

OVAKO

OVAKO **PRODUCTS 2015**





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OUR INDUSTRIAL EXPERIENCE

Ovako has extensive experience in supplying steel for an array of demanding applications in a wide range of industrial segments. We maintain and develop solutions through direct presence. As a result we are able to apply our knowledge from each field to benefit customer and end user needs.

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

Bearings have a service life bordering to the infinite. The cleanliness of the steels from Ovako has been a driver towards this status. Ovako provides this clean steel to the largest bearing manufacturers in the world.

General Engineering

This is where our knowledge from all industrial segments is condensed to a tailor made solution for each customer, supported by dimension ranges, product formats, skilled sales forces and service centers with stock for minimized lead times.

Hydraulics

The excellent performance of the Cromax and Nikrom products is widely known within the producers of hydraulic pistons. In addition we offer premium grades for demanding hydraulic cylinders as well as pumps, motors and valves.

Light and heavy vehicles

The strive towards lighter and stronger systems are supported by our clean steels and the need for reduced total cost of manufacturing from steels with improved machinability.

Mining and Construction

Rock drilling and processing require steels that can withstand the toughest environments. Ovako has a strong tradition in this field supplying products with superior fatigue and wear resistance.

Oil and Gas

The oil and gas market is no stranger to hard conditions. When combining our portfolio the Oil and Gas business can benefit from improvements on critical components.

Powertrain

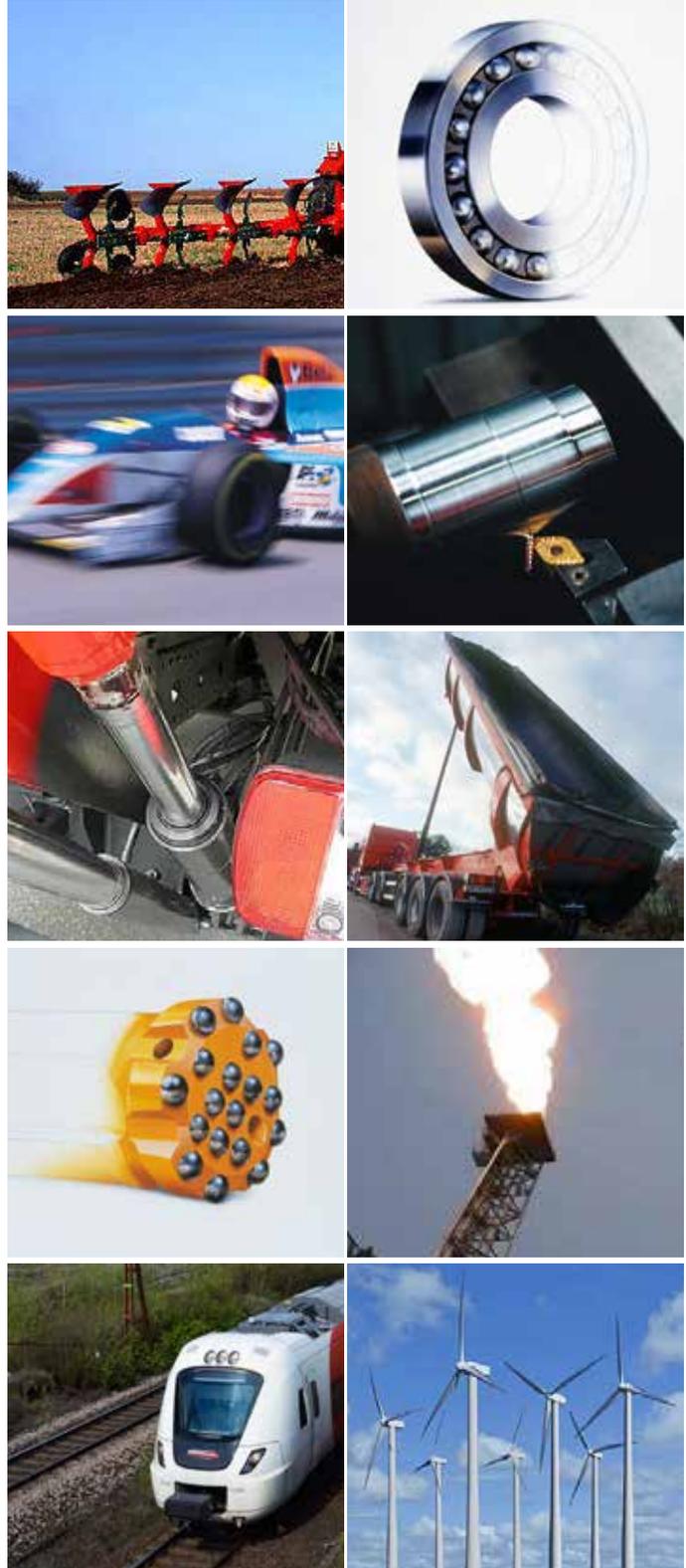
Increased power density, space under hood and energy efficiency is supported by the properties of BQ-Steel and IQ-Steel from Ovako. Specifically when load cases on gears and other critical components needs step changes to meet new environmental demands.

Railway

Our wide range of products supports applications from track to train. Strict demands, whether it's for railway clips or high speed train bearings are fulfilled.

Windpower

Ovako's steel cleanliness meets the demands of wind turbine applications such as gearboxes, transmissions, fasteners and bearings. Fatigue life is essential for low maintenance cost.



OUR HIGH PERFORMANCE STEELS

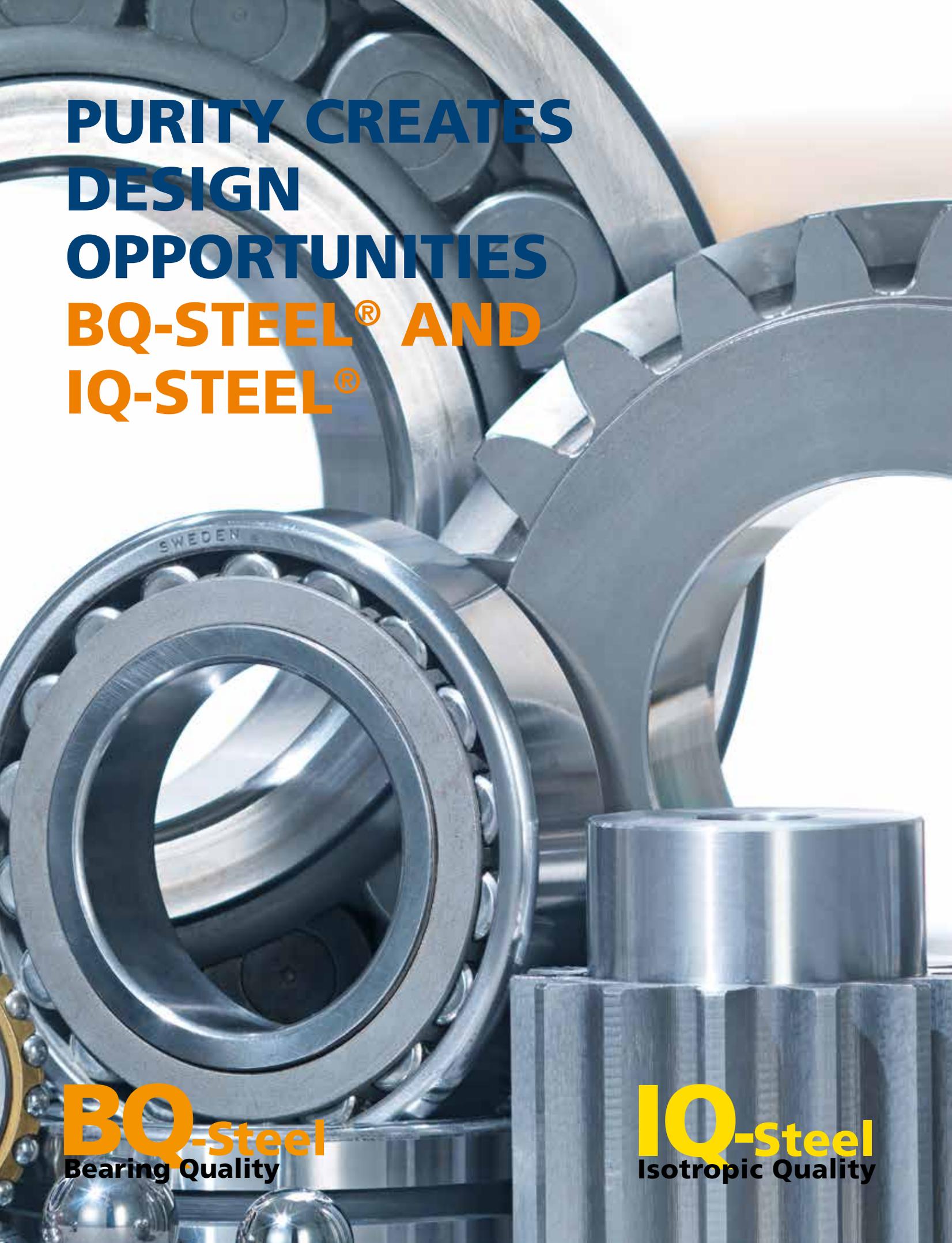


As the leading provider of highest quality engineering steel, customers around the world depend on Ovako for a high degree of operational reliability and efficiency. We are dedicated to providing outstanding know-how and support, and to developing steels that can give you a real competitive edge.

Further to this, we have now made it easier for our customers to match the right Ovako product to their unique requirements. We have classified our steel performance into straightforward groups so that it is now more simple to navigate our offerings, and therefore easier for you to do business with Ovako.

This is where our five attribute brands come into play: BQ-Steel®, IQ-Steel®, M-Steel®, WR-Steel® and also SZ-Steel® that will be launched during 2015. You can associate each product's main benefit from its name:

- BQ-Steel and IQ-Steel are both optimized for fatigue strength
 - BQ-Steel is our classic bearing quality
 - IQ-Steel is the next generation, an isotropic quality steel
- M in M-Steel stands for machinability
- WR in WR-Steel stands for wear resistance
- SZ in SZ-Steel stands for high impact toughness in sub-zero environment



**PURITY CREATES
DESIGN
OPPORTUNITIES
BQ-STEEL® AND
IQ-STEEL®**

BQ-Steel
Bearing Quality

IQ-Steel
Isotropic Quality

Ovako has a long standing reputation for producing steels optimized for fatigue strength by a strict control of steel cleanliness. The bearing quality steel, BQ-Steel from Ovako provides extensive design opportunities in many applications outside the bearing industry. The new generation of IQ-Steels from Ovako offer uniform and excellent properties in all loading directions. In cases of multiaxial stresses, the solution is often the Ovako range of customizable isotropic steels.

