumps, spindles for textile machines, round files, bolts, springs and drills are a few examples of products made out of from Ovako's drawn bar.



### Advantages of cold-drawn bar

- Supports consistently high-quality production
- Cost-effective manufacturing

### Drawn bar product properties

<b>Size range</b>	Drawn bar is produced in the 11 to 55 mm diameter size range.
<b>Diameter tolerance</b>	IT10 is the standard tolerance. IT9 can be supplied subject to separate agreement.
<b>Surface condition</b>	Drawn bar is supplied oiled as standard for efficient rust protection.
<b>Straightness</b>	Normal straightness is max. 1 mm/m.
<b>Out of roundness</b>	Max. 50 % of the diameter tolerance, measured as the difference in diameter.
<b>Lengths and length tolerances</b>	The supply lengths are normally within the 2.5–6 meter range. The length tolerance is 100 mm but 50 mm can be supplied subject to separate agreement.
<b>Heat treatment</b>	Drawn bar can be obtained in a soft annealed condition.
<b>End condition</b>	Normally, the drawn bar is supplied with cold-sheared ends. However, subject to separate agreement they can be supplied with one or both ends square-milled and chamfered.
<b>Packing and marking</b>	The bar is delivered bundled, with or without wrapping. We can also supply the bar packed in wooden cases. Max bundle weight is 2 tonnes or 1.2 tonnes for bar in wooden cases.



## Peeled bar

Ovako's peeled bar saves on material, tools, machinery and production time. Our bar peeling is a well-integrated process that uses precision equipment. The peeled bar is supplied in a polished and straightened condition. This allows for a smoother surface finish, closer tolerances and better straightness, plastic forming as well as further machining.

Peeled bar gives customers the opportunity to rationalize production and reduce production costs. The extraordinary cleanliness of the steel reduces the risk of unexpected tool failures and downtime, and the excellent straightness minimises the risk of shocks and vibrations that can occur at high cutting speeds.

The good surface finish of Ovako's peeled bar can sometimes eliminate the need for further surface finishing. This saves material, machining and production time.

### Peeled bar is characterised by

- Technical surface defect free
- Free from decarburization
- Good surface smoothness
- Close tolerances
- Adjusted structure and hardness
- Good machinability after forming

### Advantages of peeled bar

- Rationalised production
- Lower production cost
- Minimised risk of shocks and vibrations at high cutting speeds
- Reduced need for further surface finishing

### Peeled bar product properties

<b>Size range</b>	Peeled bar is produced in optional sizes in the 17 to 127 mm diameter range.
<b>Steel grades</b>	Peeled bar is produced in a wide range of steel grades – from simple engineering steels to special steels for demanding applications.
<b>Diameter tolerance</b>	Tolerance class IT11 is standard. Upon separate agreement, tolerance class IT9 can be supplied.
<b>Surface roughness</b>	Max Rt 50 µm
<b>Straightness</b>	Normal straightness is max 0.6 mm/m.
<b>Lengths and length tolerances</b>	Delivery of optional lengths in the 4 to 8 m range. Heat-treated material may have other lengths.
<b>Out of roundness</b>	Max. 50 % of the diameter tolerance, measured as the difference in diameter.
<b>End finish</b>	Cold-sheared and deburred ends without radial burrs and/or cold sawn and chamfered, one or two ends, 45°.
<b>Packing and marking</b>	The material is supplied bundled with steel straps. Each bundle is supplied with a tag containing information about the order number, steel grade, heat number, dimension, weight and quantity of bar. The material is supplied oiled as standard. Other types of packaging, e.g. wrapped paper/plastic are provided upon request.



## Ground bar

Buying finished ground bar is usually a more cost-effective and productive alternative to grinding internally.

### Quality for efficient production

Ovako's ground bar is characterised by straightness, good out of roundness and a fine surface. These are important properties as they contribute to smooth and trouble-free production, especially when it comes to high machining speeds and accurate, vibrationless feeds in automatic lathes. Straightness is also particularly important when producing components from long bar. In addition, our ground bar has a minimum of internal stresses, which significantly reduces the risk of distortion after machining. Ovako's ground bar is therefore a favourable material for the manufacturing of products like long shafts, rolling bearings and ball bushings.

### Ground bar in three quality classes

To simplify the selection of the most suitable quality, ground bar is available in three product groups:

- Rough ground bar
- Fine ground bar, standard execution
- Fine ground bar, special execution



### Advantages of ground bar

- Smooth production especially at high machining speeds
- Accurate and vibrationless feed movements in automatic lathes
- Reduced risk of distortion after machining
- Ground material offers a surface quality "ready to use", requiring no further processing by the customer

### Ground bar product properties

	Rough ground bar	Fine ground bar, standard execution	Fine ground bar, special execution
Size range	Ø 12 to 100 mm	Ø 12 to 100 mm	Ø 12 to 100 mm
Tolerances	≥ IT9	IT8	Down to IT6
Lengths	4 to 7 m	4 to 7 m	4 to 7 m
Surface smoothness	Max. Ra 5 µm	Ra 1.0 µm	Down to Ra 0.6 µm
Out of roundness	Max. 50 % of the diameter tolerance, measured as the difference in diameter	Max. 50 % of the diameter tolerance, measured as the difference in diameter	Max. 50 % of the diameter tolerance, measured as the difference in diameter
Straightness	0.5 mm/m	Down to 0.2 mm/m	Down to 0.1 mm/m



# WIRE AND BAR-IN-COIL

Wire, bar-in-coil and wire rod are major product categories from Nippon Steel Group. Ovako's own offer is a special wire product, known as SR-100, which is a Surface Removed and 100 % inspected wire.

## SR-100 Wire

Ovako's SR-100 Wire has been developed to increase the quality of the finished product. Sometimes the surface of rolled base materials is sensitive to cracking and decarburization, which can have a negative effect on the production economy of the finished product. In the production of SR-100 Wire we remove surface defects and carry out 100 % automatic inspection of the surface. This wire meets most requirements for high-grade structural steel and bearing steel. The steels we use are characterised by high consistency of analysis and cleanliness.

As a rule, our wire is manufactured in accordance with specifications established by our customers. Tolerances and dimensions are adapted to the demands of the finished product and its manufacturing routines.

Size range: SR-100 Wire is produced in any size within the diameter range 11 to 26.5 mm.

Surface treatment: By agreement, SR-100 Wire can be supplied zinc phosphated, soap coated and/or oiled.

### Advantages of SR-100 Wire

- Better economy of production
- 100% inspected for surface defects
- Defects can either be cut away or identified by the inspection protocol
- More narrow tolerances compared to conventional wire rod



Nippon Steel Group offers world-leading wire products to meet a variety of needs. Four steel mills in Japan produce a range of coiled basic product forms from 5 to 60 mm. Sister companies in the Group produce wire of many dimensions and executions.



# SEAMLESS TUBE AND HOLLOW BAR

Our tube products are characterized by uniform properties and close tolerances and with special emphasis on small machining allowances.

Seamless tubes have been part of our offer for more than 100 years. From the heritage of making tubes for bearing races the process has been developed to enhance such properties as close tolerances and small machining allowances. The aim is to provide the optimum tube for mechanical component manufacturing, mainly for bearings, gears, valves, couplings shafts and many more general engineering components.

However the tubes may also be used in longer lengths as in drill rods or wear sleeves in various mining applications, or in hydraulic cylinders.

The product range covers all grades that Ovako produces, in sizes of outer diameter 25–250 mm and a wide range of wall thicknesses, from hot rolling or further processing, to ensure even tighter tolerances and smoother surface finish, by cold drawing/cold rolling.

In some cases we can offer the tubes in peeled or ground outer diameter for optimum tolerances and minimum machining allowance.

Furthermore, we can also supply the tubes in cut to component length thanks to our large tube cutting capacity.

## Standard items and stock program

As a service to our customers we have a standard tube program offering smaller order quantities and a shorter lead time than we normally require for a production batch.

Ovako has two such standard programs; both cover tubes stocked at our mill as well as at some of our sales companies and appointed distributors.

In addition to the bearing steel program and the Ovako 280 hollow bar program, we supply tubes in all Ovako standard steel grades.

### Bearing tube program

The standard program covers a comprehensive list of sizes from outer diameter 50.6 mm up to 243.5 mm, with several ID/wall thickness alternatives per outer diameter. To make the choice easy for minimum machining, in the list you will find the largest guaranteed finished turned size per tube size, as well as all the properties of the bearing steel itself.

### Ovako 280 hollow bar program

This program covers microalloyed steel hollow bars in grade Ovako 280 based on the standard EN 10294-1. We keep roughly 250 dimensions in stock from OD 30 to 242.7 mm.

Both the bearing steel tube and the Ovako 280 hollow bar programs are based on tight machining allowances. For each item we can provide a guaranteed finished turned size for either inner or outer chucking.

The Pipe and Tube capability of Nippon Steel Corp and Sanyo Special Steel makes the group one of the world's largest producers. The pipe and tubes from Nippon steel focus on long applications such as Oil & Gas and heat exchangers. In contrast, tubes from Sanyo are very much like the Ovako products, focusing on circular machine elements such as bearing races and other short components.

## Hot-rolled tube, cold-worked tube

### Machining allowances

In most cases we sell tube for a specific application. To support this all tubes are delivered with a guaranteed finish machined size. Since we produce our products as close to final clean machined components as possible, our entire size range requires minimal machining, with inner or outer centering on a maximum part length of 2.5 x outer diameter. For longer parts an extra allowance is calculated.

### Tolerances

The level of the machining allowance is calculated from the tube tolerances. To support our small machining allowances, Ovako has very tight tolerances across the entire size range, both with regard to outer diameter and wall thickness, as well as other parameters such as straightness and ovality. In practice, this means less machining and better yield for the user, resulting in lower component production costs.

### Outer Diameter/Wall Thickness tolerances

As shown in the table below.

### Straightness

The maximum deviation from the straight line is 1 mm on a gauge length of 1,000 mm.

### Ovality

The maximum out of roundness is 65 % of the total outer diameter tolerance.

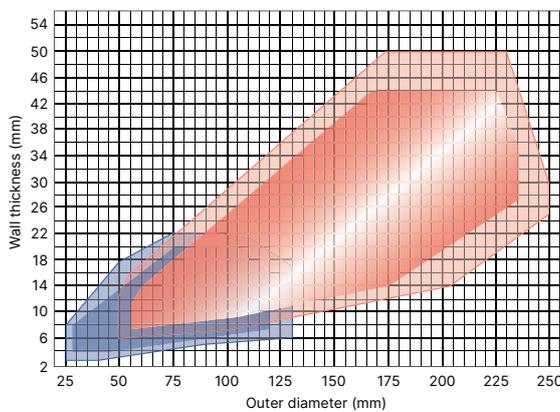
### Lengths

Tube can be delivered with random manufacturing length or to fixed length with tight tolerances.

### Tube lengths

	Hot-rolled	Hot-rolled peeled	Cold-worked (incl. ground)
Length	4–9 m	1.8–9 m	1.8–9 m

### Size ranges



### Outer Diameter (OD) and Wall Thickness (WT) tolerances

Execution	Size range	Outer Diameter (OD) tolerances	Wall Thickness (WT) tolerances
Hot-rolled tube	OD ≤ 80 mm OD > 80 mm WT < 12 mm WT ≥ 12 mm	±0.4 mm ±0.5 % of OD	±0.7 mm ±(5 % x WT + 0.1 mm)
Hot-rolled peeled tube	All sizes WT < 12 mm WT ≥ 12 mm	+0.25/-0 mm	±0.8 mm ±(5 % x WT + 0.2 mm)
Cold-worked tube cold-rolled or cold-drawn	OD < 40 mm OD 40 – (80) mm OD 80 – WT < 6 mm WT 6 – (8) mm WT 8 –	+0.30/-0 mm* +0.35/-0 mm* +0.40/-0 mm*	±0.30 mm ±0.35 mm ±0.40 mm

\* Heat treatment after cold-working alters these tolerances.



### **Packing**

The components are supplied, packed in collared pallets, arranged randomly or stacked, either unprotected or wrapped in waxed paper or plastic shrink-wrapped, depending on the method of transportation. Customer specific packing specifications can also be met.

### **Labelling and marking**

Material delivered directly from our mill is labelled in accordance with automotive standards, including both alphanumeric and bar code information. Customer specific data can be added on request.

### **Pre-components from tube**

Since many of our customers have moved their first operation, cutting, outside their operation, Ovako has a well developed tube cutting capability that we offer as a service to all customers. In many cases this service is combined with logistical JIT services from our warehouse in Hofors.

For further information about pre-components from tube, [Read more on page 36](#)

## **Standard bearing tube**

Bearing steel is a core product and competence of Ovako. We have been part of the search for the optimum bearing performance for more than 120 years. With one of our major contributions being to drive the clean steel parameter onwards.

Still though, the basic chemistry is almost the same as 120 years ago, 1 % carbon and about 1.5 % Chromium. That parameter was set close to perfection almost from the beginning. Giving a steel with high hardness and enough toughness for its application, rolling bearings.

Over the years, there have been additional versions with increased hardenability for larger bearing sizes.

### **Bearing Steel for non-bearing applications**

The Basic parameters for a Bearing performance as Hardness, Wear resistance and Fatigue are useful in many other applications.

Structural applications that need High strength and hardness with excellent wear resistance, or tool applications that require high hardness and wear resistance, with excellent form stability. All with a need of good machinability and easy to heat-treat to final shape and property.

### **Bearing steel tubes and size standard**

As long as Ovako has made the Bearing steel we have made tubes in bearing steel too. Tubes used to make bearing races.

In order to better serve this market we have developed a size standard from which we can offer smaller minimum order quantities. Several of these sizes are also kept in stock for shortest lead time and lowest minimum order quantity.

## OVAKO 280 – Hollow bar

Ovako has an extensive hollow bar stock program with approximately 250 dimensions based on the Ovako 280 general structural steel grade. Ovako 280 is produced to the greatest possible consistency with regards to properties.

### Better economy of production

Thanks to the high strength of the tube in the hot-rolled condition, it can replace conventionally used, more expensive quenched and tempered tube or eliminate heat treatment during component manufacturing. Due to the technology used in its production, the Ovako 280 hollow bar gains an inherent strength thanks to accurate monitoring of chemical composition.

Tight tolerances throughout the whole size range results in higher yield and reduced costs for raw materials and machining. The tolerances of Ovako 280 hollow bar are considerably closer than those specified by EN 10294, with regard to outer diameter and wall thickness.

### Smoother production

The narrow limits of the chemical composition of Ovako 280 hollow bar contribute to smoother production. The outcome of heat treatment is very consistent with small and predictable dimensional changes.

### Higher quality steel structures

Ovako 280 hollow bar has good weldability and a minimized risk for brittle fracture of welds due to their low carbon equivalent.

### Straightness

Maximum deviation from a straight line is 1 mm/m.

### Ovality

Maximum ovality is 65 % of the total tolerance of the Outer Diameter.

### Finished dimensions

Finished dimensions are guaranteed for the clean up of part lengths of maximum 3 x Outer Diameter.

### Mechanical properties in hot-rolled condition

Wall thickness mm	Yield stress ReHmin MPa	Tensile strength Rmmin MPa	Elongation A5 min %	Hardness Approx. HB
≤ 25	500	670	17	225
> 25	470	650	17	220

### Advantages that gives Ovako 280 hollow bar added value

- Versatility in properties covers many customer needs
- Availability – 250 sizes in stock

### Good machinability

- The machinability is well within the requirements of EN-10294-1
- The cost of machining is also influenced by the tighter machining allowance in Ovako hollow bars



# ROLLED AND FORGED RINGS

Few ring producers can match our commitment to consistent quality and our capability of rolling profiled rings.

As a producer of rolled and forged rings for almost a century, Ovako has a proven track record in this product niche. We strictly control the whole production chain, from melt to rolling of the seamless rings. For example, to ensure the superior quality of our rings, we carefully manage the levels of oxygen content in the steel to ensure the production of a cleaner steel. Few rings producers can match our commitment to consistent quality from delivery to delivery. As a result of our quality control, manufacturers can simplify production processes and reduce costs because the rings are not only predictably consistent from batch to batch, but also easy to process further. At Ovako, we produce profiled rings with very small allowances and tight tolerances close to the final shape of the end product. In addition, our machined rings enable you to concentrate resources on finishing and/or assembly. Furthermore, the rings can also be heat treated before delivery in a variety of executions such as:

- Normalized
- Soft annealed
- Stress relieved
- Isothermally annealed
- Quenched and tempered

## Rings to meet industry's needs

The vast majority of our production is consumed by the rolling bearing industry, but a substantial share is also delivered to customers in other industrial segments, such as heavy vehicle, automotive and machine tool manufacturing. Our dimensional range is 170 to 4,000 mm and the weight range is 7 to 5,000 kg. Forged rings are also supplied up to 3,400 kg.

## Advantages of rolled and forged rings

- Consistent quality from batch to batch
- The ability to produce profiled rings close to the final shape of the customer's end product results in more efficient production and cost savings
- Machined rings with close tolerances and consistent quality speeds up production and cuts costs by enabling customers to focus on finishing and/or assembly

## Parting of rings

Rings with lower widths than stated in the ring mill technical data can often be rolled in multiples and parted. Ovako has a machine park for this purpose and expanded its parting capacity with additional state-of-the-art parting technology and a packaging robot.

## Machined rings

Ovako has relationships with several high-quality soft machining subcontractors and is growing fast in supplying semi-finished and finished machined rings. Single ring types or complete assortments can be supplied in these executions according to individual customer requirements with full traceability and, if desired, Ultra-sonic Testing (UT).

Rolled and forged ring is a major product within Sanyo Special Steel. The capability of hot rolled rings is in the outer diameter range up to 520 mm. In addition to this cold rolled rings from tube cuts or forged rings is offered in large volumes up to outer diameter 250 mm.

**A close profile means less machining**

Depending on the desired shape of your final product, we can roll rings with very small allowances and tight tolerances.

Some examples of typical profiles are shown below. The specialist will immediately see that this representative sample offers interesting solutions for many manufacturing challenges. Near-net-shaped rings offer the buyer a total cost that is substantially less than other conventional methods of production.

A near-net-shaped ring can be up to 50 % lighter than a cylindrical equivalent, while at the same time reducing machining time and waste through lower volume, chip production and handling.