The extended performance, higher loads and high cleanliness of BQ-Steel are as a result of the Ovako clean steel program. Purity of production means the material has significantly smaller inclusions compared to conventional steel and, as a result, the fatigue strength of the steel is increased dramatically. Use of the material allows components to be manufactured in smaller sizes.

IQ-Steel, a further development of BQ-Steel, is an isotropic and ultra clean steel with properties that match remelted steels. Based on thousands of examinations by Ovako into the effects of defects on fatigue performance, the metallurgy of IQ-Steel is purer and far more consistent than conventional grades, and designed specifically to perform well in multiaxial loading. This enables the manufacturing of lighter, slimmed down components like gears, bearings and other critical parts. The steels are helping our customers to achieve new design solutions and implement higher standards of finished product performance.

Key to these practical advantages are Ovako's own unique, clean and consistent modern steelmaking processes that remove harmful inclusions and impurities from within the steel. IQ-Steels contain smaller and more fragmented inclusions and can handle much higher mechanical forces in all directions than conventional steels.

Enhancing processes and saving costs

BQ-Steel has for decades been the problem solver in the bearing industries. The same approach to fatigue performance is now being applied in many other applications. IQ-Steels are newer, but already now well-established in high pressure automotive applications. Modern diesel engines, with high and cyclic injection pressures, have proven to be an ideal application. Transmission components are another emerging area of strong interest.

Ovako customer service

The BQ- and IQ-processes can be applied to all our steel grades. We can work closely with customers to optimize the steel supply chain to meet your requirements, including multiple product packages. The material is available in tube, bar and ring.

All of our services are underpinned by a detail understanding of the industrial applications of our products, while paying as much attention as possible to your needs with regular direct contact. Ovako can advise you on how to best implement BQ-Steel and IQ-Steel for components in demanding applications.



BQ-STEEL® – BEARING GREATER LOADS, REDUCING COSTS

Component downsizing and increased loading are both issues facing manufacturers today as space restrictions and lower operating weight are driven by energy conservation. Ovako's new generation of bearing quality steel, BQ-Steel, are optimized and well proven in applications where fatigue strength is critical, allowing component manufacturers to rethink their design solutions.

High strength through hardening and high fatigue resistance through steel cleanliness facilitate the manufacture of components to meet the requirements of today and tomorrow. This is true for a wide range of industries where high cyclical loading is an issue.

Factors affecting fatigue

Steel quality can have a tremendous impact on the fatigue life of a component. This is brought about by the distribution and size of non-metallic inclusions within the steel. In the case of conventional steel these inclusions can be as large as 100 µm and quite densely packed. As varying loads are applied these large inclusions initiate fatigue cracks leading to material failure. Continuous research and development by Ovako over many years saw the introduction of a clean, bearing quality steel with inclusion typically less than 20 µm. Correspondingly the fatigue strength of BQ-Steel falls between 600 to over 800 MPa, depending on loading direction, while that of conventional steels falls between 300 to 500 MPa, see figure 1.

The rolling direction has a strong influence on fatigue properties for most steels. BQ-Steel is no exception, see figure 2. For an improved isotropic performance we recommend instead IQ-Steel.

For the development of these steels, it has been critical to develop the methodology for qualifying steel cleanliness. One useful approach is the immersed ultrasonic testing, which very visibly and quickly can show material defects within the tested material, see figure 3.

Customer advantages

Unique analysis of the influences of defects in steel utilizing scanning electron microscopes has allowed Ovako to build an extensive database invaluable in the development of clean steel. The resulting fatigue performance provides opportunities for manufacturers to rethink design solutions allowing weight reductions of a component through an increased power density.

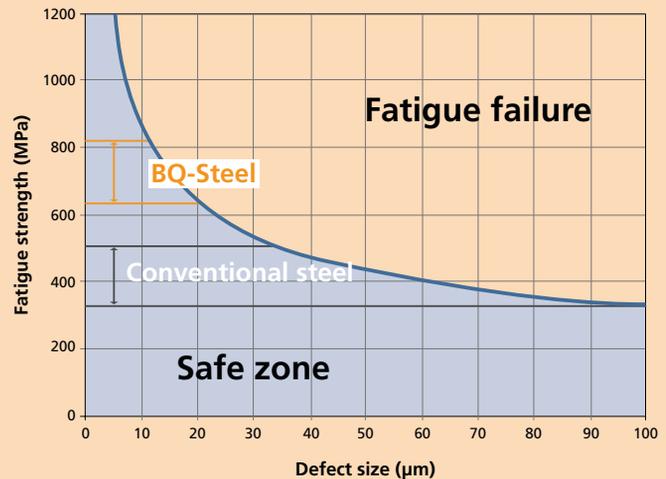


Figure 1. Fatigue strength of engineering steels vs. defect size.



Figure 2. Rotating bending fatigue results longitudinal and transverse to rolling direction. Conventional steel vs. BQ-Steel.

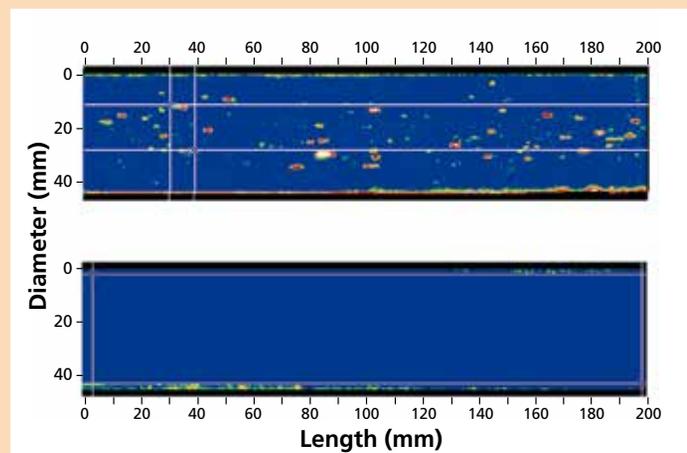


Figure 3. Immersed ultrasonic testing at 10 MHz of 65 mm bars in conventional steel. The colored areas are material defects within the assessed volume.

IQ-STEEL® – UNIFORM AND EXCELLENT MULTIDIRECTIONAL PROPERTIES

Ovako is increasingly hearing from our customers that conventional steels are no longer suitable for tougher jobs. Fatigue strength is severely limited for conventional steels, see figure 4. A specific problem is that many steel components are not able to handle cyclical loading in multi-axial directions well enough. The solution so far has been to increase dimensions. Further downsizing and increased stresses will accentuate these problems even more in the future, along with the need to handle the strain of even higher and more complex loads.

The reason for this over-sizing is because conventional steels are produced in processes where non-metallic inclusions are stretched and elongated in the rolling direction. Based on decades of continual fatigue research and an extensive database of compiled fatigue data, Ovako has developed a detailed understanding of the correlation between defect size and fatigue strength performance. The elongated inclusions have an important impact on the mechanical properties of any component by destabilizing the steel metallurgy, compromising fatigue strength and initiating cracking. Inclusions must therefore be minimized.

In contrast, IQ-Steels, with exceptional cleanliness, are designed to perform differently to conventional steels. With a higher degree of purity, smaller and much less elongated inclusions, IQ-Steels exhibit better isotropic behavior after rolling, see figure 5. They can be used to manufacture more reliable components with uniform and excellent properties which handle movement in all directions, not only in the rolling direction.

Increased lifetime of the component

Fatigue and its effects on the lifecycles of steel components are pressing concerns for Ovako customers. The accelerating drive for improved performance must be matched by the properties of the material. IQ-Steel provides opportunities because, in contrast to conventional grades, it can handle higher and more complex strains and loads over longer periods. This is a further reason why some of the world's most quality oriented original equipment manufacturers already use IQ-Steel. In fact, through the combination of the IQ-Steel properties and an alloying to optimize surface structure after carburizing, see figure 6, it is often possible to eliminate processes such as shot peening.

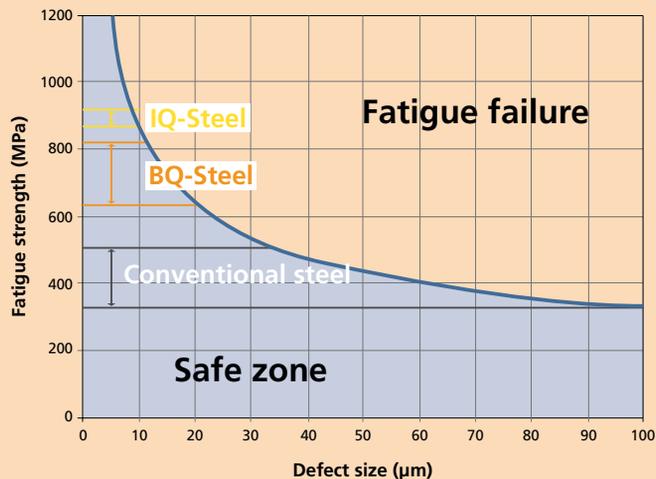


Figure 4. Fatigue strength of engineering steels vs. defect size.

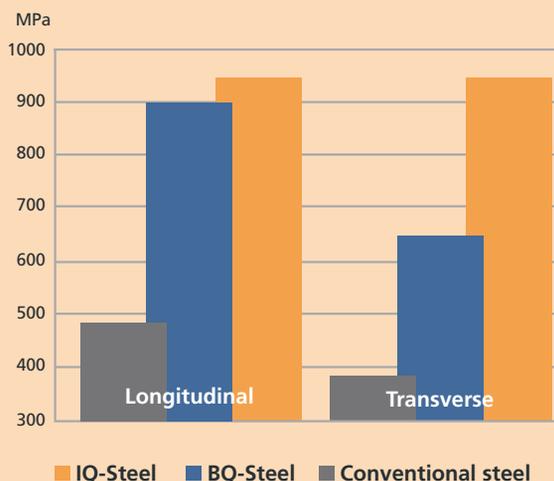


Figure 5. Rotating bending fatigue results longitudinal and transverse to rolling direction. Conventional steel vs. BQ-Steel vs. IQ-Steel.