**Size range**

Rings are made in five different ring mills and one forging press. Outline production data is provided in the table below:

	Ring diameter	Ring width	Ring weight
Ring mill 8	170–380 mm	50–120 mm	7–20 kg
Ring mill 4	200–750 mm	100–230 mm	20–85 kg
Ring mill 10	300–1,200 mm	100–350 mm	55–250 kg
Press 6	350–2,200 mm	40–1,400 mm	70–3,400 kg
Ring mill 9	400–2,500 mm	50–550 mm	80–2,500 kg
Ring mill 11	500–4,000 mm	80–950 mm	300–5,000 kg

**Advantages of profiled rings**

- Near-net-shape rings substantially lower the cost of machining
- Very small allowance
- Tight tolerances
- Lower weight
- Less machining
- Less waste
- Stable quality with testing carried out on every batch
- Customized dimensions
- Adaptable to optimal delivery needs
- Wide range of products and grades
- Ovako can handle large volume cutting requirements





The benefit of profiling rolled rings is obvious for bearing manufacturers.



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# PRE-COMPONENTS

Selecting pre-machined components is often a cost effective solution as it eliminates customers own stockholding, crosscutting and machining, and converts fixed costs to variable. At Ovako, we have comprehensive resources for manufacturing pre-components from all our basic products; bar, tube and rolled rings.

As it sounds, pre-components are semi stage product of your own, made only for you. Our pre-components are an offering where you combine our processes to meet your drawings. This means we can make pre-components from any of our long products, as bar or tube, in hot rolled or further processed condition in one of our many grades, heat treated to the mechanical property you need.

Pre-components from bar can be produced from hot-rolled, peeled, ground or drawn bar. All of these executions are available in a wide range of sizes and steel grades.

Our extensive tube cutting capacity is well suited for our tube size range and is capable of cutting fix lengths between 10 and 7000 mm.

Our ring forging and rolling is a pre-component itself, where we offer several near net shape options from ring forming to finished machined rings.

## Advantages of pre-components

- Opportunity to fully concentrate own resources on finishing and/or assembly
- Fixed costs tied to machinery are converted to variable costs
- Capital tied up in inventory is reduced
- Bulky and time consuming handling of long products is eliminated
- No chips or off-cuts to handle
- Less internal transport, simplified administration and less material to manage
- Transport costs reduced by up to 2/3 compared to long products
- Just-in-time contract for deliveries according to specific needs

Sanyo describes this product area as formed and fabricated materials. With a major capacity through a number of different process routes. These include hot ring rolling, cylindrical blanks from forgings, further processing of tube cuts by cold ring rolling and cnc machining to finished green rings. Its capabilities make Sanyo one of the larger global suppliers of green rings to eg. the bearing industry.

## Pre-components from bar

Selecting pre-machined components is often a cost-effective solution. It allows you to eliminate your own stockholding, crosscutting and machining. It opens up new potential to simplify production and to cut production costs, not least by converting fixed to variable costs.

Today, Ovako has comprehensive resources for manufacturing pre-components in various grades of machining. Our pre-components are produced with close tolerances combined with a high, even level of quality.

Pre-components from bar can be produced from hot-rolled, peeled, ground or drawn bar. All of these executions are available in a wide range of sizes and steel grades and in both round bar and profiles.

### Chamfered or blanks with radius

Sawn off and chamfered according to customers' specifications. Our standard chamfer angle is 45° and we can customize chamfering and radius according to our agreement with you.

Size range: 20 to 105 mm diameter  
Lengths: 35 to 1,900 mm

### Centre-hole drilled blanks

Blanks with sawn end surfaces, centre-drilled to customers' specifications.

Size range: 20 to 105 mm diameter  
Lengths: 35 to 1,900 mm

### Cut blanks

Length tolerance, mm at length, mm

Size mm	L ≤ 400	400 < L ≤ 800	800 < L ≤ 1600
20-100	1.0	1.4	2.0
100.1-160	2.0	2.5	3.0

Special tolerances can be provided by agreement.



### Precision-cuts

Eliminate your non-core processes and improve profitability with Ovako precision-cuts. Our precision-cut offering includes just-in-time, or flexible, delivery and provides “greener” processes.

Ovako's precision-cuts are made from peeled, ground or drawn bar and available in a wide range of sizes and more than 60 steel grades in our bar portfolio. Our offering includes chamfered blanks, centre-hole drilled and cut blanks.

### Precision-cut quality

We offer secure and exact machining precision that can be tailor-made to your specifications. This includes customized rounded or chamfered radii. We deliver precision-cuts within close tolerances and a high, consistent product quality. Our length tolerances are +/- 0.05 mm, compared with the standard +/- 0.5 mm. Other specific tolerances can be arranged by agreement.

Our precision-cuts are subject to rigorous testing and pre-production approval processes. Testing covers dimensional measurements, mechanical properties and isotropic qualities. We can guarantee the right quality, not the most expensive one, to meet your needs.

### Efficient production

By using the Ovako precision-cut offering you can eliminate up to three of the following processes, and their associated costs:

- Measuring and cutting to exact length
- Chamfering
- Machining of radius
- Centre-hole machining

Why not take advantage of our just-in-time delivery or ensure flexible delivery amounts to suit your needs. The amount ordered can range from one piece to an unlimited amount. We deliver within 48 hours through a logistics agreement.

## Pre-components from tube

The extensive tube cutting capacity that we have installed is well suited for our tube size range and is capable of cutting fix lengths between 10 and 7000 mm, with tight tolerances, according to the following table.

### Length tolerances

Fix lengths, mm	10-100	(100)-600	(600)-1200	(1200)-7000
OD 30-100	+1,0/-0	+2,0/-0	+3,0/-0	+5,0/-0
OD (100)-250	+2,0/-0	+3,0/-0	+4,0/-0	+6,0/-0

On request we can also offer a tighter length tolerance and better finish of cut surface in the following range.

Size range: 80-179 mm OD  
 Lengths: 14,5-69 mm  
 Max weight: 5,0 kg  
 Max wall: 25 mm  
 Length tolerance: +0,8 / -0 mm

Deviations from square cut are within the tolerance above, however limited to the following values:  
 Deviations from square cut max 1,0 % of outer diameter.  
 Deviations from square cut determine the tolerance when the deviation exceeds the tolerance.

### Surface finish

Basically the surface finish is as the tube surface finish, except that band sawn tube cuts also get sand blasted. Sand blasting can also be offered on other cut rings, on request.

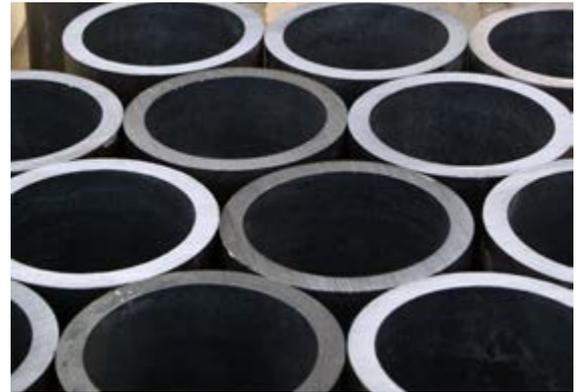
### Packaging

Cut lengths of less than 1.15 m are delivered on pallet with collars secured with steel or plastic bands (max weight app. 1000 kg). Alternative packaging can be discussed.

### Marking

Every pallet is marked with the following information if nothing else is declared, in bar coding and normal text.

- Supplier
- Customer
- Diameter
- Length
- Order number
- Weight
- Number
- Steel grade
- Heat number



### Order quantity

To optimize the order size of cut rings we can offer either a close size from our wide range of standard tube sizes in bearing steel or mechanical hollow bars in grade Ovako 280. But of course if you need cut rings from another grade we can offer the special size and grade you need.

### Minimum quantity

If the original tube is a standard tube: 900 kg  
 If the original tube is not a standard tube: 7 000 kg

A logistic agreement can replace the general minimum quantity above, as well as lead times.

### Production program

The diameter, tolerances and surface finish of components are the same as those stated for the full length tube.

Outer diameter: 25-254 mm  
 Lengths: 10-7,000 mm

Cut rings can be delivered shot blasted on request.

Deviations from square cut are within the tolerances above, albeit limited to the following values.

- Deviations from square cut are to be a maximum of 1.0% of Outer Diameter.
- Deviations from square cut determine the tolerance when the deviation exceeds the tolerance.

### Packing

The components are supplied, packed in collared pallets, arranged randomly or stacked, either unprotected or wrapped in waxed paper or plastic shrink-wrapped, depending on the method of transportation. Customer specific packing requirements can also be met.



# HARD CHROME PLATED BAR AND TUBE

With more than 40 years of experience in production of hard chrome plated bar and tube, Ovako Cromax is the pioneer and the technology leader in its field. The unique position of in-house production from steel mill to plating facilitates unmatched quality and consistency of the base materials and surface.

Today Ovako is one of the largest producers on the market, with production units in Sweden, The Netherlands, France and Italy and our offer extends to professional technical support and unique customer solutions in cut-to-length, packing and inventory management.

Chrome-plated bars and tubes are primarily used as piston rods, a critical component in hydraulic cylinders. They have the basic function of transforming hydraulic power into linear motion whilst preventing ingress of abrasive media into the hydraulic system – and this will stipulate a set of demands on a rod. Our steel grades are optimized in analysis and production to match the requirements in mechanical properties as well as amenability to our plating process.

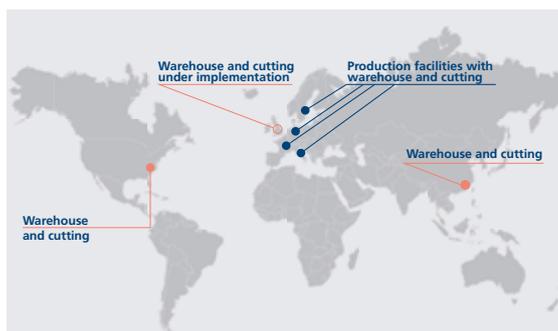
Prior to delivery, all Cromax products are controlled to ensure optimal micro-crack distribution with high crack density. These properties together with closely controlled pre-treatment, plating and finishing procedures, guarantee superior corrosion resistance. Ovako's quality assurance system includes a thorough final inspection of every single product as well as verification in salt-spray testing of all combinations of steel heat treatment, rolling operation and plating batch. When elevated corrosion resistance is required, Ovako offers Cromax C or NiKrom plating.

## Advantages of Cromax and NiKrom

- In-house production facilitates deliver unmatched quality and consistency
- Optimized to match the requirements in mechanical properties
- Every single production batch is verified in salt-spray testing
- High consistency and quality ensure well-functioning hydraulic systems

Abrasive wear on the rod due to contamination particles on both the outside and inside of the hydraulic system leads to direct oil leakage and secondary damage on the sealing system. This is unacceptable from an environmental and productivity point of view. The consistency in the Cromax process and our extensive quality control system ensures minimal variation in chrome thickness and hardness, which are the most significant parameters from this perspective.

With the right surface roughness and structure as well as an optimized micro-crack distribution, Cromax products secures correct lubrication for the sealing system.



Machining and friction welding available as add-on service in Europe.

**Standard and Cromax steel grades**

Steel grades	Selection criteria					Technical data						
	Machinability	Fusion welding	Friction welding	High impact requirements	EUR/Mpa Index	Dimension DIA. (mm)	Yield strength ReH/Rp0.2 (MPa)	Tensile strength Rm (MPa)	Elongation A5 (%)	Hardness HB	Impact toughness KV (J)	Surface hardness IH HRC
180X	Good	Quite suitable	Suitable	No	90	20-90	≥ 500	750-950	16	220-270	-	≥ 50
280X	Good	Suitable	Suitable	Yes	60	20-90 91-125 > 125	≥ 520 ≥ 440 ≥ 350	650-800 550-700 500-700	19 19 19	200-241 180-230 180-230	≥ 27 at -20°C ≥ 27 at -20°C ≥ 27 at -20°C	≥ 45
482IH	Rather good	Needs care	Suitable	No	55	< 125	≥ 580	850-100	14	250-300	-	≥ 55
42CrMo4	Moderate	Un-suitable	Suitable	Yes	70	< 40 40-95 > 95	≥ 750 ≥ 690 ≥ 550	1000-1200 900-1100 800-950	11 12 13	295-355 265-325 235-295	≥ 35 at 20°C ≥ 35 at 20°C ≥ 35 at 20°C	≥ 55
TUBE	Good	Suitable	Suitable	Yes	N/A		≥ 450	550-800	20	160-240	≥ 27 at -20°C	≥ 45

Customer-specific grades are available upon request.

**Cromax surfaces**

Surface	Corrosion resistance according to ISO 9227			Technical data			
	AASS	NSS	CASS	Surface roughness		Chrome thickness μm	Chrome hardness HV0.1
				Ra (μm)	Rt (μm)		
Cromax standard	Min 72h R9	**	**	≤ 0.2	≤ 2.0	≥ 20	≥ 850
Cromax C	Min 120h R9	**	-	≤ 0.2	≤ 2.0	≥ 20	≥ 850
NIKROM 150	Min. 150 h R10	Min. 500 h R10	-	≤ 0.2	≤ 1.6	Ni ≥ 10, Cr ≥ 20	≥ 850
NIKROM 500	Min. 500 h R10	Min. 1500 h R10	-	≤ 0.2	≤ 1.6	Ni ≥ 30, Cr ≥ 20	≥ 850

\* Verified and certified for all orders

\*\*Specified and verified according to agreement

**Cromax Manufacturing format and service options**

Location	Manufacturing format					Service options				
	Max. length	Diameter min.	Diameter max.	Hardening	Packing	Warehousing	Kan-Ban	Cutting	Machining	Friction welding
Hallsthammar, Sweden	7.8 m	18 mm	150 mm	✓	Plastic/ cardboard	✓	✓	✓	Upon request	Upon request
Twente, The Netherlands	6.4 m	18 mm	150 mm	✓	Plastic/ cardboard	✓	✓	✓	Upon request	Upon request
Redon, France	7.3 m	18 mm	160 mm	✓	Plastic/ cardboard	✓	✓	✓	Upon request	-
Molinella, Italy	6.6 m	10 mm	130 mm	✓	Plastic	✓	✓	✓	✓	-
Baltimore, USA	-	-	-	-	-	✓	✓	-	-	-
Shanghai, China	-	-	-	-	-	✓	✓	✓	-	-

# STEEL GRADES

At Ovako, we control our production from melt to finished product in order to deliver steels for unique requirements. We continually develop our services and solutions to offer ever more consistent and optimized steel performance. Our priority is to find the best solutions for our customers based on their requirements and assist in attaining sharp competitive advantages. By inclusion engineering, most of our steel grades can all be adapted to qualify as either of BQ-Steel, IQ-Steel or M-Steel.

## Through-hardening bearing steel

Through-hardening steel contains typically 1% carbon and alloying elements for hardenability, exhibiting very high strength but low ductility. Used with martensitic or bainitic hardening, typically for roller bearing components.

## Spring steel

Spring steel is used in the manufacture of springs for automotive and industrial suspension systems, generally using low-alloy manganese, medium/high-carbon steel with a very high yield strength.

## Case-hardening steel

Steels for carburizing and case hardening typically have a relatively low carbon level, 0.10–0.25 % C, and are used when there is a demand for varying properties, such as for components in transmission systems.

## General engineering and structural steel

General engineering and structural steel is used for producing various construction or machine elements, alloyed often only with carbon and manganese, but also micro alloying is added. It is the base for our hard-chrome plated products, as well as the standard hollow bar program in Ovako 280.

## Quenching and tempering steel

Steels for quenching and tempering have a carbon level of 0.25–0.60 % and can be both unalloyed and low-alloyed. Alloyed grades contain chromium, nickel and molybdenum. Quenched and tempered steel is characterized by high strength and good ductility.

## Boron steel

Boron is a small element cost-effectively added to improve hardenability and increase strength, mostly for lower and medium carbon steels with less than 0.40 % carbon. Ovako has a history of pioneering the use of boron steel and over time has innovated its use and the wide range of variants we can provide today.

## Nitriding steel

Nitriding steel grades contain strong nitride formers such as molybdenum, vanadium, aluminum or chromium. Ovako's family of Hybrid Steel can very favorably be used for nitriding. Nitriding is a heat-treating process that diffuses nitrogen into the surface of a metal to create a case-hardened surface.

## Maraging steel

Maraging steel is traditionally very costly and metallurgically advanced. Ovako is reinventing this category of steel with its Hybrid Steel family in which three hardening mechanisms are combined. The result is a unique set of properties, but places hybrid steels closest to maraging steels.

## Other steel grades from Nippon Steel Group

- Free-machining steel
- Stainless steel
- Precipitation-hardening steel
- Tool steel
- High-speed steel
- Nickel-based alloys

# THROUGH-HARDENING BEARING STEEL

EN-standard	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
C55	510	Low hardenability for small components or after surface induction hardening.	0.50	0.2	0.6	0.2			
66SiMnCrMo6-6-4*3	677	Bearing steel suitable for gas/air hardening.	0.67	1.5	1.4	1.0	0.2		
100Cr6	802, 803, 5620	The most commonly used bearing steel with a hardenability for small components (wall thickness 17 mm).	1.00	0.3	0.3	1.4			
100CrMo7	824	Increased hardenability with Cr and Mo for small- and medium-sized components (wall thickness 20 mm).	0.95	0.3	0.3	1.7	0.2		
100CrMo7-3	825	Increased hardenability with Cr and Mo for medium-sized components (wall thickness 30 mm).	0.95	0.3	0.7	1.7	0.2		
100CrMo7-4	826	Increased hardenability with Cr and Mo for medium- and large-sized components (wall thickness 50 mm).	0.95	0.3	0.6	1.7	0.4		
100CrMnMoSi8-4-6	827	Increased hardenability with Cr, Mo and Si for large-sized components (wall thickness 75 mm).	0.95	0.5	0.9	1.9	0.6		
100CrMnSi4-4	831	Increased hardenability with Cr, Mn and Si for small- and medium-sized components (wall thickness 20 mm).	0.95	0.6	1.1	1.0			
100CrMnSi6-6	832	Increased hardenability with Cr, Mn and Si for medium- sized components (wall thickness 40 mm).	0.90	0.7	1.5	1.4			
100CrMnSi6-4	837, 5625	Increased hardenability with Cr, Mn and Si for small- and medium-sized components (wall thickness 30 mm).	0.95	0.6	1.0	1.5			

EN-standard designation followed by “\*” is not an official EN standard grade but named according to the rules in EN 10027.

# SPRING STEEL

EN-standard	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
33SiMnB7-3*	SB33S17B	Lean spring steel alloyed with boron	0.33	1.7	0.9				B
38Si7	MS416	Silicon alloyed	0.38	1.6	0.7				
51CrV4	593, VC 510	High strength alloyed with chromium and vanadium	0.51	0.2	0.9	1.1			V
52CrMoV4	4296	High strength high hardenability, 51CrV4 with additional Mo	0.52	0.2	0.9	1.1	0.2		V
55Cr3	9257	High strength chromium alloyed	0.55	0.2	0.9	0.9			
56Si7	9084	High strength silicon alloyed	0.56	1.8	0.8				
56SiCr7	9071	High strength silicon and chromium alloyed	0.56	1.8	0.9	0.3			
60Cr3	5740	Variant with the highest strength. Alloyed with chromium.	0.60	0.2	0.9	0.8			

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# CASE-HARDENING STEEL

EN-standard	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
16MnCr5	234, 4306	For small-sized transmission components, low core hardness	0.16	0.2	1.2	1.0			
20MnCr5	236, 4326	For small-sized transmission components, moderate core hardness.	0.20	0.2	1.3	1.2			
18CrMo8-5*	225	Steel designed for nitriding but also suitable for carburising	0.18	0.3	0.8	1.8	0.5		
20MoCr4	124	For small-sized bearing and transmission components	0.20	0.2	0.8	0.5	0.4		
20NiCrMo2-2	152, 4548	For small to medium-sized bearing and transmission components	0.20	0.3	0.9	0.6	0.2	0.5	
16NiCrS4	146, 4730	For medium-sized transmission components	0.16	0.1	1.0	1.1		0.8	
20NiCrMo7	157	For medium-sized bearing and transmission components	0.20	0.2	0.6	0.5	0.2	1.7	
18CrNiMo7-6	159, 4761	For medium-sized bearing and transmission components	0.18	0.2	0.7	1.7	0.3	1.6	
12NiCr14-6*	245	For large-sized bearing and transmission components	0.13	0.3	0.5	1.5	0.1	3.3	
18NiCrMo14-6	255	For large-sized bearing and transmission components	0.18	0.3	0.5	1.4	0.2	3.3	
22NiCrMo12-5*	253	For large-sized components requiring high core toughness.	0.14	0.2	0.6	1.2	0.2	2.9	
24NiCrMo15-5*	256	For large-sized components requiring high core toughness	0.24	0.3	0.7	1.2	0.3	3.6	
20NiMo9-7*	158	Steel giving reduced surface oxidation after gas carburising	0.20	0.1	0.3	0.4	0.7	2.3	
30MoCrV20-7*	499	Temperature resistant carburising steel	0.30	0.2	0.3	1.7	1.8		V
16CrMnNiMo9-5-2*	277	High hardenability grade. Possible to gas/air harden	0.16	0.2	1.3	2.1	0.5	0.5	V

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# GENERAL ENGINEERING AND STRUCTURAL STEEL

EN-standard	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
C15	8362	Steel suitable for cold drawing	0.15	0.2	0.5				
C22	C22R	Steel for mechanical engineering and automotive components.	0.21	0.2	0.6				
C35	8563	Medium carbon steel for machinery parts	0.35	0.2	0.7				
C40	C40R	Suitable for surface induction hardening to 600 HV	0.40	0.2	0.7				
C45	047, 5155, 1672	Suitable for surface induction hardening to 630 HV	0.45	0.2	0.7				
C55	056, 8665	Suitable for surface induction hardening to 660 HV	0.55	0.2	0.8				
C60	061A	Used for mechanical engineering and automotive components. Suitable for surface induction hardening to 700 HV	0.60	0.2	0.8				
S235J2	1312	A low carbon, high tensile strength structural steel which is suitable for welding and cold-forming properties	0.17	0.3	1.2				
S235JR	1412	A low carbon, high tensile strength structural steel which can be used for welding.	0.18	0.3	1.2				
S355J2	520, 9817	A general construction steel suitable for welded or non-welded construction of shafts with medium strength requirements	0.20	0.3	1.2				
P355NH	2714	A pressure vessel steel grade with 355 MPa yield limit and high toughness.	0.14	0.3	1.2				
19MnVS6	7255, SB280	Micro-alloyed steel with high tensile strength, good machinability and weldability.	0.19	0.4	1.5				V
19MnV6*	280	Reduced sulfur variant 19MnVS6	0.19	0.4	1.5				V
30MnVS6	9830	Micro-alloyed cold heading steel. Used for short- and long-shaft ball points, threaded and heavy duty anchor bolts	0.30	0.5	1.4				V
38MnVS6	482, 7221	Micro-alloyed high strength steel suitable for surface induction hardening	0.38	0.4	1.3				V
46MnVS3	382	Micro-alloyed high strength steel suitable for surface induction hardening	0.46	0.3	0.7				V
S400*	SB400	General purpose micro-alloyed steel	0.20	0.3	1.2				V
S460	19MnVS6	A weldable micro-alloyed steel suitable for offshore use	0.20	0.2	1.3				
S550	SB550	A micro-alloyed steel with high yield strength and excellent cold-forming characteristics	0.18	0.4	1.5				V
24MnV6*	SB600	A high strength micro-alloyed steel for general purposes.	0.25	0.4	1.5				V
11SMn30	2715	Also known as Green Cut. Lead-free cutting steel.	0.11	0.2	1.2				S
20Mn5*	2630	Also known as Hydax 25. High temperature constructional weldable steel	0.20	0.4	1.3				S
S355J0	2720	Also known as Hydax 15. With an increase sulfur content for improved machinability	0.16	0.4	1.3				S
4CrMn16-4*	8301	Also known as EL 700. High hardenability and high toughness. Suitable for gas/air hardening	0.04	0.3	1.0	4.0			Nb

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# QUENCHING AND TEMPERING STEEL

EN-standard	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
24CrMo13-6	420	Good wear resistance in the as-rolled condition. Mainly used for drill rods	0.24	0.2	0.4	3.1	0.5		
25CrMo4	322, 6014	Low carbon Q&T steel for general purposes	0.25	0.2	0.9	1.1	0.2		
34CrMo4	34CrMo4		0.34	0.3	0.8	1.1	0.2		V
42CrMo4	327, 6082	Medium carbon Q&T steel for general purposes	0.42	0.3	0.8	1.1	0.2		
43CrMnMo4-4	L7	Steel for high strength fasteners	0.43	0.3	0.9	1.0	0.2		
44CrMnMo4-4*	B7	Steel for high strength fasteners	0.44	0.3	0.9	1.0	0.2		
50CrMo4	528, 6499,	Medium carbon Q&T steel suitable for surface induction hardening	0.51	0.2	0.7	1.0	0.2		
23MnNiMoCr5-4	4209	Steel for high strength chains with high toughness demands	0.23	0.2	1.3	0.5	0.6	1.0	
30CrNiMo8	6507	Q&T steel with high hardenability	0.30	0.3	0.7	2.0	2.0	0.3	
30NiCrMo16-6	498	High-strength, high-toughness steel, EN 30B	0.30	0.3	0.5	1.4	0.2	4.0	
31NiCrMo13-4*	453	Used for components that require high tensile strength in combination with high toughness	0.31	0.2	0.5	1.1	0.2	3.1	
34CrNiMo6	356, 6502	Q&T steel with high strength, toughness and hardenability	0.34	0.2	0.7	1.4	0.2	1.3	
40SiCrMnMo7-6-6*	477	Q&T steel suitable for gas/air hardening	0.40	1.7	1.5	1.5	0.4		
40CrMoV4-6	6098	Temperature resistant steel. ASTM A193 B16	0.40	0.3	0.7	1.1	0.6		V
21CrMoV5-7*	6130, 6132	Also known as IMANITE. Steel fasteners, also suitable for nitriding	0.21	0.3	0.6	1.4	0.7		V
37CrV3*	9217	Chromium vanadium alloyed steel for hand tools	0.37	0.3	0.8	0.8			V
40NiCrMo7-3*	355, 6514	SAE 4340 mod with V, L43	0.40	0.3	0.7	0.8	0.3	1.8	V
32CrMoV12-10*	398	High hardenability Q&T steel also suitable for deep nitriding	0.32	0.3	0.5	3.0	1.0		V
3CrMoV9	6140	High hardenability Q&T steel also suitable for nitriding	0.31	0.2	0.6	2.5	0.2		V
40CrMoV4-6*	6098	Steel for high strength ASTM A193 B16 fasteners	0.42	0.2	0.8	1.1	0.9	4.0	V
48CrMoNi4-10*	495, 6521	High strength high toughness steel with high wear resistance used in mining applications	0.48	0.2	0.8	1.1	0.9	4.0	V
42NiSiCrMo8-7-3*	497	Also known as 300M. High-strength, high-toughness steel.	0.42	1.6	0.6	0.7	0.3	1.7	V
4CrMn16-4*	8302	Also known as Imacro M. High toughness very low carbon weldable Q&T steel. Suitable for gas/air hardening	0.04	0.3	1.0	4.0			Nb
7CrMoBS4*	5450	Also known as Imaform. Very low carbon Q&T steel suitable for direct quenching	0.07	0.3	0.8	1.3			B
8CrMnMo15-4*	8303	Also known as Imacro NIT. Low carbon Q&T steel. Suitable for nitriding.	0.08	0.3	1.0	4.0	0.5		

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# BORON STEEL

EN-standard	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
20MnB4	SB23M12B, BM 212	Structural alloy steel used for mechanical parts and all kinds of engineering components	0.20	0.2	1.3				
30MnB5	SB33M13B, BM 312	Steel for wear resistance in thickness <15 mm. Good forming properties in the soft delivery state and high strength after heat treatment (hardening).	0.30	0.2	1.3				B
43MnB5-3*	SB43M14B	High hardness and wear resistance	0.42	0.3	1.4				B
22MnB5	SB24M13B	Steel suitable for quenching and tempering. Very good forming properties in the soft delivery state and high strength after hardening	0.24	0.3	1.3	0.2			B
27MnCrB5-2	SB27M12CB, BCM 311	Boron alloyed heat treatable steel for wear resisting parts such as dredger buckets, plough shares, chain wheels, mechanical engineering components, axles. Suitable for quenching and tempering	0.27	0.2	1.3	0.5			B
30MnCrB5-2*	SB30M12CB		0.30	0.3	1.3	0.5			B
33MnCrB5-2	SB33M13CB	Boron alloyed steel suitable for quenching and tempering	0.32	0.3	1.3	0.6			B
39MnCrB6-4	BCM 414	Boron alloyed heat treatable steel	0.39	0.3	1.5	0.5			B

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# NITRIDING STEEL

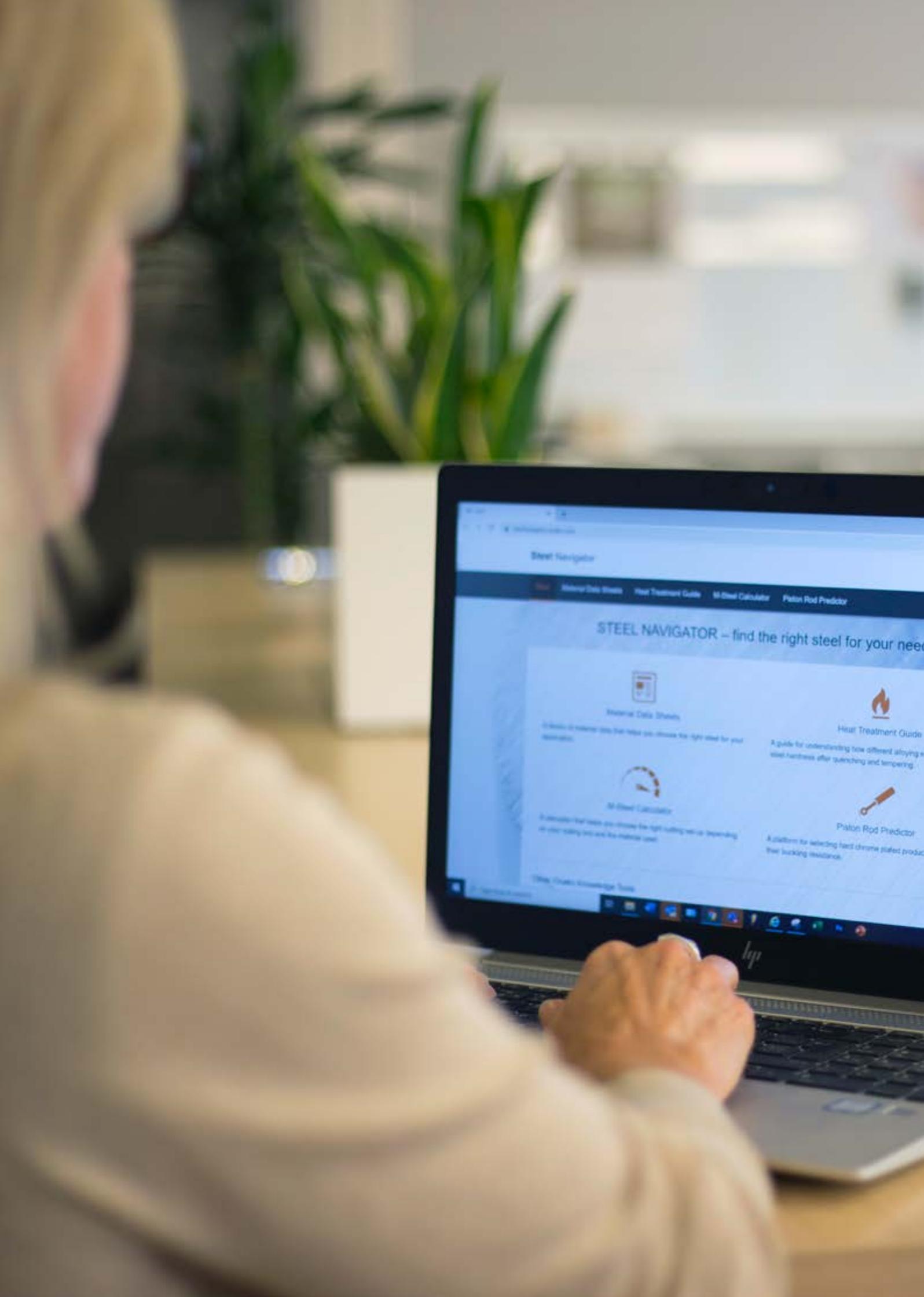
EN-standard	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
8CrMnMo16-4*	8303	Also known as Imacro NIT. Low carbon Q&T steel. Suitable for nitriding.	0.08	0.3	1.0	4.0	0.5		
42CrMo4	327, 6082	Quench and tempering steel which is also suitable for nitriding	0.42	0.3	0.7	1.0	0.2		
18CrMo8-5*	225	Steel specially designed for nitriding but is also suitable for carburizing or applications requiring Q&T steels	0.18	0.3	0.9	1.9	0.5	0.3	
21CrMoV5-7*	6132	Also known as IMANITE. Steel fasteners, also suitable for nitriding	0.21	0.3	0.6	1.4	0.7		V
30MoCrV20-7*	499	Temperature resistant carburizing steel also suitable for nitriding	0.30	0.2	0.3	1.7	1.8		V
16CrMnNiMo9-5-2*	277	Air hardening steel that is suitable for case hardening, nitriding or quench and tempering	0.16	0.1	1.3	2.2	0.5	0.5	V
31CrMoV9	6140	For Q&T parts, which are generally machined and subsequently nitrided.	0.30	0.2	0.5	2.5	0.2		V
48CrMoNi4-10*	495, 6521	High strength Q&T steel suitable for nitriding	0.48	0.2	0.8	1.1	0.9	0.5	V
32CrMoV12-10*	398	Steel suitable for deep nitriding	0.32	0.2	0.5	3.0	1.0		V
21CrMoV5-7*	6132	A steel for fasteners with good low temperature properties	0.21	0.3	0.6	1.3	0.7		V
X20NiCrAlMoV6-5-2-1*	197	Known as Hybrid Steel 50. A semi low carbon steel with unique hardening properties also suitable for nitriding	0.08	0.1	0.3	5.0	0.7	5.0	Al
X20NiCrAlMoV6-5-2-1*	297	Known as Hybrid Steel 55. A semi low carbon steel with unique hardening properties also suitable for nitriding	0.18	0.1	0.3	5.0	0.7	6.0	Al, V
X20NiCrAlMoV6-5-2-1*	397	Known as Hybrid Steel 60. A semi low carbon steel with unique hardening properties also suitable for nitriding	0.28	0.1	0.3	5.0	0.7	6.0	Al, V

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# MARAGING STEEL

EN-standard	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
X20NiCrAlMoV6-5-2-1*	197	Known as Hybrid Steel 50. A low carbon steel with unique hardening properties	0.08	0.1	0.3	5.0	0.7	5.0	Al
X20NiCrAlMoV6-5-2-1*	297	Known as Hybrid Steel 55. A semi low carbon steel with unique hardening properties	0.18	0.1	0.3	5.0	0.7	6.0	Al, V
X20NiCrAlMoV6-5-2-1*	397	Known as Hybrid Steel 60. A semi low carbon steel with unique hardening properties	0.28	0.1	0.3	5.0	0.7	6.0	Al, V

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## Steel Navigator

- General Data Sheets
- Heat Treatment Guide
- M-Steel Calculator
- Piston Rod Predictor

### STEEL NAVIGATOR – find the right steel for your needs



#### General Data Sheets

A guide to material data that helps you choose the right steel for your application.



#### Heat Treatment Guide

A guide for understanding how different alloying steel hardness after quenching and tempering.



#### M-Steel Calculator

A platform that helps you choose the right cutting tool or depending on your cutting tool and the material used.



#### Piston Rod Predictor

A platform for selecting hard chrome plated products for buckling resistance.

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## Heat Treatment Guide

Ovako has created an online heat treatment guide to help mechanical design engineers evaluate the mechanical properties after quenching and tempering of any grade of steel that contains the 13 most common alloying elements. This tool makes it possible to compare the heat treatment and tempering performance of thousands of steel alloys without the need for extensive desk research, calculations or testing.

While Ovako produces around 500–600 grades available as standard, there are many more specialist steel grades on the market. In theory, the number of grades is almost endless as steel properties vary depending on the alloying elements and their quantities.

Knowledge of hardenability is essential when designing systems and components such as bearings, power transmission systems and many other mechanical components.

Hardness is a mechanical property defined as the ability to withstand plastic deformation. The hardness of steel varies, according to the structure produced by quenching, depending on the mix and quantity of alloying elements in the steel. Engineers can adjust the final hardness through close control of the heat treatment process, specifically the cooling rate and temperature. This result is the optimum combination of toughness and hardness.

Choosing the right grade and optimizing the heat treatment and tempering can have a major influence on component performance and lifetime. Therefore, the heat treatment guide is an essential tool for mechanical engineers who need an easy way to determine the properties of their selected materials after quenching and tempering.

Using a neural network to model performance with some grades of steel, their hardenability during heat treatment and tempering are well documented. This is thanks to extensive laboratory testing, which has created a library of properties for well-known grades.