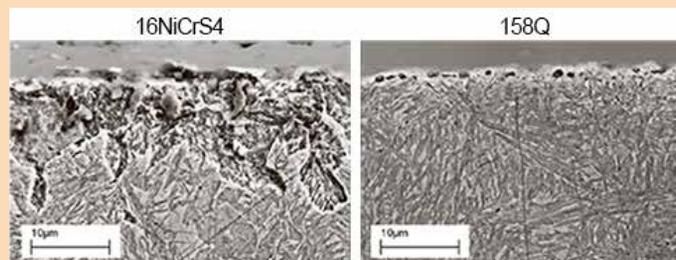


Figure 6. Surface structure of standard steel 16NiCrS4 (Ovako 146) compared to Ovako 158Q after gas carburizing.

BQ-Steel and IQ-Steel benefits vs. conventional steel

Benefits	BQ-Steel typical effects	IQ-Steel typical effects
Improved bending fatigue strength in simple load cases	30–90 % stronger depending on steel used today	40–100 % stronger depending on steel used today
Improved bending fatigue strength in multiaxial load cases	Up to 70 % stronger depending on steel used today	Up to 130 % stronger depending on steel used today
Typical application of weight reduction	Existing generations of end-user systems	Next-generation end-user systems
Typical design change possibilities	Moderate design adjustments on existing generations of end-user systems	Facilitates major design changes on next-generation end-user systems
Enhanced macroscopic defect control via immersion ultrasonic testing	Secures consistent quality level for end-user products	Secures consistent quality level for end-user products



TYPICAL BQ-STEEL GRADES

Ovako standard	EN-standard*	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
Ovako 152	20NiCrMo2-2		0.2	0.3	0.9	0.6	0.2	0.5	
Ovako 245	12NiCr14-6F		0.1	0.3	0.5	1.5	0.1	3.3	
Ovako 326	42CrMo4		0.4	0.3	0.8	1.1	0.2		
Ovako 355	40NiCrMo7-3F	SAE 4340 modified with V	0.4	0.3	0.7	0.8	0.3	1.8	V
Ovako 677	67SiMnCrMo6-6-4F	Bearing steel suitable for gas/air hardening	1.0	1.5	1.4	1.0	0.2		
Ovako 803	100Cr6	The most widely used bearing steel with a hardenability for small components (wall thickness 17 mm)	1.0	0.3	0.3	1.4			
Ovako 824	100CrMo7	Increased hardenability with Cr and Mo for small and medium sized components (wall thickness 20 mm)	1.0	0.3	0.3	1.7	0.2		
Ovako 825	100CrMo7-3	Increased hardenability with Cr and Mo for medium sized components (wall thickness 30 mm)	1.0	0.3	0.7	1.7	0.2		
Ovako 826	100CrMo7-4	Increased hardenability with Cr and Mo for medium and large sized components (wall thickness 50 mm)	1.0	0.3	0.6	1.7	0.4		
Ovako 827	100CrMnMoSi8-4-6	Increased hardenability with Cr, Mo and Si for large sized components (wall thickness 75 mm)	1.0	0.5	0.9	1.9	0.6		
Ovako 831	100CrMnSi4-4	Increased hardenability with Cr, Mn and Si for small and medium sized components (wall thickness 20 mm)	1.0	0.6	1.1	1.0			
Ovako 832	100CrMnSi6-6	Increased hardenability with Cr, Mn and Si for medium sized components (wall thickness 40 mm)	0.9	0.7	1.5	1.4			
Ovako 837	100CrMnSi6-4	Increased hardenability with Cr, Mn and Si for small and medium sized components (wall thickness 30 mm)	1.0	0.6	1.0	1.4			

This is a selection of our standard program. BQ-Steel can be applied to all our steel grades.

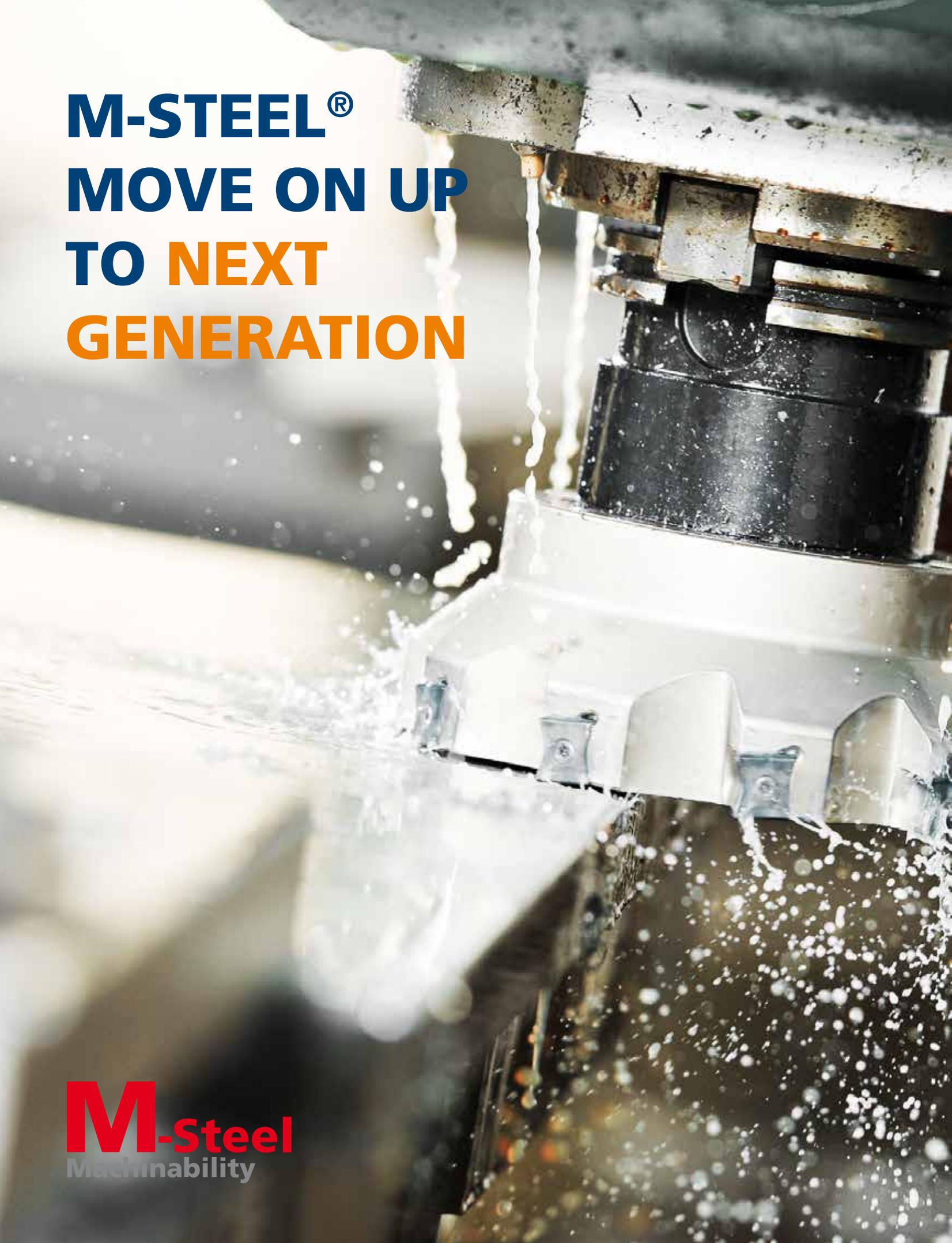
* Designation followed by "F" is not an official EN standard grade but named according to the rules in EN 10027.

TYPICAL IQ-STEEL GRADES

Ovako standard	EN-standard*	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
Ovako 158	20NiMo9-7F	Steel giving reduced surface oxidation after gas carburizing	0.2	0.1	0.3	0.4	0.7	2.3	
Ovako 159	18CrNiMo7-6	Carburizing steel used for bearing and transmission components	0.2	0.2	0.7	1.7	0.3	1.6	
Ovako 255	18NiCrMo14-6	High hardenability carburizing steel	0.2	0.3	0.5	1.4	0.2	3.3	
Ovako 277	16CrMnNiMo9-5-2F	Steel suitable for carburizing and nitriding. Possible to gas/air hardening	0.2	0.2	1.3	2.1	0.5	0.5	V
Ovako 398	32CrMoV12-10	Steel suitable for deep nitriding	0.3	0.3	0.5	3.0	1.0	0.3	
Ovako 499	30MoCrV20-7F	Temperature resistant carburizing steel	0.3	0.2	0.3	1.7	1.8		V
Ovako 497	42NiSiCrMo8-7-3F	High strength high toughness steel known as 300M	0.4	1.6	0.6	0.7	0.3	1.7	V
Ovako 498	30NiCrMo16-6	High strength high toughness steel	0.3	0.3	0.5	1.4	0.2	4.0	
Ovako 528	50CrMo4		0.5	0.2	0.7	1.0	0.2		
Ovako 593	51CrV4		0.5	0.3	0.9	1.1			V
Ovako 677	67SiMnCrMo6-6-4F	Bearing steel suitable for gas/air hardening	1.0	1.5	1.4	1.0	0.2		
Ovako 803	100Cr6	The most widely used bearing steel with a hardenability for small components (wall thickness 17 mm)	1.0	0.3	0.3	1.4			
Ovako 824	100CrMo7	Increased hardenability with Cr and Mo for small and medium sized components (wall thickness 20 mm)	1.0	0.3	0.3	1.7	0.2		
Ovako 825	100CrMo7-3	Increased hardenability with Cr and Mo for medium sized components (wall thickness 30 mm)	1.0	0.3	0.7	1.7	0.2		

This is a selection of our standard program. IQ-Steel can be applied to all our steel grades.

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M-STEEL®
MOVE ON UP
TO NEXT
GENERATION

M-Steel
Machnability

The machinability of the steel affects directly the machining costs and the plant efficiency in the production of components. Enabling higher cutting speeds next generation M-Steel from Ovako can provide a considerable cost advantage to manufacturers as well as freeing up manufacturing capacity.

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 impact on a business's profitability. With cutting speeds up to 30 % faster than conventional steel, M-Steel meets market demands for lower processing costs.

In many circumstances 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. In this way a protective layer is formed 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 to 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 by up to 30 %
- Zero production interruptions
- Less resetting – fewer tool changes
- Longer tool life
- Increased production capacity

How much can you save?