### How to use the heat treatment guide

- When you load the page, you see a simple interface with a drop-down menu and fields for 13 alloying elements. A good starting point is to choose one of around 1,000 standard Ovako or International grades. This will automatically populate the percentage content of the 13 alloying elements, which you can keep or change.
- You can then add a second and subsequent rows. This lets you compare multiple grades and explore the subtle differences in hardenability that result from varying the quantity of alloying elements.
- When you're ready, click compare and the tool's neural network will produce a set of graphs. The first two provide values for the hardness and tensile strength as tempering temperatures vary.
- The next two graphs provide data on hardenability expressed as hardness as a function of cooling rate, as determined by Jominy testing, a standard method of comparing the hardness. A further three graphs show the hardness in the center of a bar when quenched with water, oil and air.
- Finally, Continuous Cooling Transformation (CCT) curves are provided to show the transformation between steel phases as the alloys are cooled at different rates.

Engineers can estimate the performance of other, less well-documented grades by interpolation from the closest existing datasets. However, this is time-consuming and laborious.

To overcome this challenge, Ovako's guide is based on a neural network that automatically interpolates the hardenability and toughness of almost any steel alloy. It was developed with a dataset that includes all the known data on heat treatment and tempering of steel. In total, it integrates around 100,000 data points for hardenability and more than 10,000 for tempering.

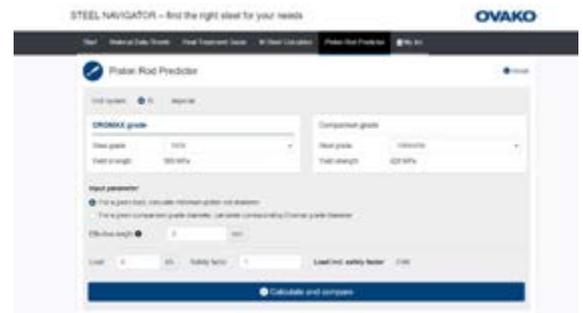
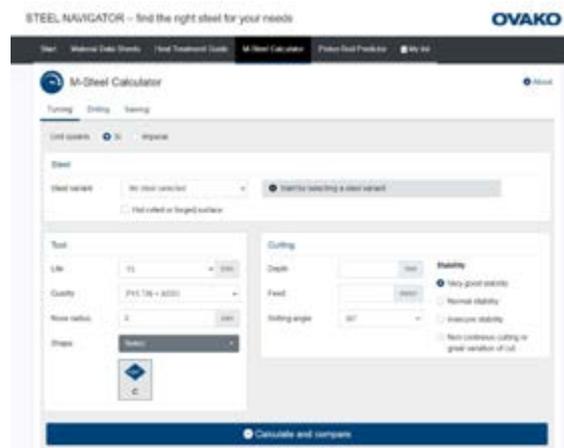
This approach provides mechanical design engineers with the best possible starting point to compare and contrast the properties of different alloys.

## M-Steel Calculator

To optimize the success of machining, Ovako developed the M-Steel concept and works closely with customers to advise on cutting data and choice of tools. This is supported by machining tests that ensure the ideal material grade and dimensional characteristics are selected for a given application.

We have now taken this service to the next level with the M-Steel Calculator, based on Ovako's Steel Navigator platform. This digital tool provides you with guidance in identifying the right machine settings based on the steel properties you wish to achieve and the cutting tools you plan to use.

To use the M-Steel Calculator visit the M-Steel Calculator site and then enter the relevant information for your cutting tool and work piece material. As the illustration shows, you are then presented with specific information on machine power, chip stream and the expected surface quality. The M-Steel calculator will also provide a comparison between these parameters when using M-Steel and a conventional steel. This will normally enable a saving of up to 30–40 % in production cost without losing any of the improvement in machining quality.



## Piston Rod Predictor

We have developed a unique online tool, called the Piston Rod Predictor, to compare the resistance of different steel grades to buckling in piston rod applications. The emphasis is on buckling because it is the key design consideration for hydraulic cylinders, especially in single-action, push-only applications.

Buckling is a sudden, large and unstable lateral deflection associated with just a small increase in axial compressive load above a critical level - the buckling load. The stress corresponding to the buckling load can be far less than the yield strength of the material used to manufacture the rod.

Should buckling occur, it will result in instability and collapse of the piston rod. Buckling is therefore regarded as a highly dangerous failure mode that might result in serious accidents.

Using steel with higher strength provides better resistance to buckling. That offers the possibility to downsize piston rods, with a consequent reduction in both weight and cost. Ovako manufactures a range of hard-chrome-plated or nickel-chrome-plated ready-to-use bars and tubes, known as Cromax® developed specifically for hydraulic cylinders. The Piston Rod Predictor enables you to compare our Cromax steel grades with the most commonly used standard grades. If the grade you wish to compare is not listed, you can still enter its relevant mechanical properties manually.

You can use the Piston Rod Predictor in two ways. You could choose to input an existing rod diameter to calculate what diameter would be required to achieve the same safety factor with an alternative steel grade. Or you could keep the diameter the same, but evaluate how using a stronger steel intended specifically for piston rods might enable the design load to be updated.

Alternatively, you can use your maximum load and desired safety factor to calculate the minimum rod diameter for different steel grades.



# HEAT TREATMENT OPTIONS

With Ovako's wide range of processes, products and steel grades, the variation of possibilities is almost infinite. To set a product offering that utilizes all this makes understanding of the customers' need and wishes critical.

## Heat-treated tube

Our tube can be supplied in the following heat-treated conditions or combinations thereof:

- Normalized
- Soft annealed
- Isothermal annealed
- Stress relief annealed
- Quenched and tempered
- Controlled cooling for case hardening steels
- Annealed in protective atmosphere to avoid decarburization

## Heat-treated bar

Our bar can be supplied in the following heat-treated conditions or combinations thereof:

- Normalized
- Soft annealed
- Spheroidized
- Stress relief annealed
- Isothermal annealed
- Quenched and tempered
- Induction hardened

## Type of heat treatment/Advantages

<b>Soft or full annealing, (Spheroidizing/globulization)</b>	Softening the steel by offering a structure well suited to machining and cold-forming.
<b>Isothermal annealing</b>	This type of annealing offers, for example, for a case hardening steel, a homogenous structure consisting of ferrite-pearlite, well suited for machining and proper control of chip formation.
<b>Stress relieving</b>	Reducing stress in the steel to avoid distortion during subsequent machining and heat treatment. Also reduces risk of cracking in connection with welding.
<b>Hydrogen annealing</b>	Reduction or elimination of hydrogen in the steel in order to prevent hydrogen embrittlement and subsequent risk of cracking.
<b>Recrystallization annealing</b>	Restores a cold-worked microstructure. Necessary for further processing involving plastic deformation. Note that the level of deformation controls the grain size and final toughness.
<b>Normalizing</b>	Offers the steel a predictable even microstructure of fine grains, ensuring toughness and impact strength as well as improved machinability.
<b>Homogenizing</b>	Evens out segregations in the steel. The soaking is performed at high temperature over a long time.
<b>Hardening</b>	Hardening is the general name for heat treatment methods, when the temperature is increased until the structure is transformed into austenite, then dissolving alloying elements (soaking), followed by a rapid cooling (quenching) creating a martensitic or bainitic structure. Hardening is performed in order to increase the hardness or strength of the steel and is normally followed by tempering.
<b>Surface induction hardening</b>	Surface induction hardening offers a hardened surface layer a few millimeters deep with compressive residual stresses.
<b>Tempering</b>	The aim with tempering is to improve the toughness and reduce stresses of the steel. After quenching the martensitic structure has a relatively low toughness with residual stresses. Toughness can be increased and stresses reduced if the steel is reheated to a temperature between 160 to 650°C for 1 to 2 hrs depending on grade. Tempering will reduce the risk of cracking.

Please study how to use our Heat Treatment Guide  
[Read more on page 50](#)



# SERVICES

Beyond the physical product, Ovako's services are designed to create real value and competitive advantage. We help our customers streamline their supply chain, simplify their production process, and access digital tools for booking re-orders and fast access to technical data.

As our customer, Ovako is devoted to ensuring that you receive the ideal steels for their project requirements when they need them. We are committed to providing a wide range of value-added services that gives you the edge. This commitment starts before we have even agreed on a contract and in some cases extends all the way to end use.

Our comprehensive set of integrated, value-added services focuses on your needs. These services range from working in close collaboration during conceptual design to providing logistical services with short lead times, online ordering and much more. Many of our customers want to try out new ideas to improve the performance of their products, and we have the expertise that takes your product to the next level. Beyond supplying steel, our services are designed to create real value, and true competitive advantage.

As a subsidiary of Sanyo Special Steel and part of Nippon Steel Corporation, we have access to a world-class range of products, research and development expertise and sustainable production. This means we can provide the world's widest range of specialty steel products.

## Ovako Science and Visitor Center

Ovako Science and Visitor Center in Hofors, Sweden, offers the opportunity to take advantage of Ovako's expertise in order to develop innovative steel solutions. The center combines the opportunity to get an overview of Ovako's products and their applications as well as offering ways of collaboration with Ovako's specialists to identify and develop steel solutions that are optimally adapted to your needs. The center also hosts virtual mill tours where you can be guided through Ovako's production flows in an exciting way.

Another way to experience the heritage of Ovako, is to stay at our historic company accommodation in Hofors, Smedjebacken or Hällefors. When you as a customer pay a visit to one of our sites, it is highly recommended to stay at our hotels, hosted by your Ovako contact.



### Our services include

- World-leading range of products
- Optimal global production and supply
- Cutting-edge R&D resources
- Sustainable ownership and production
- Global supply chain and customer support



# SUPPLY CHAIN AND TAILORED SOLUTIONS

Our customers rely on taking delivery of the right raw materials at the right time. Our supply chain services are focused on availability and lead time. And our tailored solutions provide you with the right steel grade in the volumes you need, delivered in the right near-net-shape with heat or surface treatments for any processing route.

It is easy to focus entirely on the hardware, the steel product itself. But our commitment to service extends to reliable and efficient delivery. We have longstanding experience in supplying steel products to customers all over the world with dedicated just-in-time delivery.

We continuously refine our solutions for shorter lead times, rationalized and cost-effective transportation, and efficient warehousing. Our goal is to simplify your material handling processes, reduce your capital costs and ultimately optimize your material supply. In Finland we even operate a leading distribution site.



Our global sales teams work shoulder-to-shoulder with our customers and with technical and logistical specialists at our mills. Expertise in specific industrial sectors further enhances our ability to offer the optimum product. For example, we can propose alternative steel grades to achieve the desired performance. Alternatively, we can deliver profiled steel products to minimize machining time and improve yield.

To illustrate our breadth of offering, we have more than 500 steel grades and a wide range of product shapes and formats. We can also enhance our product offering through partnerships outside Ovako, including everything that is available from Nippon Steel Group.

We offer different lead times depending on how deeply our customers integrate into our planning. We support long- and short-term forecasts and EDI ordering.

Our wide range of processes, products and steel grades means that possibilities are almost infinite. To achieve the maximum benefit, it is essential for us to develop a deep understanding of our customers' needs and wishes.



# DIGITAL TOOLS

Our easy-to-use online tools provide customers with technical support, logistics support and more. Our customers can access tools that make it easy to track orders, find documentation and even book re-orders. Our Steel Navigator makes it straightforward to find exactly the right steel grade, access material data sheets, heat treatment guides and our machining calculator.

## Steel Navigator

Steel Navigator is our digital platform that helps designers and engineers choose the right steel for their application. It includes features such as Material Data Sheets, M-Steel Calculator, Heat Treatment Guide and Piston Rod Predictor. [Read more on page 49.](#)

## OvaTrack

OvaTrack is our online tool for order tracking, reordering and certificates. OvaTrack includes automatic email alerts for deviations, as well as claims handling and order amendment. The system also provides up-to-date information on production schedules, deliveries to selected destinations and stock levels.

You can download documents such as inspection reports, certifications, order confirmations, dispatch advice and invoices. Data can be exported for processing. With an OvaTrack account, customers receive daily updates known as the Personalized Information Service. This service enables subscription of alerts about activities related to orders, such as production, delivery and invoicing status. Users can also use OvaTrack for entering repeat orders.

Order ID	Date	Status	Material	Quantity	Unit	Weight	Volume	Value	Lead Time	Delivery Date
12345678	2023-10-26	Open	SA 5083	1000	kg	1000	0.000	1000	10	2023-11-05
87654321	2023-10-25	Open	SA 5083	500	kg	500	0.000	500	10	2023-11-04
11111111	2023-10-24	Open	SA 5083	200	kg	200	0.000	200	10	2023-11-03
22222222	2023-10-23	Open	SA 5083	100	kg	100	0.000	100	10	2023-11-02
33333333	2023-10-22	Open	SA 5083	50	kg	50	0.000	50	10	2023-11-01



## EDI

For integrated logistics, we can also offer EDI links direct into our planning systems and we work with our customers' own integrated electronic tools at every step from order to delivery.

## Surcharges

We provide online access to our scrap, alloy and climate surcharge systems. Scrap and alloy surcharges are applied to adjust steel prices to account for cost variations for scrap and alloying elements. The climate surcharge helps to finance our investments needed for zero carbon emissions. Surcharges provide stability when negotiating long-term price agreements that benefit both customers and suppliers. For transparency, we show the influence of each alloying element, as well as historic data.

# CERTIFICATIONS AND TESTING CAPABILITIES

At Ovako, we have an extensive range of quality and environmental certifications. Independent third party organizations and quality assurance companies such as DNV GL and LRQA regularly evaluate our mills. These audits result in quality approvals of many types for a wide range of industries and are downloadable at [ovako.com](http://ovako.com).

## Audits

Our comprehensive certifications include ISO 9001, ISO 14001, ISO 50001, ISO 45001, IATF 16949. With restrictions on international travel during the pandemic, we introduced a new digital approach to quality management certification. When delivered in person, the certification process covers an inspection of our production line, followed by an in-depth meeting to review process steps and technical documentation. This requires a full day for each mill. Our new digital audit process replicates this with live video calls to inspect the production site and web conferencing to discuss the documentation. The digital approach has enabled us to achieve quality certifications and continue uninterrupted delivery to our customers without them having to face potential health risks of travel and the time commitment of quarantine.

## Environmental Product Declarations (EPDs)

Our EPDs cover the full environmental impact of hot-rolled steel bar from our Hofors, Imatra, and Smedjebacken and Boxholm mills. They are based on life cycle analysis of our products from cradle to gate. They take account of all the recycled scrap and alloying elements, transport, energy and waste products, as well as the environmental footprint of incoming goods and services and the full yield loss in production.

Ovako also publishes climate declarations, outlining the carbon footprint of our products from cradle to gate. We adhere to the Environmental Product Declaration (EPD) system, and our latest declarations can be found on our website and at [environdec.com](http://environdec.com). These declarations confirm that the CO2 footprint of our bar steel products is approximately 80 % lower than the global industry average. Climate declarations help customers select steel on the basis of carbon footprint. In turn, they enable customers with steel-intensive products to create world-leading carbon footprints of their own.



## Carbon Footprint Calculator

Our Carbon Footprint Calculator provides accurate data for customers to compare products and precisely establish the carbon footprint for their own products. It takes account of the data in the EPDs as well as the energy required for further processing, and the impact of the specific alloying variant. Our expert team can help customers access and use this tool.

## Testing Capabilities

Our wide range of inhouse testing capabilities enables customers to set their own exacting demands on steel quality, often beyond industry standards. One example is ultrasonic testing of intermediate product forms to ensure high steel cleanliness. Ovako even has published its own standard for ensuring highest possible steel cleanliness and therefore providing exceptional fatigue strength.

Our comprehensive certifications and testing capabilities include ISO 9001, ISO 14001, OHSAS 18001, IATF 16949.

# EXPERIENCE AND KNOWLEDGE

Making steel is only one part of our job. Just as important is our collaboration with each individual customer, helping them to meet their technical requirements.

## Know-how

Access the experience and knowledge of our global network of engineering steel specialists.

Ovako's comprehensive technical support draws on our knowledge and experience in a wide range of applications and production methods. This not only covers the properties of our steel but also heat treatment and machining. We can help customers get the most out of their steel products and attain the highest quality results, with the best production economy.

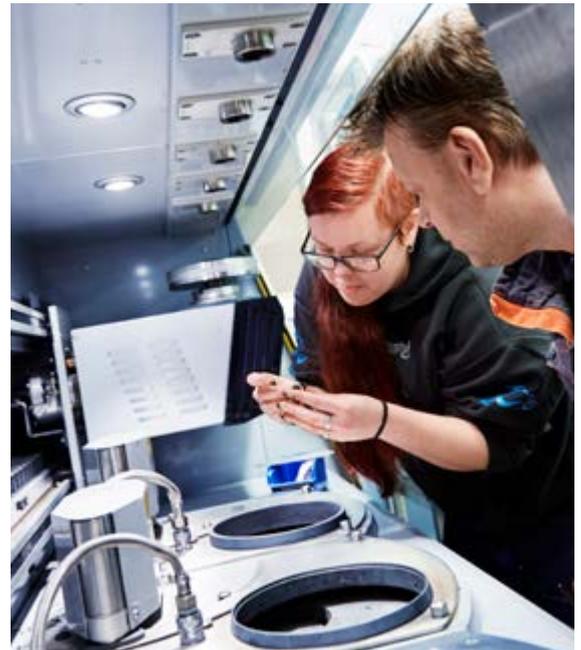
We have deep experience based on our world-leading product portfolio and extensive knowledge of customer applications. Dedicated teams serve most of our industrial sectors and have developed in-depth understanding of our customers and their technologies.

Our R&D network is at the forefront of engineering steel development. Our researchers work closely with our sector teams.

Our transparent approach to service places Ovako at the forefront for helping our customers develop smaller and lighter components for ever higher levels of cost efficiency.

## Prototypes

We provide specialist support for prototyping to shorten the lead time for components and system development projects. These projects typically benefit from short lead times and tailored prototype materials. Forgings, bars and machined pre-components are our main prototype formats, but we can also deliver tube components such as precision blanks, as well as rolled rings on request. Lead times vary, depending on the level of service required and availability of stock.



## Material investigations

Steel specifications can allow for large variations in component performance, especially if they rely only on old established standards. Our comprehensive material analysis service focuses mainly on establishing the cleanliness levels of steels. The aim is to reduce lead time for development projects and to establish performance level of existing solutions. The analysis will indicate the current material's performance level and recommend alternative materials to achieve the desired performance level.

We can also handle emergency cases, where customers have experienced unexpected failure. Our researches can report within a few days to support root cause analysis. Lead times for emergency cases vary depending on our available laboratory capacity.



# OUR PERFORMANCE BRANDS

In order to better communicate our engineering steel offering, we have classified our grades into different steel families to better explain their properties.

## **BQ-Steel® and IQ-Steel®**

BQ-Steel (Bearing Quality) is a bearing quality clean steel optimized for fatigue strength by strict control of steel cleanliness. It is used in a wide array of demanding applications in bearings and other industries.

IQ-Steel (Isotropic Quality) is an isotropic quality ultra clean steel, optimized for fatigue strength by strict control of steel cleanliness. It provides uniform and excellent properties in all loading directions.

## **Hybrid steel®**

Reimagine. Rethink. Redesign. Hybrid Steel is a ground-breaking innovation for the steel industry, made possible by a new alloying philosophy and a sophisticated hybrid hardening metallurgy.

## **M-Steel®**

Machine less, manufacture more. For more than 40 years, M-Steel has been the ultimate choice for superior machinability. In case after case, we have identified clear savings.

## **WR-Steel®**

As a pioneer in boron steel and steel for mining applications, we offer the broadest range of WR-Steel available anywhere with the mission to optimize the wear resistance of your products.

## **SZ-Steel®**

The brand promise of SZ-Steel is a performance standard that enables high strength solutions at sub-zero temperatures. High strength with high impact toughness.

## **CROMAX®**

Benefit from the world's largest chrome plating company with in-house steel production and optimized chemistry to safeguard structural integrity and eliminate slag inclusions.





# BQ-STEEL® AND IQ-STEEL® PURITY CREATES DESIGN OPPORTUNITIES –

For components and systems to survive a specified load collective under a certain amount of time, the purity of the steel is a key enabler. Not only is there a need for high absolute values for performance in the steel but it needs to be consistent and provide a narrow span in each relevant property. Over decades, Ovako has provided the market with such products for all kinds of engineering steel grades when they are processed to reach the BQ-Steel® and IQ-Steel® performance levels.

Independently of which steel grade you need, it is important to define what you demand from the steel you acquire. In simple terms, this divides into three categories

1. Direct cost efficiency
2. Direct value creation
3. End user value creation

The common denominator in providing high fatigue resistance is the metallurgically design of small and controlled inclusions. BQ-Steel and IQ-Steel represent the two highest steps on the “fatigue ladder” for steels produced in high volume production.

IQ-Steel is a top premium level due to the isotropic properties providing equal strength in all loading directions, which otherwise is a well-established but little known fact in conventional steels. This enables designers to design towards equal strength in the material independent of the direction of the applied loads.

## Direct cost efficiency

In fatigue strength, the IQ-Steels are on par with some of the most advanced remelted steels and outperform standard ESR remelted steels. The carefully controlled IQ-Steel process achieves both dramatically reduced direct cost as well as a narrow spread of properties within a large number of components. Figure 1 shows results from a comparative rotating bending test of a remelted VAR steel and an Ovako IQ-steel, 35 mm bar heat treated to 53 HRC. In this particular case the mean values are similar, but the IQ-steel has provided less scatter.

### Advantages of BQ-Steel and IQ-Steel

- Consistent quality for secure and stable production of end-user components
- Improved bending and contact fatigue strength
- Increased load per weight capacity, e.g. Nm/kg
- Decreased cost per load unit, e.g. €/Nm
- Component size reduction at fixed torque

The price of the IQ-Steel produced cost-efficiently in high volumes is significantly lower than the competing remelted solution. In Figure 2 the principal relationships between the steel price and fatigue performance versus metallurgical routes are displayed.

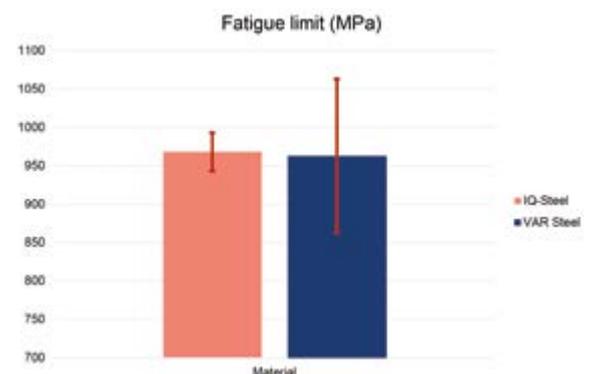


Figure 1.

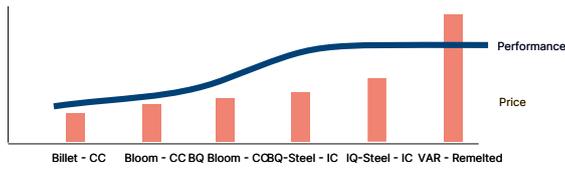


Figure 2.

Ovako is a true one-stop-shop for engineering steel, providing cost efficient products from all types of high volume steel production routes. Our three metallurgies provide different levels of fatigue performance with BQ- and IQ-Steel on top, independent of steel grade.

**Direct value creation**

The consistent quality in a material with narrow spread in properties is a major driver for optimizing the further processing of the delivered steel product. No matter if the component is going to be a heavily loaded bearing ring or a gear in a transmission system, being able to optimize the machining parameters always creates value.

In addition to the high fatigue resistance of clean steel, the repeatability within a narrow span enables the further manufacturing to reach high cost efficiency. One example is modern gear milling operations such as powerskiving where significant productivity increases can be reached.

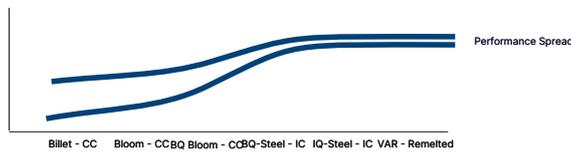


Figure 3.

The narrow spread is not only a result of the cleanness. The heat to heat repeatability in alloying is also of great importance. Figure 3 illustrates the relationship between spread in fatigue performance and metallurgical route.

Another way to create direct value is predictability in distortion. Such stability can provide higher yield as well as productivity in the component manufacturing processes. Increased distortion stability is vital for all kind of rotating parts, such as bearings, shafts and gears. One example is reduced need for grinding after heat treatment.

Costly surface fatigue improvement methods such as shot peening in gear manufacturing can also be reduced or eliminated when converting to clean steels.

**End user value creation**

Clean steel provides significant advantages for end users. For example, a system designer can optimize the component utilization to increase the power density of a complete application. Power density can be defined in many ways. Newton meters per kilogram system (Nm/kg) or Mega Pascal per Euro (MPa/€) are typical key performance indicators.

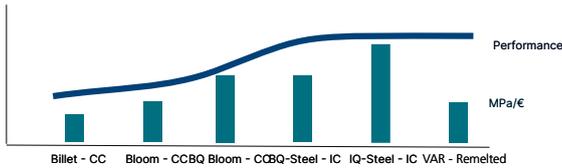


Figure 4.

Figure 4 shows the relationship between power density (MPa/€) and material performance, expressed as fatigue resistance.

To describe end user system benefits one can divide it into two basic approaches:

- Same size – Increased torque
- Downsize – Same torque with reduced size

The choice of strategy can differ, but the common denominator is achieving increased energy efficiency with total cost benefits. Ovako has long since been providing this for on-road solutions for e.g. final drive units for both light and heavy vehicles.

Clean steel can be an excellent tool to handle new demands on already highly loaded systems. For example, in e-mobility when changing to electric motors, most of the subsystems will need to change with it. The different motor characteristics in combination with the increased RPM will put new demands on the transmission, expecting it to handle an increased amount of cycles and at higher peak torque.

With clean steel as a solution, the challenges can be approached in new ways previously unavailable to designers. The improved fatigue resistance can be used as an enabler to make new design solutions and approaches that were previously limited by material fatigue or space constraints.

The increased material performance can also be used to handle NVH (Noise, Vibration and Harshness) in the system by allowing the gear design to optimize in ways that otherwise would not be possible while maintaining a high power density

Ovako's leading position in low CO2 emissions and the highest level of fatigue performance on the engineering steel market makes the choice of BQ- or IQ-Steel a true and competitive option for most systems on the market when looking at the future.

## Some component specific opportunities

### Bearings

BQ-Steel and IQ-Steel are the premium and top premium performance levels when it comes to solving highly demanding bearing applications. Ovako has more than a century of experience in producing bearing steel to energy efficient solutions. In the same manner as for the contact pressure on the flank of a gear, the bearing races, rollers and balls are continuously subjected to surface stresses. These are best supported through the high fatigue resistance provided by clean steels with metallurgically controlled and minimized inclusions.

Consistent material quality reduces product distortion and thereby hard machining costs. It also provides equal properties for bearing components as outer and inner races, as well as for rolling elements, which gives the bearing a predictable life.

### Gears

A gear is typically subjected to high contact pressures in the flank and high bending stresses within the tooth root. All gears, regardless if they are externally or internally cut, transfer torque through the gear itself or to the shaft it is mounted on. To optimize gear performance the combination of geometry, manufacturing and materials must be on the same level. Clean steel is an excellent way to increase power density and increase the life of a system.

### Axles

In its most primitive design, an axle is just a rotating carrier of other components such as bearings, gears, pulleys and lobes. It is not uncommon that the axle integrates parts of these other components (e.g. bearing races and cam lobes), hence the axle must have properties to handle the same performance demands as the components. Some shafts include gears and must thus fulfill the properties required for the gears.

### High pressure hydraulics

For high pulsating pressure details in hydraulic components, it is very important that the material fatigue strength is homogeneous and isotropic throughout the whole component. It is not uncommon that the pressure is concentrated to the center of the component, thus the need for high and consistent quality at all positions in the steel. No detrimental inclusions should exist in geometrically critical positions of the component as these might be subjected to cyclical peak loads. In that sense IQ-Steel is perfectly suited for these applications and was initially designed and developed for this purpose.

## Securing the right quality

To shorten the lead time for component and system development projects, Ovako has developed a system to deliver everything from long products to near net shape pre components. Through this service, combined with performance and design discussions, customers and other stakeholders can shorten their project lead times by several months or allow for more iterations in the system development process.

As classical material standards often lacks relevant methods to secure and verify the cleanness level in high performance clean steels, Ovako provides open source availability of methods such as ultrasonic testing to detect relevant material inclusion sizes.

Clean steel will respond in exactly the same manner to heat treatment as any conventional steel of the same grade. However, variations within a given alloying tolerance will result in different hardness and thus Ovako published a Heat Treatment Guide online as part of its Steel Navigator. Customers can use this tool to extract results for each specific composition as regards the properties after heat treatment.

Last but not least, Ovako has introduced the machining cube to support customers in optimizing their machining operations. Simply said, we have taken initiative to provide our customers with the right starting values for turning, milling, drilling, threading, grinding etc based on their material's.

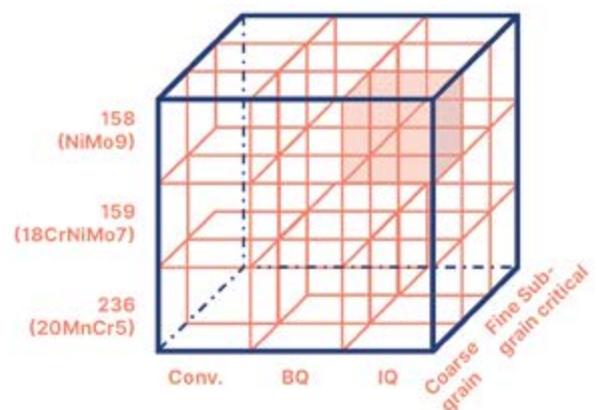


Figure 5.

**Common grades with BQ and IQ-Steel performance**

EN-standard	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
20MoCr4	124	Carburizing steel for heavier sections, available as IQ	0.20	0.2	0.8	0.5	0.4		
20NiCrMo2-2	152	SAE 8620 available as BQ	0.20	0.3	0.9	0.6	0.2	0.5	
20NiMo9-7*	158	Steel giving reduced surface oxidation after gas carburizing, available as IQ	0.20	0.1	0.3	0.4	0.7	2.3	
18CrNiMo7-6	159	Carburizing steel used for bearing and transmission components, available as both IQ and BQ	0.18	0.2	0.6	1.7	0.3	1.6	
20MnCr5	236	For small-sized transmission components, moderate core Hardness, available as IQ	0.20	0.2	1.3	1.2			
12NiCr14-6*	245	SAE 3311, available as BQ	0.13	0.3	0.5	1.5	0.1	3.3	
18NiCrMo14-6	255	High hardenability carburising steel, available as both IQ and BQ	0.18	0.3	0.5	1.4	0.2	3.3	
16CrMnNiMo9-5-2*	277	Steel suitable for carburizing and nitriding. Possible to gas/air harden, available as IQ	0.16	0.2	1.3	2.1	0.5	0.5	V
42CrMo4	326	SAE 4140, available as BQ	0.40	0.3	0.8	1.1	0.2		
40NiCrMo7-3*	355	SAE 4340 modified with V, available as BQ	0.40	0.3	0.7	0.8	0.3	1.8	V
32CrMoV12-10	398	Steel suitable for deep nitriding, available as IQ	0.32	0.3	0.5	3.0	1.0		V
42NiSiCrMo8-7-3*	497	High-strength, high-toughness steel known as 300M, available as IQ	0.42	1.6	0.6	0.7	0.3	1.7	V
30NiCrMo16-6	498	High-strength, high-toughness steel, available as IQ	0.30	0.3	0.5	1.4	0.2	4.0	
30MoCrV20-7*	499	Temperature resistant carburizing steel	0.3	0.2	0.3	1.7	1.8		V
50CrMo4	528	Medium carbon Q&T steel suitable for surface induction Hardening, available as both IQ and BQ	0.51	0.2	0.7	1.0	0.2		
51CrV4	593	High strength alloyed with chromium and vanadium, available as IQ	0.51	0.3	0.9	1.1			V
66SiMnCrMo6-6-4*	677	Bearing steel suitable for gas/air hardening, available as both IQ and BQ	0.67	1.5	1.4	1.0	0.2		
100Cr6	803	The most widely used bearing steel with a hardenability for small components (wall thickness 17 mm), available as both IQ and BQ	1.00	0.3	0.3	1.4			
100CrMo7	824	Increased hardenability with Cr and Mo for small- and medium-sized components (wall thickness 20 mm), available as both IQ and BQ	0.95	0.3	0.3	1.7	0.2		
100CrMo7-3	825	Increased hardenability with Cr and Mo for medium-sized components (wall thickness 30 mm), available as both IQ and BQ	0.95	0.3	0.7	1.7	0.2		
100CrMo7-4	826	Increased hardenability with Cr and Mo for medium- and large-sized components (wall thickness 50 mm), available as BQ	0.95	0.3	0.6	1.7	0.4		
100CrMnMoSi8-4-6	827	Increased hardenability with Cr, Mo and Si for large-sized components (wall thickness 75 mm), available as BQ	0.95	0.5	0.9	1.9	0.6		
100CrMnSi4-4	831	Increased hardenability with Cr, Mn and Si for small- and medium-sized components (wall thickness 20 mm), available as BQ	0.95	0.6	1.1	1.0			
100CrMnSi6-6	832	Increased hardenability with Cr, Mn and Si for medium- sized components (wall thickness 40 mm), available as BQ	0.90	0.7	1.5	1.4			
100CrMnSi6-4	837	Increased hardenability with Cr, Mn and Si for small- and medium-sized components (wall thickness 30 mm), available as BQ	0.95	0.6	1.0	1.5			

\* Designation followed by “\*\*” is not an official EN standard grade but named according to the rules in EN 10027.

# HYBRID STEEL®

## REMOVING COMPROMISES

Modern steels are divided into separate categories of tool steel, stainless steel, and lower alloy engineering steel, as well as more sophisticated maraging steels. Ovako's latest invention is to challenge these long-established divisions and to merge the unique properties in each category into one high performance steel.

### Creating a new steel category

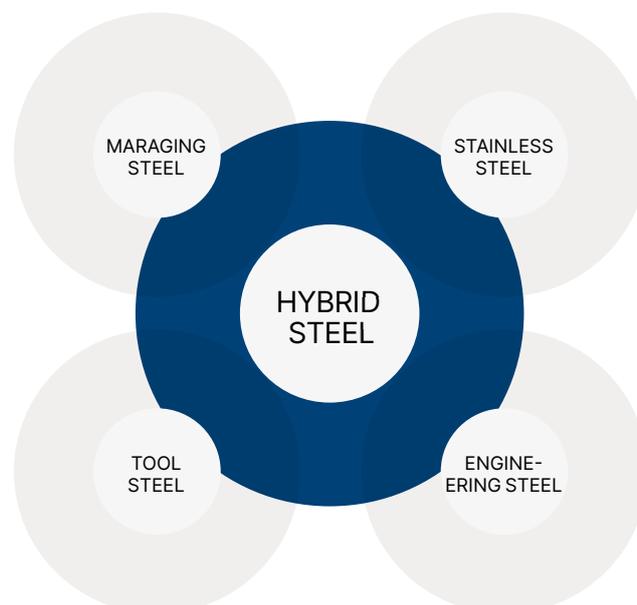
A few years ago, we set out on a mission to find and test alternative steel hardening mechanisms. Our aim? To meet the demands of high-stress, elevated-temperature applications where mechanical and fatigue strength are critical – without the need for expensive small-batch processes.

### Hybrid Steel is here

This development work resulted in a new steel category. We named it Hybrid Steel® – a new range of steel grades that combine the properties of maraging steel, stainless steel, tool steel and lower alloy engineering steel. By bridging longstanding performance gaps in ways few thought possible, Hybrid Steel opens up completely new opportunities in performance gains, cost savings and elimination of processing steps. It's a remarkable breakthrough, enabled by the first successful combination of secondary carbide hardening and precipitation hardening.

### Advantages of Hybrid Steel

- Ultra-high strength especially at elevated temperatures
- High-volume, cost-efficient production
- High hardenability enabling low distortion
- High fatigue strength at elevated temperatures and in corrosive environments
- Uniform properties with low microstructural segregation
- Weldable corrosion resistant ultra-high strength steel
- Excellent surface treatment possibilities
- Good corrosion and hydrogen resistance



**Groundbreaking steel grades**

Hybrid Steel 50, Hybrid Steel 55 and Hybrid Steel 60 are the first three commercially available grades in the growing Hybrid Steel range. The former is designed to 50 HRC hardness and the second to 55 HRC, which provides an array of engineering steel capabilities. The third is designated to 60 HRC hardness and is an equally unique grade of bearing steel for applications where added strength is needed. All are produced with the help of large-scale, automated ingot cast processes. And all are already in the hands of customers, testing teams and research institutes worldwide.