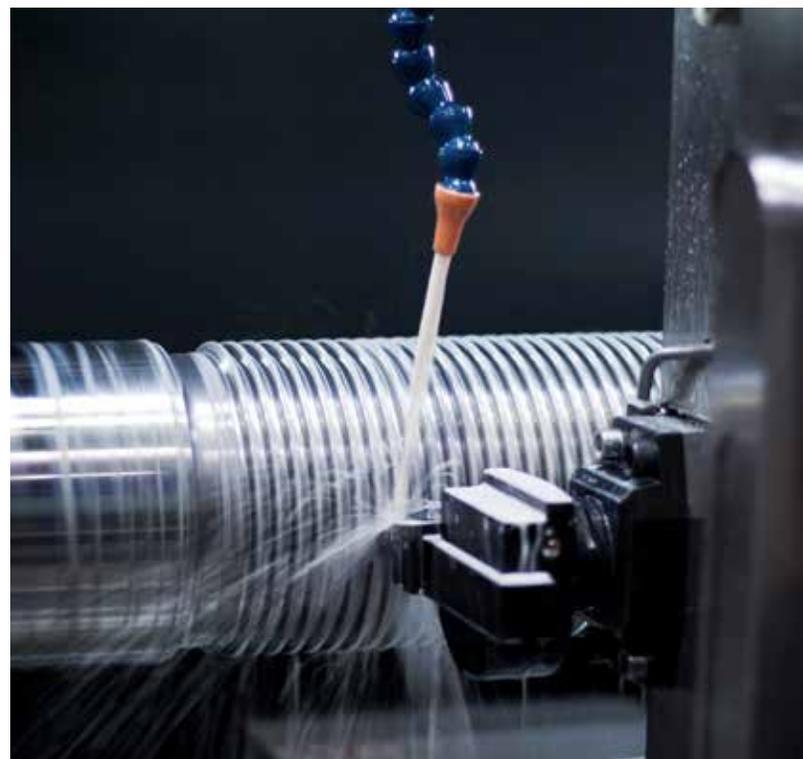
By replacing conventional steel with M-Steel it is possible to lower machining costs by 30–40 % boosting both your productivity and profitability. This is down to M-Steel's ability to facilitate faster run times by higher cutting speeds, more predictable and longer tool lives and easier chip formation.

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 extra 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.

Ovako customer service

We work closely with our customers advising on cutting data recommendations, choice of tools and quality assurance through machining tests to ensure the correct material grade and dimensional characteristics are selected for a given application.



M-STEEL® – DURABILITY YOU CAN COUNT ON

A key part of the M-Steel process is the modification and control of non-metallic inclusions with calcium treatment, important steps in secondary metallurgy which affect the composition and inclusion structure, as well as heat treatment.

Fine tuning the process

Hard, non-metallic inclusions in conventional steel cause considerable wear of the machine tool, but in M-Steel these are transformed to softer, calcium contained inclusions that are softer. They even create a beneficial protective layer between the tool and the chip interface during machining. Additionally, the sulfur content is optimized to achieve the best possible machinability. All of this is done in a way to balance performance vs. other properties, such as hardenability, impact toughness, tensile and fatigue strength.

Figure 1 illustrates how M-Steel compares with two conventional steels with regard to life of inserts used at the same machining parameters. Figure 2 shows a customer example of number of items completed with the same insert, comparing M-Steel with three conventional steels. Figure 3 shows the remarkable difference in tool wear between M-Steel and conventional steel.

Tailored to your requirements

M-Steel is available in a wide range of standard dimensions as round and square bar. Alternatively the material can be supplied to customer's requirements to tight dimensional tolerances. It can be supplied cut-to-length to fit the specific needs of individual machining centers.

Select your M-Steel

M-Steel high quality, low alloy engineering steels with improved machinability are available in a range of steel grades with bar sizes from 20 mm up to 200 mm and square bars up to 150 mm. A selection of popular grades is given in the table on next page.

Test of wear on turning inserts

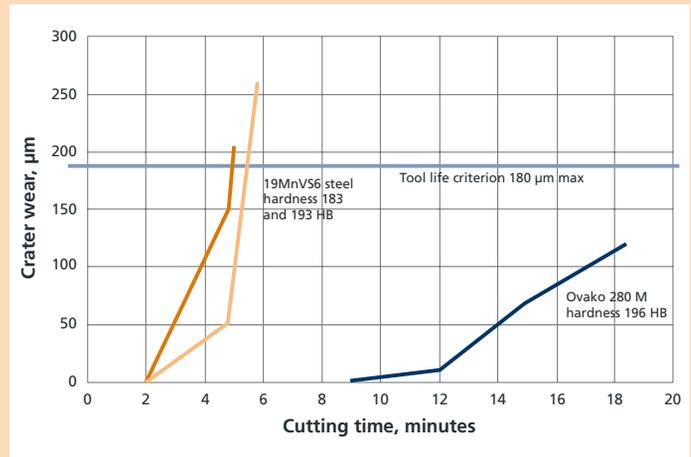


Figure 1. Wear on turning inserts when comparing M-Steel with two conventional steels of the same steel grade. Cutting speed 380 m/min.

Shaft/Turning insert

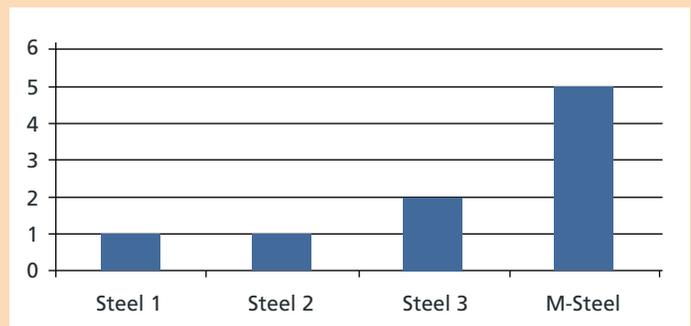


Figure 2. Number of machined items using the same insert, comparing M-Steel with three conventional steels one turning.

Crater wear comparison



M-Steel

Conventional steel

Figure 3. Crater wear comparison between M-Steel and a conventional steel.

M-Steel in short

- Every stage of manufacture is optimized to improve machinability
- Modification and control of non-metallic inclusion with calcium treatment
- Reduced need to change tools or cutting data
- Quality assurance – machining tests
- Repeatability of even and high machinability properties
- Close control on dimensional stability
- Customer service
 - Cutting data recommendations
 - Choice of tools
 - Planning and supervision of machining trials

Key benefits

- Reduced total machining costs
- Faster throughput – up to 30 %
- Zero production disturbances
- Less resetting and fewer tool changes
- Increased production capacity

TYPICAL M-STEEL GRADES

Ovako standard	EN-standard*	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
30MnVS6	30MnVS6	Micro-alloyed	0.3	0.5	1.4				V
CN 110 M	16NiCrS4		0.2	0.2	0.6	0.8		1.0	
Green Cut	11SMn30	Lead free cutting steel	0.1	0.2	1.2				S
Hydax 15	S355J0		0.1	0.4	1.3				S
Hydax 25	20Mn5F		0.2	0.4	1.3				S
Imacro M	5CrMn16-4F		0.1	0.3	1.0	4.0			Nb
IMAFORM	7Cr5F	Low carbon hardenable steel suitable for direct quenching	0.1	0.3	0.8	1.3			
IMANITE M	21CrMoV5-7F	Steel suitable for nitriding	0.2	0.3	0.6	1.4	0.7		V
Imatra 4M	C45E	Steel suitable for cold working and quenching and tempering	0.5	0.3	0.7				
Imatra 520	S355J2		0.1	0.3	1.2				
MC 110 M	16MnCr5		0.2	0.2	1.2	1.0			
MC 212 M	20MnCr5		0.2	0.2	1.3	1.2			
MoC 210 M	25CrMo4		0.3	0.2	0.9	1.1	0.2		
MoC 310 M	34CrMo4	Steel suitable for cold heading	0.3	0.3	0.8	1.1	0.2		
MoCN 315	34CrNiMo6		0.3	0.2	0.7	1.4	0.2	1.3	
MoCN206M	20NiCrMo2-2		0.2	0.3	0.9	0.6	0.2	0.5	
Ovako 280	19MnVS6	Micro-alloyed	0.2	0.4	1.5				V
P355NH	P355NH		0.1	0.3	1.2				
S355J2 SBM	S355J2		0.1	0.3	1.2				
VC 510	51CrV4		0.5	0.2	0.9	1.1			V

This is a selection of our standard program. The steel grades above can all be made as BQ-Steel, IQ-Steel or M-Steel.

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**WEAR
RESISTANCE
FOR YOUR
ADVANTAGE
WR-STEEL®**

WR-Steel
Wear Resistant

WR-Steel® grades from Ovako gives you a wear resistant advantage that covers a wide range of hardness levels, dimensions and steel grades. The whole idea is to combine cost efficiency in the manufacturing stage with just the right wear resistance in your end product.

The WR-Steel mission is to optimize the wear resistance of your products and in the manufacturing stage give you the flexibility you want to be able to form, shape and weld the steel to fit your engineering needs precisely. With three main metallurgies of billets, blooms and ingots 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.

Over 680 special profiles supplied close to net shape, are available alongside many different sizes of hot-rolled round and flat bars and grinding media. All products cover a wide range of hardness levels, in order to be flexibly tailored to your needs.