**What can Hybrid Steel do for you?**

True to its name, Hybrid Steel can mean many things to many people. By combining high strength at elevated temperatures with good weldability, high hardenability, low segregation and excellent surface treatment possibilities, it offers the best of many worlds. Which is why we've compiled this guide to Hybrid Steel to highlight eight key properties, as verified by the outcomes of our most recent validated tests.

The advantages of Hybrid Steel go far beyond its strength. Because the steel develops its hardness through heat treatment, it's possible to machine components in a softer condition closer to their finished form. Similarly, it is well suited for welding, since post-welding heat treatment will actually enhance strength. It also offers a range of advantages for nitriding, polishing and much more.

The original goal behind the development of Hybrid Steel was to create a steel grade that could successfully maintain its strength at elevated temperatures.

As seen in Figure 1, tests show that Hybrid Steel maintains remarkable levels of strength even when subjected to elevated-temperature conditions.

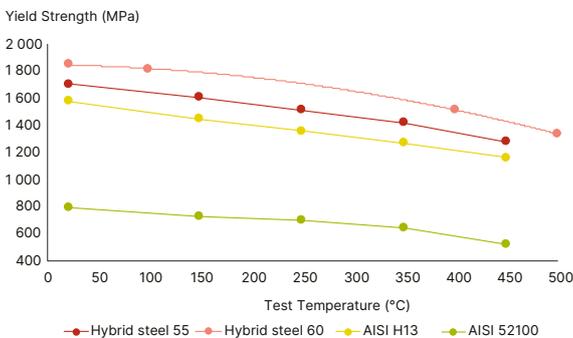


Figure 1. Yield strength tests show superior performance at elevated temperatures, compared with other commonly used high- strength steels. All grades tempered at 550°C before testing.

At ambient temperatures, Hybrid Steel offers superior mechanical fatigue strength compared to conventional steels. However, it is at elevated temperatures that the steel truly excels. At temperatures of 250°C, the fatigue strength of Hybrid Steel decreases by just 8 % vs room temperature, compared to 22 % for conventional bearing steels.

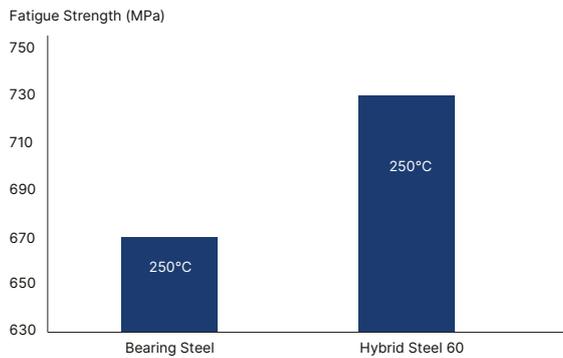
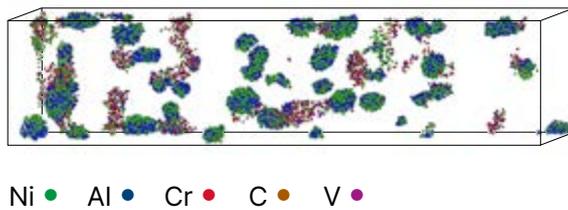


Figure 2. Hybrid Steel maintains its fatigue strength even at 250°C

The strength of Hybrid Steel depends on a uniform distribution of very small precipitated compounds. These intermetallic particles and secondary carbides are so small, in fact, that a volume of just 1 μm³ of Hybrid Steel contains more than 500,000 particles.

In terms of performance, this means that Hybrid Steel provides all the same high-strength benefits as tool steel and maraging steel, but without the costly compromises.

Hybrid steel requires no expensive remelt process to achieve low segregation. It also contains fewer expensive alloying elements, e.g. titanium (Ti) and cobalt (Co), compared to levels found commonly in maraging steels.



The low carbon content of Hybrid Steel provides yet another promising advantage for manufacturers: a truly weldable ultra-high-strength steel.

With welding tests still in their early stages, Ovako has been able to confirm that welded joints maintain the same high-strength properties as raw, untreated Hybrid Steel.

Ongoing tests are now being performed to expand on our initial findings, which suggest a wide range of breakthrough applications that were previously impossible with traditional high-strength steels.

Thanks to its high content of aluminum (Al) and chromium (Cr), which are strong nitride-forming elements, Hybrid Steel is particularly well suited for nitriding. The ability to achieve high surface hardness and beneficial residual compressive stresses, with maintained or even strength-ened core hardness, makes it possible to reduce both case depth and nitriding process time.

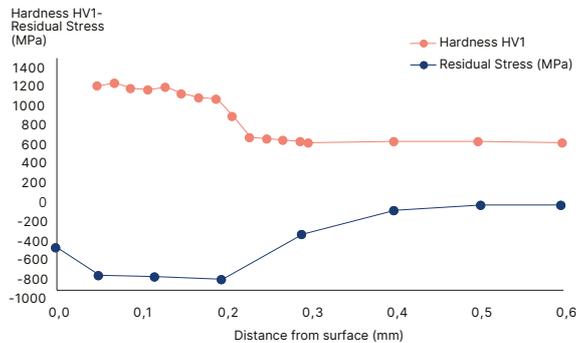


Figure 3. Nitriding generates high surface hardness. With Hybrid Steel 55, the core strength is maintained.

**Typical Hybrid Steel grades**

EN-standard	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
X20NiCrAlMoV6-5-2-1*	197	Known as Hybrid Steel 50. A low carbon steel with unique hardening properties	0.08	0.1	0.3	5.0	0.7	5.0	Al
X20NiCrAlMoV6-5-2-1*	297	Known as Hybrid Steel 55. A semi low carbon steel with unique hardening properties	0.18	0.1	0.3	5.0	0.7	6.0	Al, V
X20NiCrAlMoV6-5-2-1*	397	Known as Hybrid Steel 60. A semi low carbon steel with unique hardening properties	0.28	0.1	0.3	5.0	0.7	6.0	Al, V

\* Designation followed by "\*" is not an official EN standard grade but named according to the rules in EN 10027.

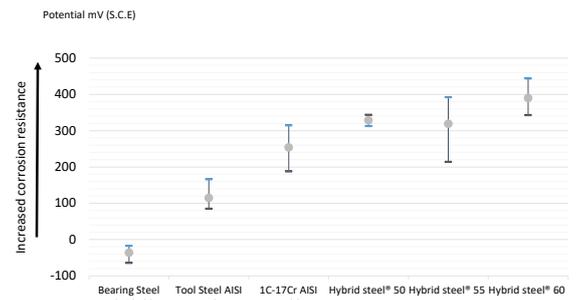


Figure 4. Higher corrosion resistance compared to engineering steels.

For demanding applications in corrosive environments, Hybrid Steel offers a hugely favorable alternative to common engineering steels. As seen in Figure 4, it not only outperforms bearing steels, tool steels and martensitic stainless steels in corrosion tests – it also can be left outdoors for more than a year with little surface corrosion.

Future developments of the Hybrid Steel family should allow for even better corrosion resistance. Thanks to a higher chromium (Cr) content than engineering steel, in combination with its aluminum content, Hybrid Steel's excellent corrosion resistance challenges the commonly held notions behind today's corrosion rating systems. The aluminum content also provides strong resistance to oxidation at elevated temperatures.



# M-STEEL® MACHINE LESS, MAKE MORE

M-Steel is a low alloyed, or non-alloyed, M-treated steel that is the ultimate choice when you need superior machinability combined with exceptional toughness and fatigue strength. It has proven its ability to achieve significant reductions in machining costs for component manufacturers which have replaced conventional steel with M-Steel. M-Steel enables higher cutting speeds and improved efficiency. Tests show that M-Steel can reduce machining costs by 30–40 %, significantly boosting profitability.

In a highly competitive world, maximum utilization of machining equipment is vitally important as is the time taken to produce each single component. Tool life and operational efficiency are also factors that have an impact on business profitability. With cutting speeds up to 30 % faster than conventional steel, M-Steel meets market demands for lower processing costs. In many circumstances, the tool life span can be more than doubled when machining components from M-Steel. This not only saves on the actual machining time, but also reduces the true cost per component.

## The M-Steel concept

Our M-Steel treatment can be applied to any steel grade. The basis for the concept is that non-metallic inclusions are modified and controlled with calcium treatment. These inclusions are modified in a way to maximize machinability and to improve transverse fatigue strength. The treatment also forms a protective layer on the cutting tool during machining that very significantly reduces the wear on the tool and increases the tool life. At every stage of the M-Steel production process the material is optimized to improve machinability, from raw material through melt, to casting, hot rolling and the final heat treatment. Individual delivery requirements can be met to supply your material in the best form for your machines in compliance with tight straightness and dimensional tolerances. M-Steel has a consistent machinability from cast to cast, meaning that machines can be run with fixed high cutting rates and predictable tool change intervals from one production run to another.

## Advantages of M-Steel

- Reduced machining costs
- Faster throughput of up to 30 %
- Zero production interruptions
- Less resetting – fewer tool changes
- Longer tool life
- Increased production capacity

## How much can you save?

By replacing conventional steel with M-Steel it is possible to lower machining costs by 30–40 %, boosting both your productivity and profitability. This is down to M-Steel's ability to facilitate faster run times through higher cutting speeds, more predictable and longer tool lives, and easier chip formation. More than 400 customers have already proven the manufacturing advantages of M-Steel, achieving significant reductions in machining costs for component manufacture.

Recent findings also show that the M-Steel effect is particularly pronounced in turning in very hard condition using Cubic Boron Nitride (CBN) inserts. Replacing traditional grinding of case- or induction-hardened surfaces with Hard Part Turning can mean very large cost savings, together with production lead time and quality improvements.



### Typical M-Steel grades

EN-standard	Ovako	Comments	Typical analysis							
			C	Si	Mn	Cr	Mo	Ni	Other	
16NiCrS4	4730	Good toughness, controlled hardenability, good machinability	0.16	0.2	0.9	0.9			0.9	S
11SMn30	2715	Lead-free cutting steel, also known as Green Cut	0.11	0.2	1.2					S
S355J0	2720	Also known as Hydax 15. A low-carbon, high tensile strength structural steel which can be readily welded to other weldable steel	0.16	0.4	1.3					S
20Mn5*	2630	Also known as Hydax 25. High temperature constitutional weldable steel	0.20	0.4	1.3					S
4CrMn16-4*	8302	Also known as Imacro M. Suitable for gas/air hardening	0.04	0.3	1.0	4.0				Nb
21CrMoV5-7*	6132	Also known as Imanite. Steel suitable for nitriding	0.18	0.2	0.6	1.3	0.7			V
C45	5081	Also known as 4M. Steel suitable for cold working and quenching and tempering	0.47	0.3	0.7					
S355J2	2723	Also known as 520. A low carbon, high tensile strength structural steel which can be readily welded to other weldable steel	0.14	0.3	1.2					V
16MnCr5	4306	Used for small-sized components	0.16	0.2	1.2	1.0				
25CrMo4	6014	High toughness and good weldability. Suitable for heat treatment	0.27	0.2	0.9	1.1	0.2			
34CrMo4	MoC 310 M	Steel suitable for cold heading	0.30	0.3	0.8	1.1	0.2			
34CrNiMo6	6502	Steel for high strained automotive and motor construction components. Suitable for heat treatment	0.34	0.2	0.7	1.4	0.2	1.3		
42CrMo4	6082	Medium carbon Q&T steel for general purposes	0.42	0.3	0.8	1.1	0.2			
20NiCrMo2-2	4548	A high cleanliness steel used for small-sized bearing and transmission components	0.20	0.3	0.9	0.6	0.2	0.5		
20MnVS6	7266	Also known as 280M. A low carbon, high tensile strength structural steel which can be readily welded to other weldable steel	0.20	0.4	1.5					V
S355J2	9864	A low carbon, high tensile strength structural steel which can be readily welded to other weldable steel	0.15	0.3	1.2					

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**OVAKO**

# WR-STEEL®

## A WEAR-RESISTANT ADVANTAGE

WR-Steel, which stands for wear-resistant steel, includes a broad range of steel grades with a wide range of hardness levels, dimensions and properties. It is designed to offer a wear-resistant advantage for products exposed to a high degree of wear and where service life is important.

The WR-Steel mission is to optimize the wear resistance of your products precisely and cost-effectively. At the manufacturing stage, it also gives you the flexibility to form, shape and weld the steel to fit your engineering needs precisely. With three main metallurgies of billets, blooms and ingots, the WR-Steel product range is the broadest of its kind in Europe and includes more than 30 different types of boron steel and special grades for mining applications. High carbon steels can also be applied for particularly demanding applications. By choosing the correct WR-Steel you can prolong the service life of your critical components. Longer service lifecycles mean fewer part replacements, greater work efficiency and, ultimately, cost-reductions.

WR-Steel is available in a wide range of shapes and sizes. This includes hot-rolled round and flat bar, special profiles, tube and ring. Over 700 special profiles can be supplied close to net shape. All products cover a wide range of hardness levels to allow the flexibility to be tailored to your needs.

### Advantages of WR-Steel

- Proven for superior wear resistance
- Steel grades for different types of wear
- Flat, profile, round, square, tube, ring
- Cost-effective boron steels available
- Tightly controlled composition for consistent production

### Advantages of the Ovako Wear Index

- Straightforward evaluation of materials
- Evaluation of alternative solutions
- Reduced development cost

### Ovako as your technical partner

With a centuries-old steelmaking heritage and decades in innovating boron steels, Ovako works closely with customers in the development and supply of specialized steel alloys. We can offer advice on applying the diverse WR-Steel program that is available for demanding applications. We also understand fully how alloying and heat treatment steps can boost your productivity and help you to achieve just the right hardening properties.

**The Ovako Wear Index**

Wear exists in many challenging forms across industries such as agriculture, construction and rock tools for mining. Different wear mechanisms may include plowing, wedge formation, cutting and cracking. There are several steel properties that are vital for the best wear resistance. These can be divided into mechanical strength (often measured as hardness), abrasive resistance (which we can establish in wear drum tests) and toughness. The Ovako Wear Index combines these three properties and can be used to illustrate the wear resistance of any given steel.



With the Ovako Wear Index, it is possible to make better-informed decisions in material selection. The Ovako Wear Index allows fast screening of materials for an existing application, to identify the most cost-effective solutions. It can also be used to determine which property is most important for the application and through this identify materials that offer longer service lives.

**Customized heat treatment**

No two heat-treating facilities or forging shops have exactly the same needs. You might be running a highly automated operation where furnace temperatures and quenching times are all pre-set by a computer. Or maybe you operating a more traditional shop where the skill and experience of the staff are key factors in providing a superior steel end product. Either way, you depend on a consistent level of quality to get the same high-quality hardening result – batch after batch. Ovako's range of WR-Steels is characterized by consistent quality, tight process controls and good repeatability.

**Savings across your operations**

The product forms in which we can supply WR-Steels eliminate or minimize time-consuming fabrication steps. This includes special profiles that are close to net shape. Furthermore, if you need to punch, drill or shape a WR-Steel component there might be an advantage in doing this in the steel's soft condition to minimize tool wear and tear. Furthermore, a special profile may allow you to avoid torch cutting of a sheet product and the resulting soft zone.

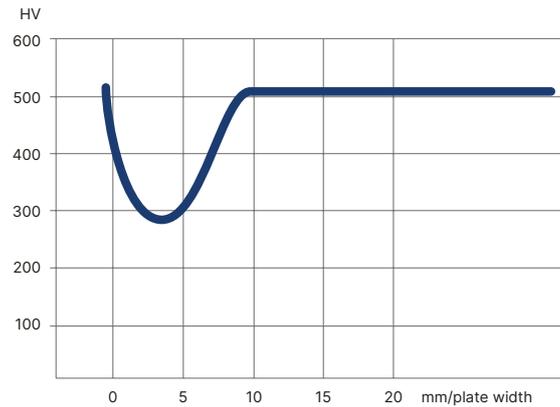


Figure 2. shows how the hardness profile from a gas cut edge declines significantly around the edge of the plate where the cut occurs. This can be avoided with WR-Steel in the form of hot-rolled bar or special profiles that require less cutting where wear resistance is critical.



Processing benefits of WR-Steel include the flexibility that comes from Ovako's many sizes of hot-rolled flat bar and round bar with >700 special profiles. This in turn can eliminate costly and time-consuming machining by using steel products nearer to net shape. The Boron steels in particular are easier to shape and mold as they are supplied in a softer condition, prior to quenching and tempering. They also provide consistent quality from batch to batch as well as a low level of alloying elements that impair cold formability. In addition, Boron steels are energy savers, due to lower tempering temperatures and the capability for many grades to be water quenched. They also exhibit favorable weldability due to low carbon content and lower amounts of alloying elements.



**Typical WR-Steel grades**

EN-standard	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
24MnB5*	SB24M13B	Steel suitable for quenching and tempering. Very good forming properties in the soft delivery state and high strength after hardening	0.24	0.3	1.3				B
27MnCrB5-2	SB27M12CB	Boron alloyed heat treatable steel for wear resistant parts such as dredger buckets, plough shares, chain wheels, mechanical engineering components, axles	0.27	0.2	1.3	0.5			B
30MnCrB5-2*	SB30M12CB		0.30	0.3	1.3	0.5			B
30MnB5	SB33M13B	Steel for wear resistance in thickness <15 mm	0.30	0.2	1.3				B
33MnCrB5-2	SB33M13CB	Boron alloyed steel suitable for quenching and tempering	0.32	0.3	1.3	0.6			B
43MnB6-3*	SB43M14B	Boron steel for general purposes without any specified mechanical properties. SB43M14B has the highest level of hardness and wear resistance achievable in the standard range of boron steels. Therefore is it an excellent choice for use in machine knives and garden tools	0.42	0.3	1.4				B
48CrMoNi4-10*	495	Ovako 495 is a high strength quench and tempering steel with high wear resistance, good toughness and good dimensional stability. The steel can be tempered at high temperatures and still maintain a high hardness and high strength. It is micro alloyed to obtain a precipitation hardening effect	0.48	0.2	0.8	1.1	0.9	0.4	V

\* Designation followed by “\*” is not an official EN standard grade but named according to the rules in EN 10027.

# SZ-STEEL® SUB-ZERO PERFORMANCE

SZ-Steel is a family of steel produced by Ovako for safe and reliable applications at sub-zero temperatures. These steels are ideal for situations where toughness is crucial in creating weight-saving components for use in extreme conditions.

The “SZ” stands for both Sub-Zero, and also for “Safety” at temperatures far below “Zero” degrees Celcius (°C). “Safety” in this context is provided by good impact toughness so that the mechanical strength of the steel is not affected by low temperatures.

Toughness is the ability of steel to deform plastically and absorb considerable amounts of energy when a load is applied. The area under the tensile stress-strain curve is a measure of toughness. Hence, toughness depends on a combination of both strength and ductility. Steel that offers a high percentage of elongation or reduction in area cannot guarantee high toughness if it is low strength. Similarly, steels with very high strength and low elongation have low toughness because the area under the tensile curve is small.

Toughness is typically measured by the Charpy V-notch impact test, as this allows the severity of the service condition and environment to be replicated. We have testing equipment that comply with international standards at each site producing SZ-Steel. At the extreme, we can test stud bolt materials at -101°C.

In the Charpy V-notch impact test, a notched specimen is struck by a falling pendulum. High energy absorption indicates ductile fracture, while low energy absorption indicates brittle fracture. Figure 1 shows a typical ductile to brittle transition curve for steel with decreasing temperature. The transition temperature can be altered and moved to a lower temperature to promote ductile fracture at low temperature by a change in chemical composition, steel cleanliness and microstructure. For a steel grade to be designated as a member of the SZ-Steel family, all of the mentioned parameters are strictly controlled. Furthermore, technical specialists are available to help customers in choosing the correct steel for any particular application.

#### Advantages of SZ-Steel

- Enables the application of high strength steel at sub-zero temperatures
- Retains critical material properties and offers a reduced risk of embrittlement and fracture at low temperature
- Enables weight-saving design that ensures safety for workers, service crews and the environment
- Meets key global safety standards



The conventional impact tests provide only a single toughness value. This effectively limits the test methods to quality control and material ranking. To further our understanding of the steel we produce, we use the Instrumented Impact Testing procedure to monitor the total impact fracture process. The typical output of the test is shown in Figure 2, in this case a shift of toughness with different tempering conditions is observed. By studying the shape of the force versus time or force versus deflection curve, different failure mode can be analyzed.

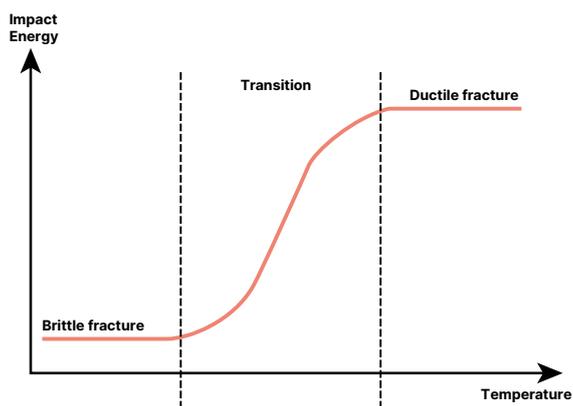


Figure 1. Schematic diagram of the effect of temperature on the ductile to brittle transition observed in steel.

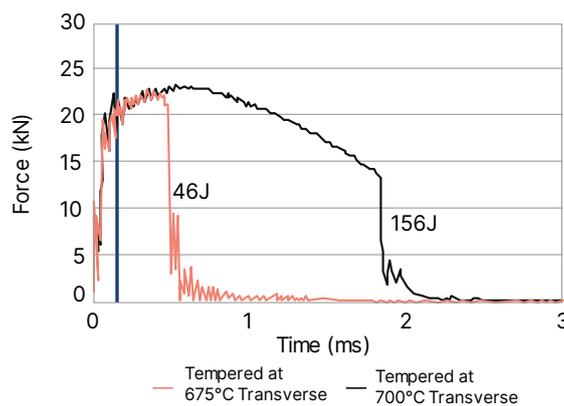


Figure 2. Effect of heat treatment on Ovako 277 on the force versus time curve measured by Instrumented Impact Testing. The energy absorbed by both samples during the impact testing is indicated.

**Typical SZ-Steel grades**

EN-standard*	Ovako	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
42CrMo4	326	Ingot cast SAE 4140,	0.40	0.3	0.8	1.1	0.2		
19MnV6	281	Micro-alloyed steel with high tensile strength, good machinability and weldability. Suitable also for case hardening and nitriding. Good dimensional stability.	0.19	0.4	1.5				V
25CrMo4	322	Ingot cast SAE 4130	0.30	0.2	0.9	1.1	0.2		
42CrMo6*	6116	Also known as Cromobolt. Conforms to the recommendations in ISO 898- 1:2009 for fasteners 8.8 or 10.9 properties. Suitable for quenching and tempering.	0.43	0.3	0.9	1.5	0.3		P
4CrMn16-4*	8302	Also known as Imacro M. A weldable quenched and tempered steel with lath martensitic structure.	0.04	0.3	1.0	4.0			Nb
27MnCrB5-2	SB27M12CB	Boron alloyed heat treatable steel for wear resisting parts such as dredger buckets, plough shares, chain wheels, mechanical engineering components, axles. Suitable for quenching and tempering.	0.27	0.2	1.3	0.5			B
30MnCrB5-2*	SB30M12CB		0.30	0.3	1.3	0.5			B
42CrMo4 (if Ø = 25-60 mm)	6137	ASTM 320 L7 used mainly for applications within the oil-, gas- and chemical fields where american standard 4140 is used.	0.42	0.3	0.9	1.0	0.2		
S355J2	2723	Also known as 520M. A low carbon, high tensile strength structural steel which can be readily welded to other weldable steel	0.14	0.3	1.2				
23MnNiMoCr54	4209	Steel for high strength chains and components.	0.23	0.2	1.3	0.5	0.6	1.0	
16CrMnNiMo9-5-2*	277	Steel suitable for carburizing and nitriding. Possible for gas/air hardening.	0.16	0.2	1.3	2.1	0.5	0.5	V
34CrNiMo6	6499, 356D	Quench and Tempering steel with high strength, toughness and hardenability. Used for large axles, machines components, tools and high strength fasteners.	0.34	0.2	0.7	1.4	0.2	1.3	V
40NiCrMo7-3*	355, 6514	American std 4340, typically used in high strength fasteners as grade L43.	0.40	0.3	0.7	0.8	0.3	1.8	V

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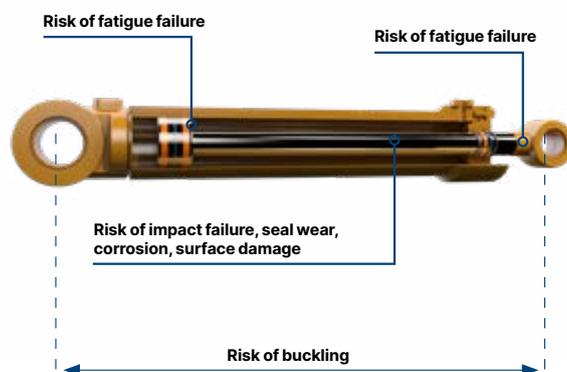
# CROMAX® FOR DESIGNING OPTIMIZED HYDRAULIC PISTON RODS

The diameter and the surface of the rod are important properties of piston rod material when considering factors like fatigue risk, buckling and impact damage. The material should also contribute to efficient chrome plating, machining and minimized cost without weakening the design.

Chrome-plated and nickel-chrome-plated bar and tube are primarily used as piston rods in hydraulic cylinders.

Principal parameters in hydraulic piston rod design are:

- 1) Dimensioning against fatigue, buckling and impact failure
- 2) Tailoring the surface for low seal wear and limiting the risk of surface damage or corrosion



## How to reduce cost

The main driver of cost is the diameter of the bar. The costs of material, handling and cutting increase with the weight of the bar while the cost of surface operations (machining, grinding, chrome plating etc.) increase with the surface area. As a result, the cost of a rod increases exponentially with the diameter.

As a general rule, the cost of a piston rod decreases by 15 % if the diameter is reduced by 5 mm. Other effects are lower weight and reduced space requirements, which could translate into lower energy consumption and possibilities for alternative designs.

## Advantages of Cromax

- Lowest cost to transmit a specific hydraulic force
- Enables new designs such as lower weight, less space and less energy consumption
- Surfaces to solve the corrosion-, impact- and seal wear challenge of any application

The Cromax offering combines materials, surfaces and services taking into account all the parameters required to minimize the total cost and capital required. See Figure 1.

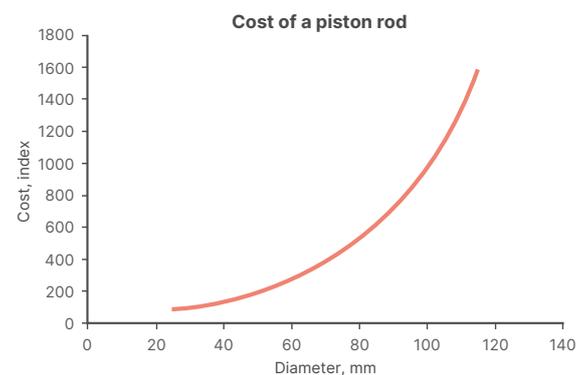


Figure 1. Cost of a piston rod as a function of the diameter

The steels used by Cromax have been developed specifically with the design and manufacturing of piston rods in mind – they can be thought of as “piston-rod steels” in the same way that steels developed specifically for ball and roller bearing applications are called bearing steels and steels developed for springs are called spring steels.

**High strength – lower cost**

Hydraulic piston rods must be dimensioned against buckling, fatigue and impact failure.

The risk of buckling depends on the yield strength, the elastic modulus of the material and the geometry of the rod, as defined by the slenderness ratio. Generally speaking, the buckling stress at small slenderness ratios corresponds to the yield stress of the material and decreases with an increasing slenderness ratio to the extreme case where it becomes independent of yield strength. In practice, 70–80 % of all hydraulic cylinders are designed with low or moderate slenderness ratios (below 100) meaning that the yield stress of the material has an important influence in defining the required diameter of the rod for cylinders operating in conditions where there is risk for buckling.

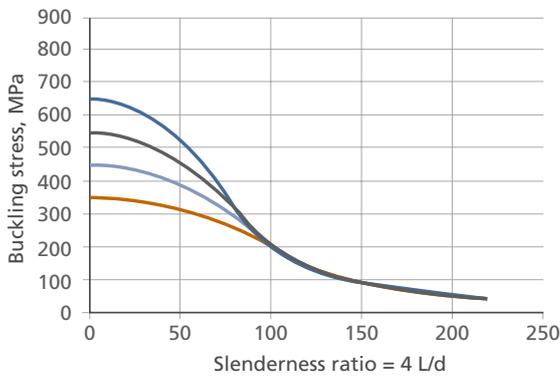


Figure 1 Buckling limit for materials with different yield strength as per ECCS and AISC.

However, a piston rod in many instances operates in a dynamic environment with push-pull forces and in which it will be susceptible to fatigue. Each rod has a unique fatigue limit and dimensioning is made on the basis of experience or through fatigue testing of finished piston rods or cylinders. Generally, fatigue strength increases with the tensile strength of the rod material. Guaranteed impact toughness might be considered in addition for safety critical applications.

Since the main cost driver is the diameter of the rod, the strength of the rod material is the main lever to reduce cost. Compared with the most commonly used material for hydraulic cylinder rods (C45E), the cost reduction potential by using stronger materials is of the order 20–30 %, see figure 2.

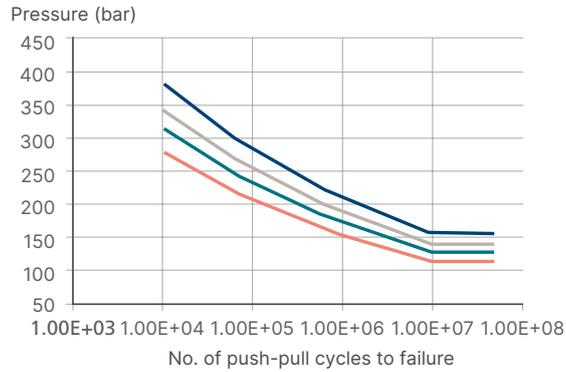


Figure 2 Fatigue limit for materials with different tensile strength.

Not all high-strength steels are suitable for piston rods. The main problems derive from the inherent impact of slag inclusions which intersect the surface and segregation at the center of the rod. It is not unusual for chemical compositions, aimed at promoting strength or machinability, to cause of problems in welding and friction welding in particular. Moreover, certain slag inclusions at the surface of the material will dissolve during the chrome-plating process and give rise to porosity which could translate into weaknesses in the chrome layer.

The true cost effect of different steel materials for a piston rod is complicated to assess, but a simple approach could be to first select several grades with sufficient impact toughness and suitable machinability/welding characteristics and then to choose the one which offers the lowest price per MPa of yield strength, see Figure 3.

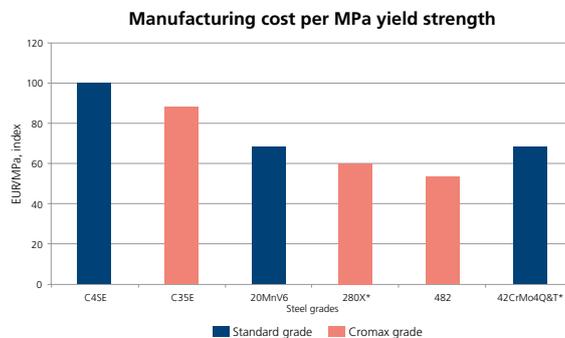


Figure 3 Cromax vs. standard steels expressed in EUR/MPa, C45E index 100. \* Impact toughness guaranteed.

### Right surface – lower cost

In order to minimize the cost of guaranteeing that the cylinder will last its economic life in different environments, Ovako can adapt the surface to meet the requirements, with minimum additional surface treatments and the thinnest possible layer of chrome or nickel-chrome.

Plating with chromium is by far the most common surface treatment for piston rods. However, chromium has limited ductility and all chrome-plated layers have micro-cracks which can permit the external environment to penetrate the layer and cause corrosion when operating conditions reduces the effect of the protective oil film. Having worked with hydraulic system manufacturers in a wide range of applications, we know that no two operating environments are exactly alike. With that in mind, Ovako Cromax has developed products with enhanced corrosion resistance for virtually all uses.

### Cromax C

Many applications demand components that can withstand harsher conditions that risk penetrating even a high-quality single chrome layer. This is why we created Cromax C, a series of double-chromed ready-to-use bars that provide twice the protection against penetration and pitting of the underlying steel.

The interface between the two chrome layers work as a barrier that prevents macro-cracks propagating through to the base material. This design enables operation under harsh environmental conditions and applications where the cylinders remain unused for longer periods.

Cromax C guarantees AASS 120 hours rating 9 (ISO 9227 AASS). This is verified and certified in accordance with EN10204 certificate 3.1.

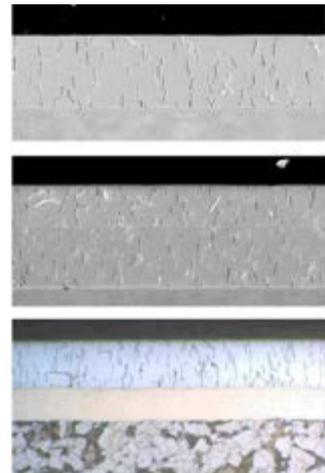


Figure 4 Cross sections of Cromax standard, Cromax C and Nikrom (top to bottom).

### NiKrom

For extreme environmental conditions, Ovako offers the duplex layer of nickel + hard chrome, known as NiKrom. In the NiKrom process, steel bars or tubes are first coated with a layer of corrosion resistant nickel, followed by an outer layer of hard chrome. The combination of the anti-corrosion characteristics of nickel and the favorable surface properties of chrome results in a rod material exhibiting outstanding corrosion resistance for case where functionality must be guaranteed in long-term usage or long periods of storage.

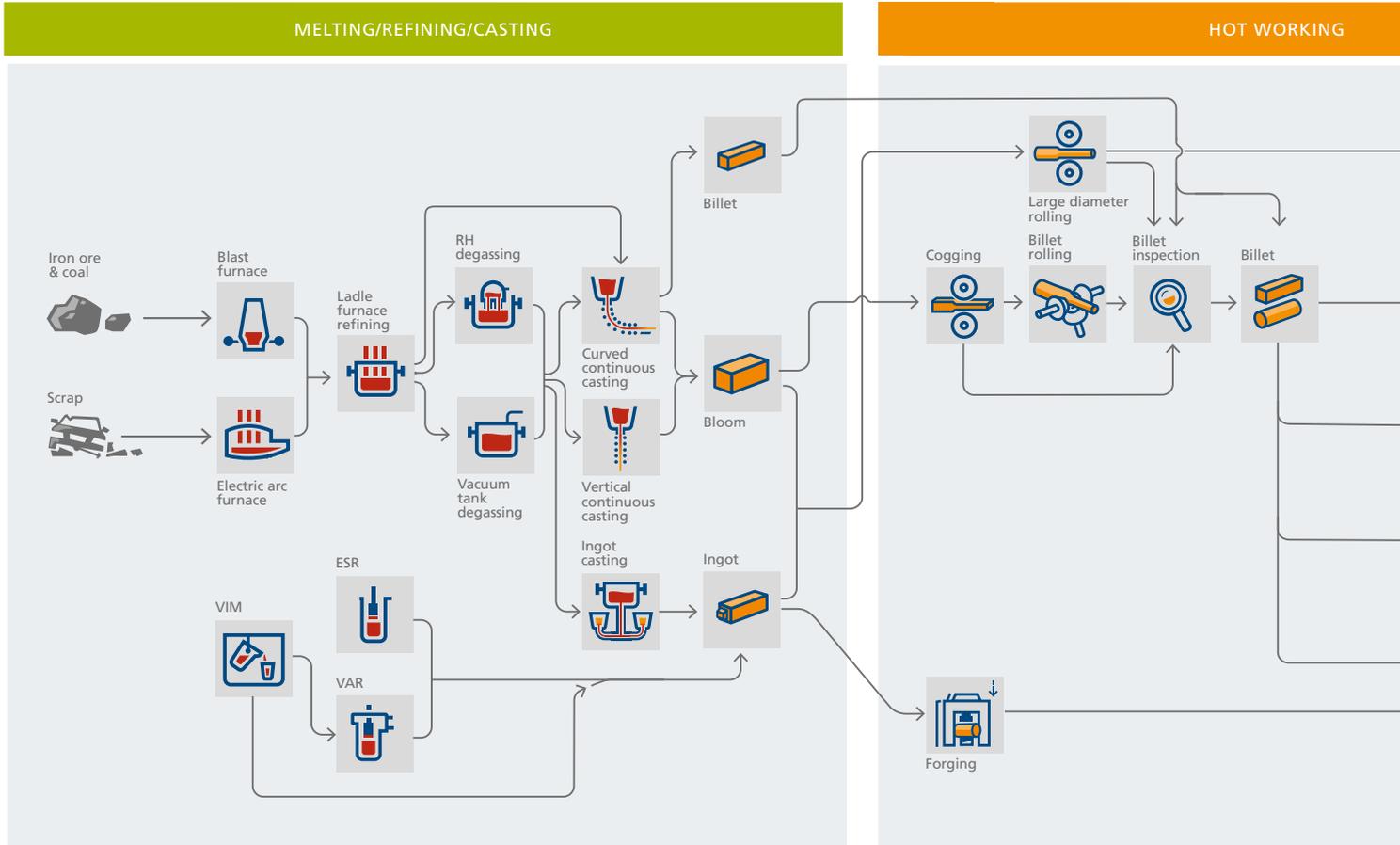
As the softer, more ductile and crack-free nickel layer is stable over time and when mechanical stress is applied, the nickel layer will fully compensate for the inevitable crack-propagation in the chrome-layer.