Customized heat treatment

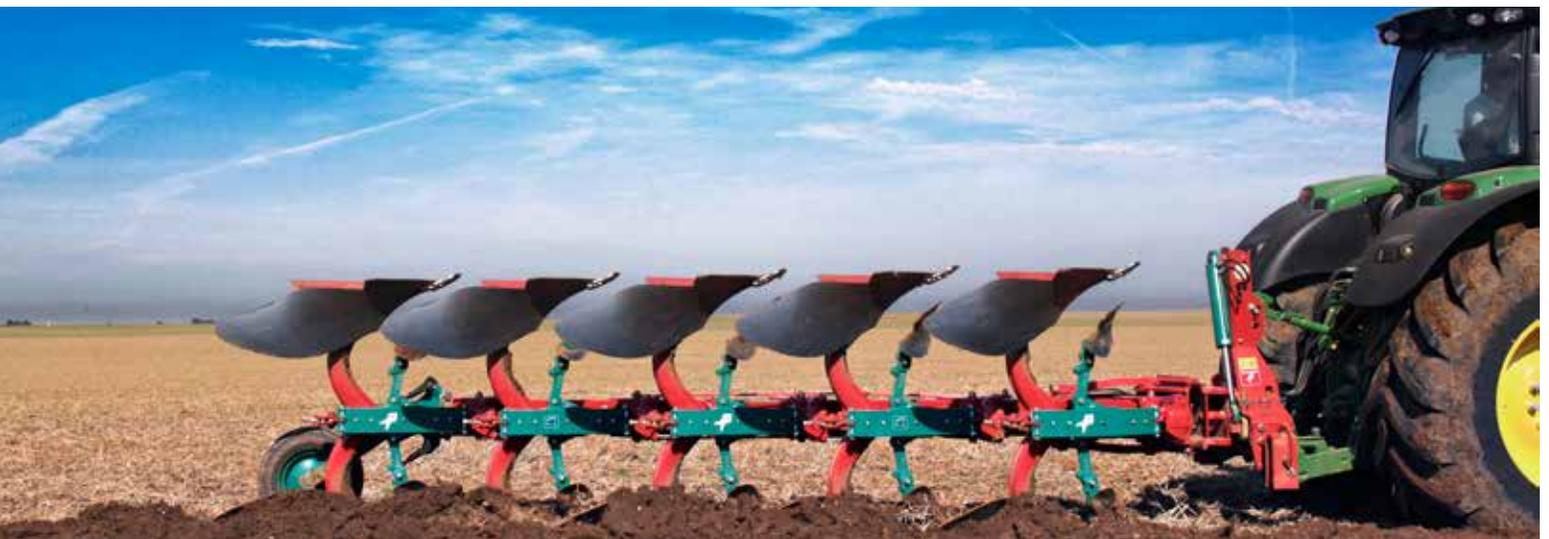
No two heat-treating facilities or forging shops have exactly the same needs. You might be overseeing a highly automated operation where furnace temperatures and quenching times are all pre-set by a computer. Or maybe you are at a more traditional shop where the skill and experience of the staff is something you are known for 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 the steel's consistent quality, tight process controls and good repeatability.

Advantages of WR-Steel

- Proven superior wear resistance
- Broad range of hardness intervals (350–650 HV)
- Right properties after rolling or heat treating
- Cost-effective due to optimized alloy content for different end applications
- Wide range of steel grades in different dimensions

Ovako as your technical partner

With a centuries-old steelmaking heritage and decades spent 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 and we fully understand how alloying and heat treatment steps can boost your productivity and help you to achieve just the right hardening properties.



WR-STEEL® – WEAR RESISTANT

Service life

With choosing the correct WR-Steel you can prolong your service life. Longer service lifecycles mean fewer parts replacements, greater work efficiency and ultimately a cost-reductions. Rather than just promising you that our WR-Steel grades can save money by extending your service life, Ovako turned to the independent Swerea KIMAB test facility to simulate extreme industrial conditions and see how we measure up against other hardening and pre-hardened steels.

Savings across your operations

The product forms in which we can supply WR-Steels eliminate or minimize time-consuming fabrication steps. You can choose from a diverse range of hot-rolled round and flat bars or special profiles that are close to net shape. Furthermore if you need to punch, drill or shape a WR-Steel component then it may be advantageous to do this in the steel's soft condition in order to minimize tool wear and tear.

Processing benefits of WR-Steel

Benefits	Typical effects
Flexible choice	Many sizes of hot-rolled flat bar and round bar with > 680 special profiles and growing
Consistent quality	No variations from batch to batch due to even steel quality and rigorous process controls
Easier to shape and mold	Softer steel prior to quenching and tempering due to low level of alloying elements that impair cold formability
Saves time; more efficient	Eliminate costly and time-consuming advanced machining by using our hot-rolled bar or close-tonet-shape special profiles
Energy savings	Less costly due to lower tempering temperature; many boron steels can be water quenched
Save your tools	Ease of machining of softer material helps to reduce tooling costs
Easier to weld	Favorable weldability due to low carbon content and lower amounts of alloying elements

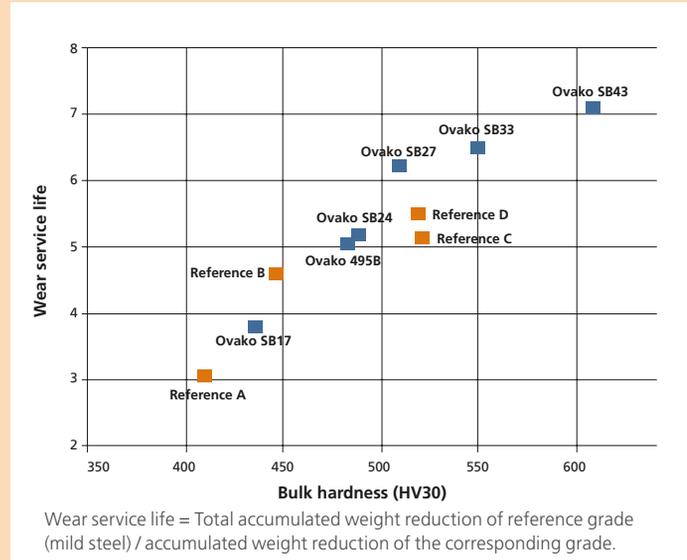


Figure 1 shows the results from simulation of industrial abrasive sliding wear, which provides a good relative performance indicator for prolonging service life.

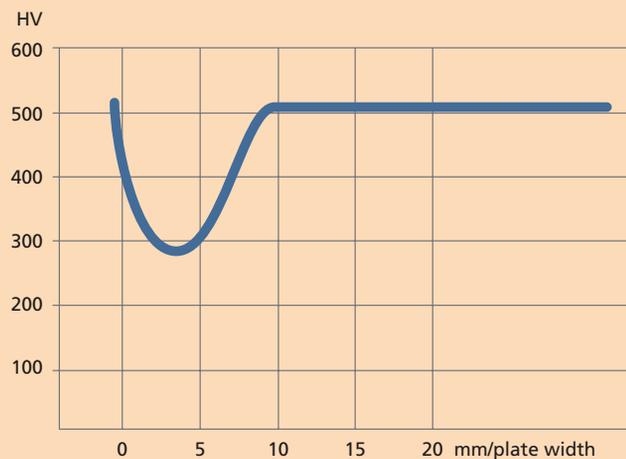


Figure 2 shows how the hardness profile from a gas cut edge declines significantly around the edge of the plate where the cut occurs. This can be avoided with WR-Steel in the form of hot-rolled bar or special profiles that require less cutting where wear resistance is critical.

Grinding balls

Optimized for hardness in the quenched and tempered condition, our grinding media are delivered as-rolled or in the quenched and tempered condition. The standard grinding ball steel (A810) is of the type 0.83 % C, 0.8 % Mn, 0.3 % Cr. The A810 grinding balls, which range in size from 20 to 70 mm, maintain the same wear resistance from start to finish. Special grinding media is available upon request.

Grinding rods

Developed for rugged grinding applications, our grinding rods are delivered in the as-rolled condition. Grinding rod steel is of the type CHA with 0.90 % C and 0.70 % Cr, or type C100 with 1.0 % C and 0.75 % Cr. Dimensions range from Ø 40–120 mm, with a hardness range of 300–400 HBW.

Key benefits

- Proven superior wear resistance
- Broad range of hardness intervals (350–650 HB)
- Right properties after rolling or heat treating
- Cost-effective due to optimized alloy content for different end-applications
- Wide range of steel grades in different dimensions
- Reliable partner with centuries-old steelmaking heritage

TYPICAL WR-STEEL GRADES

Ovako standard	EN-standard*	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
SB24M13B	24MnB5F		0.24	0.3	1.3				B
SB27M12CB	27MnCrB5-2		0.27	0.2	1.3	0.5			B
SB30M12CB	30MnCrB5-2F		0.30	0.3	1.3	0.5			B
SB33M13B	30MnB5		0.30	0.2	1.3				B
SB33M13CB	33MnCrB5-2		0.33	0.3	1.3	0.6			B
SB43M14B	43MnB6-3F		0.43	0.3	1.4				B
Ovako 495	48CrMoNi4-10F		0.48	0.2	0.8	1.1	0.9	0.4	V

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

ENGINEERING STEEL

At Ovako, we not only make high-quality steel products. Our priority is to find the best solutions for your requirements as your technical partner and collaborator.

Ovako is dedicated to working with you to help better understand your technical requirements and assist you in attaining sharp competitive advantages across your operations. You can gain our expertise, services and our infrastructure which are so crucial to controlling the purity, hardenability, machinability and lifecycles of our steels.

Ovako has total control of its production from melt to finished product, in order to supply you with low-alloy steels for your unique requirements when you want them. We continually develop our services and solutions to offer ever more consistent and optimized steel performances.



**With the right steel,
imagination is your only limit**

There is an Ovako steel to suit almost every design and engineering challenge, no matter how extreme. Don't let your material limit your imagination. See the possibilities at ovako.com

OVAKO

THROUGH-HARDENING BEARING STEEL

Ovako standard	EN-standard*	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
Ovako 677	67SiMnCrMo6-6-4F	Bearing steel suitable for gas/air hardening	1.0	1.5	1.4	1.0	0.2		
Ovako 803	100Cr6	The most widely used bearing steel with a hardenability for small components (wall thickness 17 mm)	1.0	0.3	0.3	1.4			
Ovako 824	100CrMo7	Increased hardenability with Cr and Mo for small and medium sized components (wall thickness 20 mm)	1.0	0.3	0.3	1.7	0.2		
Ovako 825	100CrMo7-3	Increased hardenability with Cr and Mo for medium sized components (wall thickness 30 mm)	1.0	0.3	0.7	1.7	0.2		
Ovako 826	100CrMo7-4	Increased hardenability with Cr and Mo for medium and large sized components (wall thickness 50 mm)	1.0	0.3	0.6	1.7	0.4		
Ovako 827	100CrMnMoSi8-4-6	Increased hardenability with Cr, Mo and Si for large sized components (wall thickness 75 mm)	1.0	0.5	0.9	1.9	0.6		
Ovako 831	100CrMnSi4-4	Increased hardenability with Cr, Mn and Si for small and medium sized components (wall thickness 20 mm)	1.0	0.6	1.1	1.0			
Ovako 832	100CrMnSi6-6	Increased hardenability with Cr, Mn and Si for medium sized components (wall thickness 40 mm)	0.9	0.7	1.5	1.4			
Ovako 837	100CrMnSi6-4	Increased hardenability with Cr, Mn and Si for small and medium sized components (wall thickness 30 mm)	1.0	0.6	1.0	1.4			