NiKrom is used in all applications with aggressive atmospheres such as mining, offshore or chemical plants, but also where rods are exposed for long periods of time, like tailgate lifts, snow ploughs or ski lift systems.

NiKrom 500, or Socatri 1500 (USA), has a minimum 30 µm nickel layer and carries a guarantee that the product will withstand 500 hours in acetic-acid salt spray (ISO 9227 AASS) or 1500 hours in neutral salt spray (ISO 9227 NSS).

By special agreement, a nickel-chrome-plated product with a 10 µm nickel layer can be supplied, NiKrom 150. For this, the corrosion guarantee is no attack after 150 hours exposure in acetic-acid salt spray (ISO 9227 AASS) or 500 hours in neutral salt spray (ISO 9227 NSS).

# PRODUCTION ROUTES



## Sweden

The collaboration between Nippon Steel, Ovako and Sanyo Special Steel includes specialty steel melting at nine global locations, enabling a world-leading range of products for many applications.



**Hofors/Hälsjöfors**  
100t EAF. Ingot casting of higher alloyed and high-quality clean steel. Bar, tube, rings.



**Smedjebacken/Boxholm**  
125t EAF. Billet-sized continuous casting. Specializes in flat/profiled bar.

## Finland



**Imatra**  
75t EAF. Bloom-sized continuous casting. Specializes in clean steel and several bar formats.

## India



**Khopoli**  
50t EAF. Ingot and continuous casting process. Specializes in clean steel, bar and rings.

## Japan



**Kyushu**  
BOF. New 350t continuous casting. Wide range of bar and wire. In-house secondary processing facilities.



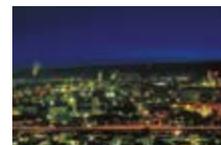
**Kansai**  
BOF. Continuous casting. Produces large diameter bar as well as seamless pipe and tube.



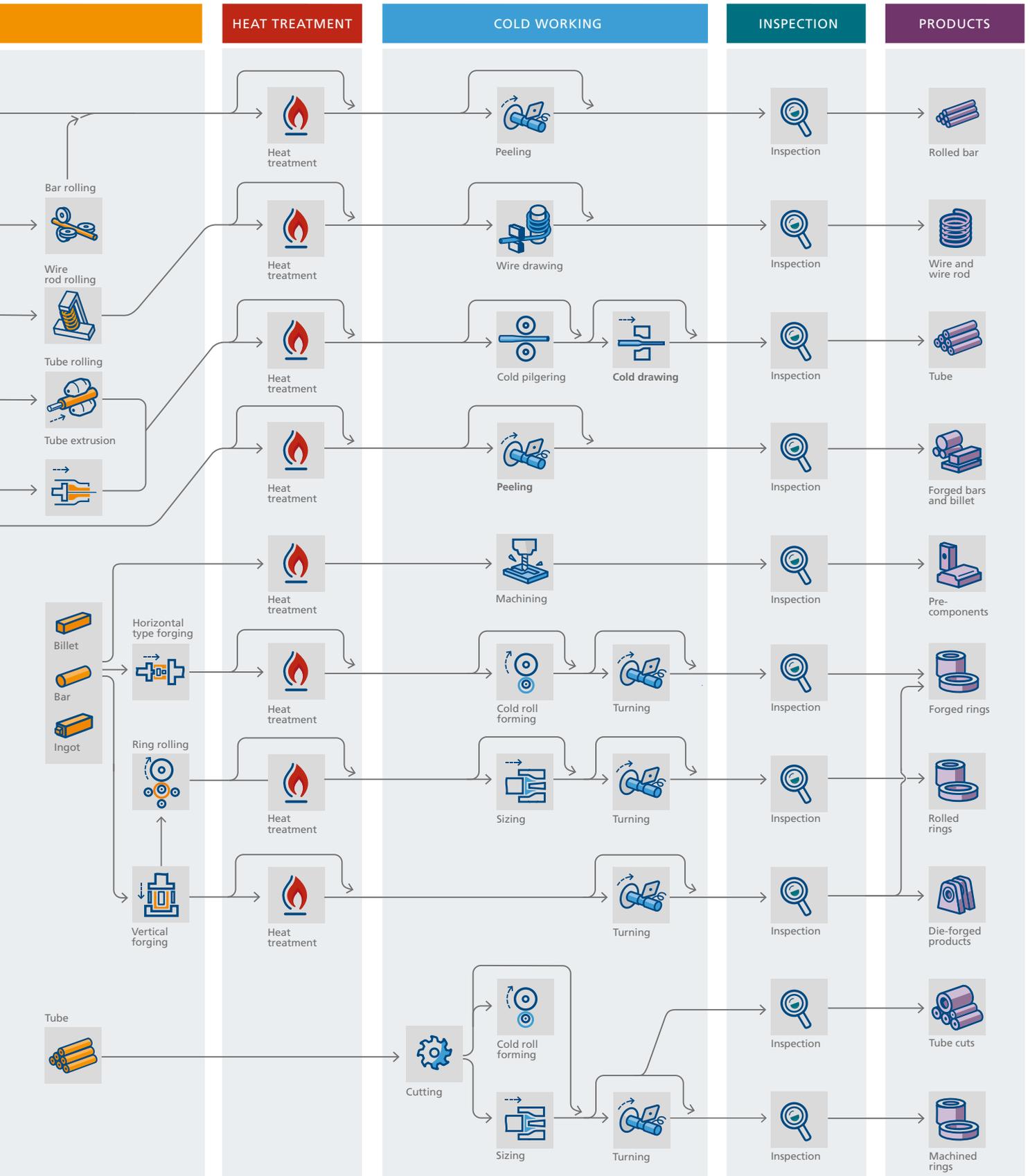
**Himeji**  
150/60t EAF. Vertical continuous casting. Bearing/alloy/stainless/tool steel. Bar, tube, rings.



**East Nippon**  
BOF. Continuous casting. Specializes in high carbon wire, specialty steel wire for cold heading.



**North Nippon**  
BOF. Continuous casting. Wide range of bar and wire. In-house secondary processing facilities.



# DELIVERY CONDITIONS

## Terms of delivery

For the sale and delivery of goods from the seller ("Ovako") to the buyer, the following terms of delivery shall apply.

The buyer shall acknowledge the application of these terms of delivery by a written confirmation thereof by letter, fax or email. In case these terms of delivery have been invoked in a quotation, then the buyer confirms the application of the terms by accepting the quotation

### General provisions

General Conditions, ALBIF 2000, for Delivery of Iron and Steel Products, etc. (Appendix 1) shall apply between the parties with the additions and adjustments set forth below.

### Delivery clause, ALBIF 2000 Clause 4

Stated delivery clause, according to INCOTERMS 2010, in quotation or order acknowledgement, shall apply. The risk to the goods is transferred to the buyer when the goods have been delivered by Ovako according to INCOTERMS 2010.

### Conditions for late payment, ALBIF 2000 Clause 24

Instead of Clause 24) of ALBIF 2000, the following shall apply.

In the event of late payment, penalty interest shall be payable with 18 % annual interest from the date of the invoice. In the event of late payment Ovako will issue two notices of delay and the claim

will thereafter be submitted to debt collection. Ovako will charge a fee in connection with an issued notice of delay and, in the event that actions for debt collection are being taken, Ovako have the right to charge reasonable costs for such actions.

### Disputes, ALBIF 2000 Clause 26

Instead of Clause 26) of ALBIF 2000, the following shall apply.

Any dispute, controversy or claim arising out of or in connection with these delivery terms, or breach, termination or invalidity thereof, shall be finally resolved through arbitration administered by the Arbitration Institute of the Stockholm Chamber of Commerce (the "SCC"). The Rules for Expedited Arbitrations shall apply, unless the SCC in its discretion determines, taking into account the complexity of the case, the amount in dispute and other circumstances, that the Arbitration Rules shall apply. In the latter case, the SCC shall also decide whether the Arbitral Tribunal shall be composed of one or three arbitrators. The site of arbitration shall be in Stockholm, Sweden.

The parties undertake and agree that all arbitral proceedings conducted shall be kept strictly confidential and all information, documentation, materials in whatever form disclosed in the course of such arbitral proceeding shall be used solely for the purpose of those proceedings.

## ALBIF 2000, General Conditions for delivery of Iron and Steel Products

### Introduction

- 1) These conditions shall form an integral part of all contracts for the sale of goods entered into by the Seller. Inconsistent conditions put forward by the Buyer in orders or otherwise shall be of no effect. Additions to and changes in these conditions are valid only if agreed in writing by and between Seller and Buyer.
- 2) Unless otherwise stated, written offers are binding 14 days from date of issue.
- 3) If an offer, order or order acknowledgement of an order has been made or given in writing, agreements collateral to the contract are not binding until they have been confirmed in writing.

### Delivery

- 4) If delivery terms have been agreed, these shall be interpreted in accordance with the INCOTERMS in force on the date of the contract. If no specific delivery terms have been agreed, the term "Ex Works" shall apply.
- 5) In regard to deliveries of goods not stocked by the Seller, the Seller shall, unless otherwise agreed, be entitled to make excess delivery or short delivery in accordance with the practice generally applied in the sector of Swedish industry for the category of goods concerned.

### Product information, etc.

- 6) Statements in product information or price lists are binding only if expressly restated in the contract. The Seller does not warrant that the goods are fit for a particular purpose unless expressly agreed in writing.
- 7) Unless otherwise agreed, samples provided are to be regarded as type samples and complete conformity of delivered goods with samples is not promised.

### Drawings and technical documents

- 8) All drawings and technical documents supplied by either party to the other shall remain the property of the supplying party and may not by the receiving party be improperly used, reproduced, or disclosed to third parties.

### Inspection

- 9) Prior to delivery, the Seller shall inspect the goods to verify compliance with the contract. Any testing, inspection or documentation requested by the Buyer after the conclusion of the contract shall be for the Buyer's account unless otherwise agreed. The Buyer shall inspect the goods upon delivery, as set out in Clause 17.

### Delivery time

- 10) If a delivery time is stated as a certain period, that period shall be deemed to commence on the date of the contract.

### Delivery delays

- 11) If the Seller or the Buyer finds that he cannot observe the agreed time for the delivery or receipt of the goods, or if a delay appears probable, he shall within a reasonable time give notice to that effect to the other party (notice of delay), stating when delivery or receipt of the goods can be expected.
- 12) If a notified or actual delay in delivering the goods or part of the goods is attributable to the Seller, and if, as the Seller has understood or should have understood, such delay would cause the Buyer material inconvenience, the Buyer shall have the right to cancel the contract with respect to the goods whose delivery is delayed, by giving notice in writing thereof to the Seller. If the Seller has given notice of the delay, the Buyer shall exercise his right to cancel the contract within ten days from receipt of that notice; otherwise the time stated in the notice shall be deemed to be a new agreed time of delivery. If no notice has been given, the right to cancel shall be exercised within ten days from the agreed time of delivery.

- 13) If a notified or actual delay in delivering the goods or part of the goods is attributable to the Buyer, the Seller has the right to extend the delivery time by a period that is reasonable in consideration of the circumstances. If the delay, as the Buyer has understood or should have understood, causes the Seller material inconvenience, the Seller shall have the right to cancel the contract with respect to the goods whose delivery is delayed, by giving notice in writing thereof to the Buyer. If the Buyer has given notice of delay, the Seller shall exercise any cancellation rights within ten days of receiving notice thereof. If no notice has been given, the right to cancel shall be exercised within ten days from the agreed time of delivery.
- 14) If delivery cannot be made at the time stipulated for reasons attributable to the Buyer, the Buyer shall nevertheless be liable to fulfil all payment obligations as if delivery had been made. The Seller shall arrange for storage of the goods at the Buyer's risk and expense. At the Buyer's request, the Seller shall insure the goods at the Buyer's expense.
- 15) If delayed goods are related to goods already delivered, or goods to be delivered later in such a way that the party entitled to cancel the contract would suffer material inconvenience if he were partially to stand by the purchase, the contract may be cancelled in its entirety by that party.
- 16) If delivery of the goods is delayed, damages or liquidated damages shall be payable by the party who has caused the delay only to the extent agreed upon by the parties in writing. However, this limitation does not apply to a party who is guilty of gross negligence.

#### Claims

- 17) When the goods have been delivered, the Buyer shall verify them in the manner prescribed by sound business practice. Claims regarding any faults in the goods shall be made in writing, specifying the nature and extent of the fault. Claims shall be issued within a reasonable time after the Buyer discovered or should have discovered the fault. The liability of the Seller is limited to faults in respect of which claims in accordance with the above provisions are made within one year of delivery. Claims regarding any fault in the goods caused by damage during transportation carried out by an independent carrier shall be addressed directly to the carrier in accordance with the terms and conditions applicable to the carriage, and, if the damage occurred when the Seller bore the risk for the goods, also to the Seller in accordance with the preceding paragraph. The above-mentioned provisions regarding faults in the goods shall also in their relevant parts apply with respect to shortages in quantities.

#### Remedies in respect of faults or shortages

- 18) If there is in goods delivered any fault for which the Seller is liable and in respect of which a claim has been made in accordance with the provisions of section 17, the Seller shall at his own expense and with the promptness demanded by the circumstances at his own option, but after consultation with the Buyer, either rectify the fault (e.g. by repair or reprocessing), reduce the price in proportion to the fault, or deliver new and faultless goods in return for the faulty goods. The Seller shall thereby defray the necessary costs of transportation, but not any expenditure incurred for dismantling, installation or processing, unless otherwise agreed. If the Seller neglects to fulfil his obligations in accordance with the provisions of the first paragraph of this section, the Buyer has the right – after notification in writing to the Seller, but not subject to his consent – to remedy the fault himself and receive justifiable compensation from the Seller in respect thereof, or, if such a remedy is impossible and the fault is substantial, to cancel the contract in so far as the faulty goods are concerned. If faulty goods are related to goods already delivered, or goods to be delivered later in such a way that the Buyer would suffer material inconvenience if he were partially to stand by the purchase, the Buyer may cancel the contract in its entirety. Apart from the remedies expressly set out in the contract or in these conditions, no other remedies can be invoked in respect of a fault in the goods. The Seller is not liable for direct or indirect damage or losses suffered in consequence of a fault in the goods. However, this limitation of the Seller's liability does not apply if the Seller is guilty of gross negligence. The above-mentioned provisions regarding faults in the goods shall also in their relevant parts apply with respect to shortages in quantities.

#### Grounds of discharge from liability (force majeure)

- 19) The Seller and the Buyer have no right in relation to each other to appeal to negligence in the fulfilment of the contract, if such fulfilment is substantially rendered difficult by industrial action, or by circumstances beyond the control of the party that could not have been anticipated when the contract was concluded, such as, but not limited to war, mobilisation, political disturbances, governmental intervention of various kinds, currency restrictions, fire, act of God, power shortages, interference with transport, extensive operational breakdowns, or substantial scrapping of goods by a party, or by deficient performance on the part of sub-suppliers owing to any circumstance such as is referred to in this section. If a party has not immediately notified the other party in writing that such a circumstance has occurred, he has no right to appeal to this as grounds for discharge from liability. If any circumstance such as is referred to in this section has the effect that the contract cannot be fulfilled within a reasonable time, either of the parties has the right to cancel the contract in writing to the extent that it has not been fulfilled. If, in such a case, the Buyer cancels the contract, the Seller shall be entitled to receive compensation for the costs incurred by discharging delivery obligations up to the time of the contract's cancellation; but not for what he can gain in the course of his business.

#### Infringement of rights of third parties

- 20) If goods are delivered in accordance with drawings, models or other patterns submitted by the Buyer, or in accordance with analysis prescriptions or descriptions given by him, the Buyer shall indemnify the Seller for any infringement of the rights of third parties, such as patents, patterns, or trademarks.

#### Tools and models

- 21) Repairs of tools and models, belonging to the Buyer and in the custody of the Seller, shall be paid for by the Buyer, if such repairs are caused by wear and tear or reasons not attributable to the Seller. The Seller shall be liable for keeping such tools and models during the agreed period of delivery. If they remain with the Seller after the period of delivery, the Seller shall keep them at the expense of the Buyer, unless otherwise agreed. All storage of such tools and models shall be at the risk of the Buyer. After three years have lapsed since completion of delivery of the goods, the Seller has the right – after notification to the Buyer in writing – to discard or return such tools and models unless otherwise agreed. Transportation of such tools and models shall be effected at the risk and expense of the Buyer. The term "tools and models" in this context includes other equipment required for the production of the goods and belonging to the Buyer.

#### Cancellation

- 22) The Buyer may not without the consent of the Seller cancel any contracted deliveries.

#### Retention of title

- 23) The Seller reserves the title to and property in goods delivered until full payment thereof.

#### Payment

- 24) Amounts overdue for payment will entitle the Seller to charge the Buyer interest. Such interest shall be calculated on a day-to-day basis on the amount outstanding from the date of maturity until paid at a rate 6 % above the official Repo Rate of the European Central Bank.

#### Governing law

- 25) The contract shall be governed by Swedish law, with exclusion of its conflicts of law rules as well as the International Sale of Goods Act (1987:822).

#### Disputes

- 26) Any disputes shall be settled by arbitration in Stockholm, Sweden, in accordance with the provisions of the Swedish Act on Arbitration. Either party may, however, initiate legal proceedings against the other in a court of law that has jurisdiction to collect sums of money that are indisputably due and outstanding under the contract.

At Ovako, we specialize in clean, high quality engineering steel tailored to the needs of customers in the bearing, transport, and manufacturing sectors. Our high-quality steel, based on 97% recycled steel, not only ensures lightweight and resilient products but also enables more sustainable and environmentally friendly solutions.

Ovako, a subsidiary of Sanyo Special Steel and a proud member of Nippon Steel Corporation, stands at the forefront of the steel industry. Our purpose is clear:  
**Together we create steel for a decarbonized society.**

Discover more about our innovative solutions at [ovako.com](https://ovako.com), [sanyo-steel.co.jp](https://sanyo-steel.co.jp), and [nipponsteel.com](https://nipponsteel.com)

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