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TYPICAL CASE-HARDENING STEEL

Ovako standard	EN-standard*	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
C15E	C15E	Steel suitable for cold drawing	0.2	0.2	0.5				
CN 110 M	16NiCrS4	Good toughness, controlled hardenability, good machinability	0.2	0.2	0.6	0.8		1.0	
MC 110 M	16MnCr5	Continuous cast steel suitable for cold heading	0.2	0.2	1.2	1.0			
MC 212 M	20MnCr5		0.2	0.2	1.3	1.2			
MoCN 216	18CrNiMo7-6		0.2	0.2	0.7	1.7	0.3	1.6	
MoCN206M	20NiCrMo2-2	Continuous cast	0.2	0.3	0.9	0.6	0.2	0.5	
Ovako 124	20MoCr4	A high cleanliness steel used for small sized bearing and transmission components	0.2	0.2	0.8	0.5	0.4		
Ovako 146	16NiCrMo7	Ingot cast steel used for medium sized components	0.2	0.1	1.0	1.1	0.1	0.8	
Ovako 152	20NiCrMo2-2	A high cleanliness steel used for small sized bearing and transmission components	0.2	0.3	0.9	0.6	0.2	0.5	
Ovako 157	20NiCrMo7	A high cleanliness steel used for medium sized bearing and transmission components	0.2	0.2	0.6	0.5	0.2	1.7	
Ovako 158	20NiMo9-7F	Steel giving reduced surface oxidation after gas carburizing	0.2	0.1	0.3	0.4	0.7	2.3	
Ovako 159	18CrNiMo7-6	Carburizing steel used for bearing and transmission components	0.2	0.2	0.7	1.7	0.3	1.6	
Ovako 225	18CrMo8-5F	Steel designed for nitriding	0.2	0.3	0.8	1.8	0.5		
Ovako 234	16MnCr5	Ingot cast steel used for small sized components	0.2	0.2	1.2	1.0			
Ovako 245	12NiCr14-6F	A high cleanliness steel used for large sized bearing and transmission components	0.1	0.3	0.5	1.5	0.1	3.3	
Ovako 253	14NiCrMo13-4	High hardenability, excellent toughness, high wear resistance, good dimensional stability	0.2	0.2	0.6	1.2	0.2	2.9	
Ovako 255	18NiCrMo14-6	High hardenability carburizing steel	0.2	0.3	0.5	1.4	0.2	3.3	
Ovako 256	24NiCrMo15-5F	High hardenability carburizing steel	0.2	0.3	0.7	1.2	0.3	3.6	
Ovako 277	16CrMnNiMo9-5-2F	Steel suitable for carburizing and nitriding. Possible to gas/air hardening	0.2	0.2	1.3	2.1	0.5	0.5	V
Ovako 499	30MoCrV20-7F	Temperature resistant carburizing steel	0.3	0.2	0.3	1.7	1.8		V

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TYPICAL GENERAL STRUCTURAL STEEL

Ovako standard	EN-standard*	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
30MnVS6	30MnVS6	Micro-alloyed	0.3	0.5	1.4				V
38MnVS6	38MnV6	Micro-alloyed also suitable for quenching and tempering	0.4	0.4	1.3				V
C22R	C22R		0.2	0.2	0.6				
C40R	C40R	Steel suitable for quenching and tempering	0.4	0.2	0.7				
C45E/R	C45	Steel suitable for quenching and tempering and surface hardening	0.5	0.2	0.8				
C55R	C55R	Continuous cast steel suitable for quenching and tempering and surface hardening	0.6	0.2	0.8				
C60R	C60R	Steel suitable for quenching and tempering and surface hardening	0.6	0.2	0.8				
EL 400	S420N	Micro-alloyed	0.2	0.3	1.2				V
Green Cut	11SMn30	Lead free cutting steel	0.1	0.2	1.2				S
Hydax 15	S355J0		0.1	0.4	1.3				S
Hydax 25	20Mn5F		0.2	0.4	1.3				S
Imacro EL 700	5CrMn16-4F	Suitable for gas/air hardening	0.1	0.3	1.0	4.0			Nb
Imatra 4M	C45E	Steel suitable for cold working and quenching and tempering	0.5	0.3	0.7				
Imatra 520	S275J2		0.1	0.3	1.2				
Imatra 520	S355J2		0.1	0.3	1.2				
Ovako 056	C55R	Ingot cast steel suitable for quenching and tempering and surface hardening	0.6	0.2	0.8				
Ovako 280	19MnVS6	Micro-alloyed	0.2	0.4	1.5				V
Ovako 382	46MnVS3	Micro-alloyed also suitable for quenching and tempering	0.4	0.3	0.7				V
Ovako 482	38MnV6	Ingot cast micro-alloyed also suitable for quenching and tempering	0.4	0.4	1.3				V
P355NH	P355NH		0.1	0.3	1.2				
S235J2	S235J2		0.1	0.3	1.2				
S275J2	S275J2		0.1	0.3	1.2				
S355J2 SBM	S355J2		0.1	0.3	1.2				
SB400	S420N	Micro-alloyed	0.2	0.3	1.2				V
SB500	S460	Micro-alloyed	0.2	0.2	1.3				V
SB550	S550	Micro-alloyed	0.2	0.4	1.5				V
SB600	S600	Micro-alloyed	0.2	0.4	1.5				V

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TYPICAL QUENCHING AND TEMPERING STEEL

Ovako standard	EN-standard*	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
21NiCrMoV5-7	21NiCrMoV5-7F	Temperature resistant steel suitable for cold drawing	0.2	0.3	0.6	1.3	0.7		V
23MnNiMoCr5-4	23MnNiMoCr5-4	Steel for high strength chains	0.2	0.2	1.3	0.5	0.6	1.0	
31CrMoV9	31CrMoV9	Steel suitable for nitriding	0.3	0.2	0.6	2.5	0.2		V
37CrV3	37CrV3F		0.4	0.3	0.8	0.8			V
40CrMoV4-6	40CrMoV4-6	Temperature resistant steel	0.4	0.3	0.7	1.1	0.6		V
B7	44CrMnMo4-4F	Steel for high strength fasteners	0.4	0.3	0.9	1.0	0.2		
B16	42CrMoV4-6F	Steel for high strength fasteners	0.4	0.3	0.6	1.0	0.6		V
C35E	C35E	Steel suitable for cold heading	0.4	0.2	0.7				
Imacro M	5CrMn16-4F		0.1	0.3	1.0	4.0			Nb
Imacro NIT	8CrMnMo16-4F	Steel suitable for nitriding	0.1	0.3	1.0	4.0	0.5		
IMAFORM	7Cr5F	Low carbon hardenable steel suitable for direct quenching	0.1	0.3	0.8	1.3			
IMANITE M	21CrMoV5-7F	Steel suitable for nitriding	0.2	0.3	0.6	1.4	0.7		V
L7	43CrMnMo4-4	Steel for high strength fasteners	0.4	0.3	0.9	1.0	0.2		
MoC 210 M	25CrMo4	Continuous cast	0.3	0.2	0.9	1.1	0.2		
MoC 310 M	34CrMo4	Steel suitable for cold heading	0.3	0.3	0.8	1.1	0.2		
MoC 410	42CrMo4	Continuous cast	0.4	0.3	0.8	1.1	0.2		
MoC 510	50CrMo4	Continuous cast	0.5	0.2	0.7	1.0	0.2		
MoCN 315	34CrNiMo6	Continuous cast	0.3	0.2	0.7	1.4	0.2	1.3	
MoCN 320	30CrNiMo8		0.3	0.3	0.7	2.0	2.0	0.3	
Ovako 322	25CrMo4	Ingot cast	0.3	0.2	0.9	1.1	0.2		
Ovako 326	42CrMo4	Ingot cast	0.4	0.3	0.8	1.1	0.2		
Ovako 355	40NiCrMo7-3F	SAE 4340 mod with V	0.4	0.3	0.7	0.8	0.3	1.8	V
Ovako 356	34CrNiMo6	Ingot cast	0.3	0.2	0.7	1.4	0.2	1.3	
Ovako 398	32CrMoV12-10	Steel suitable for deep nitriding	0.3	0.3	0.5	3.0	1.0	0.3	
Ovako 420	24CrMo13-6		0.2	0.2	0.4	3.1	0.5		
Ovako 453	32NiCrMo13-4F		0.3	0.2	0.5	1.1	0.2	3.1	
Ovako 477	40SiCrMnMo7-6F	Steel suitable for gas/air hardening	0.4	1.7	1.5	1.5	0.4		
Ovako 495	48CrMoNi4-10F	High strength high toughness steel with high wear resistance used in mining applications	0.5	0.2	0.8	1.1	0.9	0.4	V
Ovako 497	42NiSiCrMo8-7-3F	High strength high toughness steel known as 300M	0.4	1.6	0.6	0.7	0.3	1.7	V
Ovako 498	30NiCrMo16-6	High strength high toughness steel	0.3	0.3	0.5	1.4	0.2	4.0	
Ovako 528	50CrMo4	Ingot cast	0.5	0.2	0.7	1.0	0.2		

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TYPICAL SPRING STEEL

Ovako standard	EN-standard*	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
52CrMoV4	52CrMoV4		0.5	0.2	0.9	1.1	0.2		V
55Cr3	55Cr3		0.6	0.2	0.9	0.9			
56Si7	56Si7		0.6	1.8	0.8				
56SiCr7	56SiCr7		0.6	1.8	0.9	0.3			
Imatra MC 608	60Cr3		0.6	0.2	0.9	0.8			
MS416	38Si7		0.4	1.6	0.7				
Ovako 593	51CrV4	Ingot cast	0.5	0.3	0.9	1.1			V
SB33S17B	33SiMnB7-3F	Boron alloyed spring steel	0.3	1.7	0.9				B
VC 510	51CrV4	Continuous cast	0.5	0.2	0.9	1.1			V

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TYPICAL BORON STEEL

Ovako standard	EN-standard*	Comments	Typical analysis						
			C	Si	Mn	Cr	Mo	Ni	Other
BCM 311	27MnCrB5-2		0.3	0.2	1.3	0.5			B
BCM 414	39MnCrB6-4		0.4	0.3	1.5	0.5			B
BM 212	20MnB5		0.2	0.2	1.3				B
BM 312	30MnB5		0.3	0.2	1.3				B
SB23M12B	20MnB5		0.2	0.2	1.3				B
SB24M13B	24MnB5F		0.2	0.3	1.3	0.2			B
SB27M12CB	27MnCrB5-2		0.3	0.2	1.3	0.5			B
SB30M12CB	30MnCrB5-2F		0.3	0.3	1.3	0.5			B
SB33M13B	30MnB5	Steel for wear resistance in thickness <15 mm	0.3	0.2	1.3				B
SB33M13CB	33MnCrB5-2		0.3	0.3	1.3	0.6			B
SB43M14B	43MnB6-3F		0.4	0.3	1.4				B

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PRODUCT OFFERING

Hot-rolled bar

Ovako hot-rolled bars are available in a wide range of sizes. They are characterized by close tolerances, excellent straightness as well as roundness, good surfaces and low decarburization. This makes them ideally suited for forging. Our rolling mills have excellent capabilities to produce tighter tolerances, including half the standard tolerance.

Further processed bar

Our bright bar offering contains peeled bar, drawn bar, ground bar and pre-components diameters: from 10 to 127 mm and in lengths from 10 to 8,000 mm. By using further processed bars from Ovako you can eliminate processing steps and unnecessary build-up of stock.

Seamless tube and hollow bar

Our tubes and hollow bars are used when there are stringent demands on the material such as in rolling, bearing, automotive, hydraulic and general engineering applications. Ovako tube products are characterized by uniform properties, close tolerances and small machining allowances. They are available in all grades and can be cut according to customer requirements.

Rolled and forged ring

For almost a century, Ovako has built a proven track record in this product niche. We strictly control the whole production chain from melt to the rolling of the rings. Manufacturers can simplify their production processes and reduce their costs, because our rings are not only predictably consistent from batch to batch but also easy to process further.

Cromax – Hard-chrome plated bar and tube

Cromax is one of the major manufacturers in Europe of hard-chrome plated products in bar and tube. The main application is piston rods for hydraulic cylinders. The majority of the base-material are supplied by Ovako's own steel production units. The high and reproducible quality and superior mechanical characteristics of Cromax products are made with a complete control over the entire manufacturing chain from steel melting to finished bar.

Grinding media

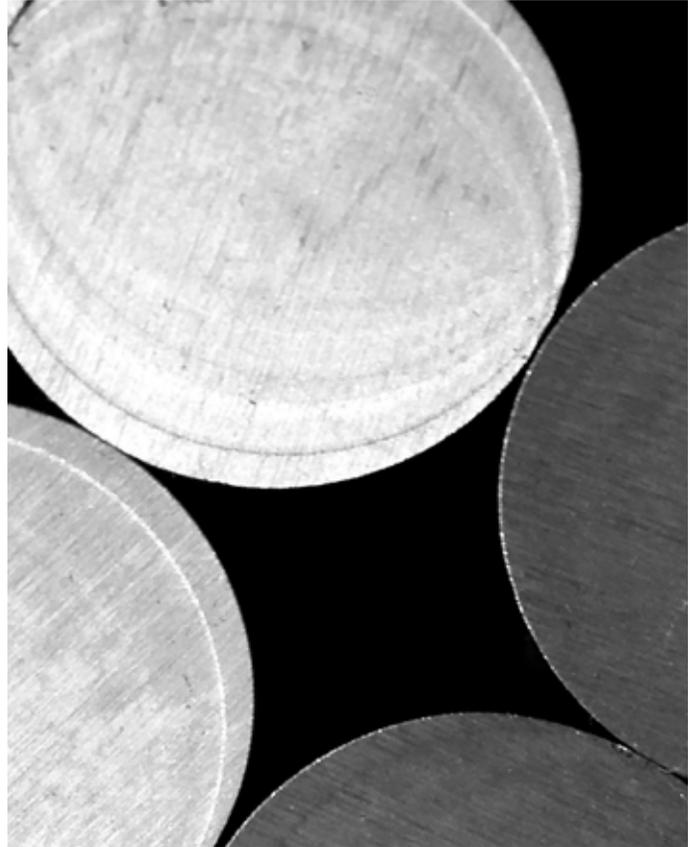
Ovako grinding balls are delivered as-rolled or in the quenched and tempered condition. They are available in A810 grinding ball steel, or other grades upon request, and can maintain the same wear resistance and hardness from start to finish. Grinding rods are delivered in the as-rolled condition in dimensions of 0.75 to 120 mm or hardness 340 to 400 HBW.

HOT-ROLLED BAR

Over the years we have gained a good reputation for products in which 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 bars can be further processed by heat treatment, machining and chrome plating. A major part of our round bars are supplied as peeled, ground or drawn bright bar. The Ovako hot-rolled bar offering also contains, round bars, flat bars, round corner squared bars, special properties bar, special profiles and pre-components plus our SR-100 Wire and the Cromax product family. All available in a variety of sizes.

Our hot-rolled bars are characterized by close tolerances, excellent straightness as well as roundness, good surfaces and low decarburization. This makes them ideally suited for forging and machining.



Our hot-rolled bars are available in a wide range of sizes. They are characterized by close tolerances, excellent straightness as well as roundness, good surfaces and low decarburization. This makes them ideally suited for forging and machining.

HOT-ROLLED ROUND BAR

Size range

Standard hot-rolled round bars are delivered in diameters from 13 mm to 230 mm, and in many different sizes. Up to \varnothing 75 mm they can be delivered at 1 mm intervals. Larger dimensions are available at 5 mm intervals.

Tolerances on dimensions and shape

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

Lengths

The most common bar length is 6 meters, but can also range between 3.5 and 18 meters, depending on the producing rolling mill. Heat treatments may restrict the maximum length.

Manufacturing lengths

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

Exact lengths

At the time of the order, bars 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 at most two-thirds of the diameter tolerance.



Straightness

Straightness is measured as the maximum height of arch; in other words, the largest deviation from the straight line. Normally the test length is 1.0 meter. Normal straightness is 2 mm/m maximum.

Surface quality

Standard surface crack depth is max. 1 % of diameter. When an order is made the bars can be inspected, for example, by magnetic dispersion or the magnetic particle method. Normally, surface quality class D can be achieved for diameters up to \varnothing 80 mm and C for diameters up to \varnothing 120 mm that comply with EN 10221.

Flat bar by Ovako combines precisely controlled manufacturing processes with the clean steel program for superior impact toughness and high yield strength across a range of applications.

HOT-ROLLED FLAT BAR

Ovako deliver hot-rolled flat bar in a broad dimension range. The bars are characterized by excellent straightness and shape as well as good surfaces and low decarburization.

Shape and dimensions

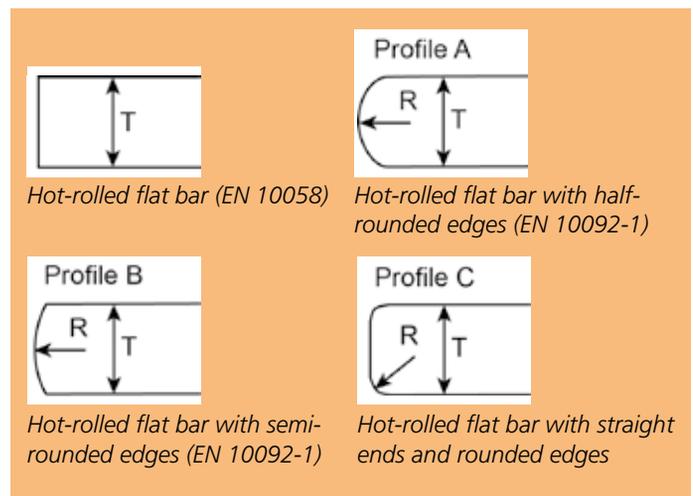
The rolled shape is generally flat bars with square corner edges. It can on request also be rolled as flat bars with different corner radius. The tolerances on dimensions for flat bars fulfill the European standard EN 10058. Our rolling mills have excellent capability to produce even tighter tolerances. 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 treatments may restrict the maximum length. Bars can be delivered sawn to exact lengths.

Straightness

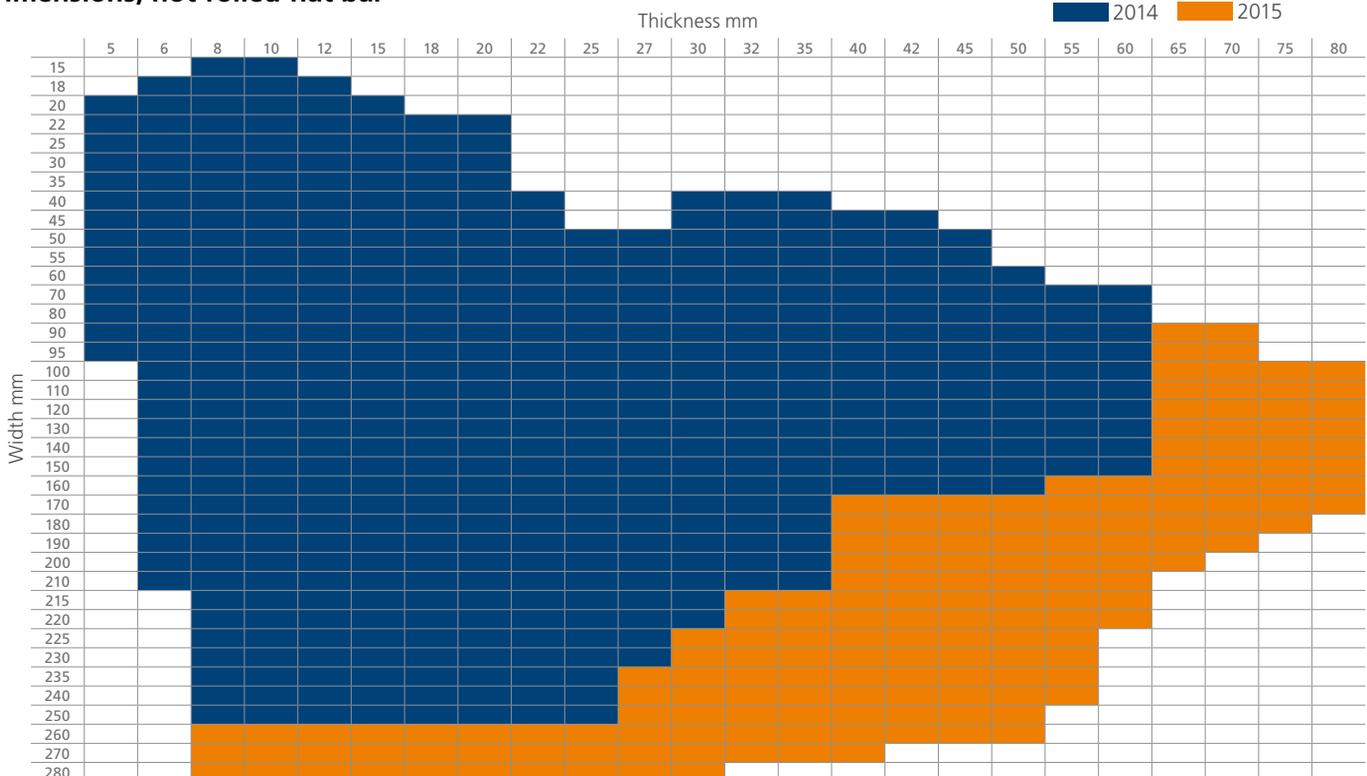
The out of straightness is measured and our flat bars comply with European Standard EN 10058 as-rolled, but can also be delivered in as straightened condition.

Hot-rolled spring steel flat bar

Ovako deliver 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 properties for the end product.



Dimensions, hot-rolled flat bar



Square bars by Ovako have a uniform inner structure with a very good surface finish and are available in our standard steel grades or even M-treated – all tailored to your own specifications.

ROUND CORNER SQUARE BAR

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

Round corner squared bars is 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 which makes it possible to produce forging blanks with a small variation in weight.

Round corner square bars have no sharp edges which could provoke formation of laps and surface defects during forging operations



Benefits

- 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 bars
- Easier handling in rotary hearth furnaces since it needs no rolling like round bars
- Safer handling since it needs no rolling

As a hot-rolled bar with enhanced properties, Special Properties bar by Ovako is not limited to any specific grade to therefore offer increased added value and substantial cost savings.

SPECIAL PROPERTIES BAR

Special properties round bar, commonly known as SP-Bars, is the result of Ovako's never-ending product development. SP-Bars are not limited to any specific steel grade, which creates opportunities for customers wishing to use this advanced technology. By optimizing the properties of the bar material, customers can benefit from increased added value and substantial cost savings in manufacturing operations.

Size range: 13 to 50 mm

Lengths: 4 to 12 m

Tolerances

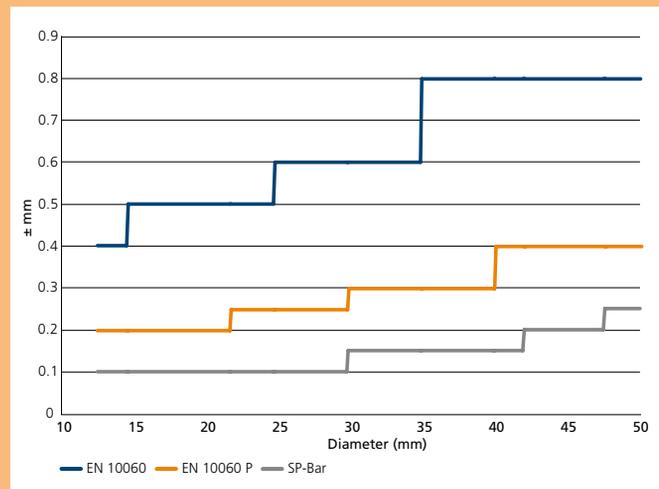
SP-Bars offer extremely tight tolerances. Consequently SP-Bars can often replace peeled or drawn bar. Customers can decrease the nominal size and get more manufactured pieces per ton of purchased SP-Bar.

Surface quality

Scale thickness is generally reduced on SP-Bars. 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.



Dimensional tolerances SP-Bar



Advantages of SP-Bar

- SP-Bar can often replace more expensive peeled or drawn bar
- More manufactured pieces/tonne
- Cleaner environment in cold forming and heat treatment

Because special profiles by Ovako are designed and hot-rolled to match your own unique needs, manufacturing and machining processes can be eliminated in order to significantly lower your costs.

SPECIAL PROFILES

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

Size range

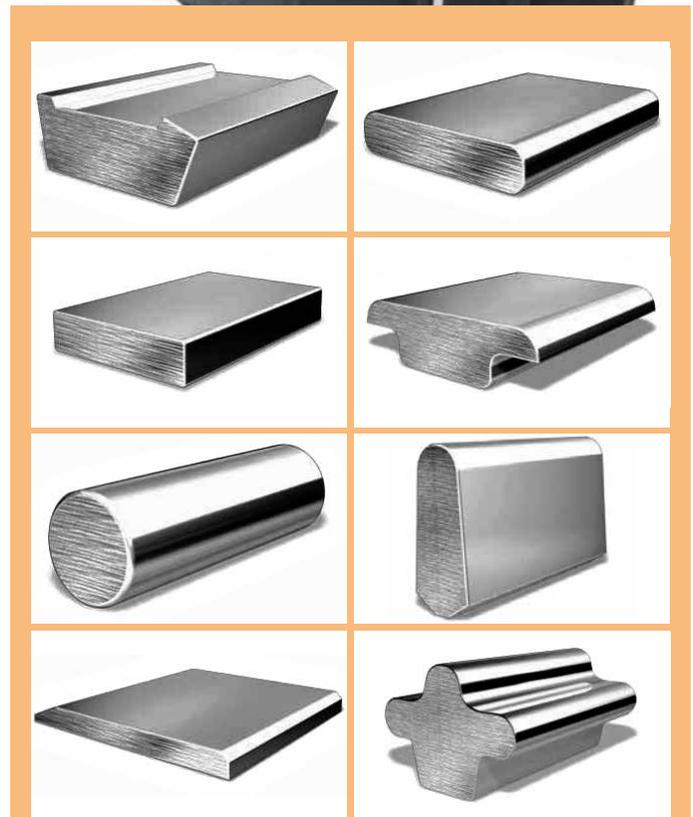
Our special profiles are rolled in widths ranging from 15 mm to 270 mm and thickness from 5 mm to 60 mm.

Cut production cost

Being able to produce hot-rolled special profile bars tailored to suit your needs, we can often 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 bars can be marked with a customer logo or other information.



Advantages of Ovako's special profiles

- Manufacturing steps may be eliminated, lowering costs
- Tailored to customer needs
- High productivity. Process steps such as machining can be eliminated
- Lower costs for raw material due to lower weight
- Ovako helps you design your unique profile
- Profiles can be produced from the whole range of Ovako steel grades

FURTHER PROCESSED BAR

BRIGHT BAR

Available in a wide range of shapes, our bright bar grades eliminate processing steps and unnecessary stock build-up. Our bright bar offering contains the peeled bar, drawn bar, ground bar and pre-components listed under the further processed bar products.

Diameters: from 10 to 127 mm,
with tolerances down to IT6

Lengths: from 10 to 8,000 mm,
with tolerances down to +/-0.05 mm

Benefits for further processed bar

- Rationalized production by delivery closer to end product
- Lower total cost due to lower stock levels and less production steps
- Cleaner production with lower maintenance cost
- Greener production with a minimum of chips handling
- Minimized risk for shocks and vibrations at high cutting speeds by using high and consistent quality bars from Ovako
- Reduced need for further surface finishing
- Just-in-time contract for deliveries according to specific needs
- Lean production by a wide range of packaging solutions
- Create additional floor space in operations and/or warehouse
- Reduce capital tied-up in raw material
- Avoid spend CAPEX on non-core processes



PEELED BAR

Ovako's peeled bar saves material, tools, machines and production time.

Our bar peeling is a well integrated production that uses precision equipment. The peeled bar is supplied in a polished and straightened condition. This allows for 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 minimizes the risk for 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.

Ovako's peeled bar is characterized:

- No surface defects
- Decarburization-free surface
- Good surface smoothness
- Close tolerances
- Adjusted structure and hardness
- Good ductility
- Low content of non-metallic inclusions
- Good machinability after forming

Advantages of Ovako's peeled bar

- Rationalized production
- Lower production cost
- Minimized risk for shocks and vibrations at high cutting speeds
- Reduced need for further surface finishing

Peeled bar product properties

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

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 get a material that supports consistently high quality production and contributes to cost-effective manufacturing.

Due to the availability of the material and the possibility to tailor the bar to customer requirements, the 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 drawn bar from Ovako.

Advantages of Ovako's drawn bar

- Supports consistently high quality production
- Cost-effective manufacturing

Drawn bar product properties

Size range	Drawn bar is produced in the 11 to 55 mm diameter size range
Diameter tolerance	IT10 is the standard tolerance. IT9 can be supplied subject to separate agreement
Surface condition	Drawn bar is supplied oiled as standard for an efficient rust protection
Straightness	Normal straightness is max. 1 mm/m
Out of roundness	Max. 50 % of the diameter tolerance, measured as the difference in diameter
Lengths and length tolerances	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
Heat treatment	Drawn bar can be obtained in a soft annealed condition
End condition	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
Packing and marking	The bars are delivered bundled, with or without wrapping. We can also supply the bars packed in wooden cases. Max bundle weight is 2 tons or 1.2 tons for bars in wooden cases



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 bars are characterized 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 feed movements in automatic lathes. Straightness is also particularly important when producing components from long bars. In addition, our ground bars have a minimum of internal stresses, which significantly reduces the risk of distortion after machining. Ovako's ground bar is therefore a favorable material for the manufacturing of products like long shafts, rolling bearings and ball bushings.

Ground bars 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 Ovako's ground bar

- Smooth production especially at high machining speeds
- Accurate and vibrationless feed movements in automatic lathes
- Reduced risk of distortion after machining

Ground bar product properties

	Rough ground bars	Fine ground bars, standard execution	Fine ground bars, 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

PRE-COMPONENTS FROM BAR

Going for pre-machined components is often a cost-effective solution. It allows you to eliminate your own stockholding, crosscutting and machining. It opens up new possibilities 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 and stable 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.

Chamfered or blanks with radius

Sawn off and chamfered according to the customers' specifications. Standard chamfer angle is 45°. Customized chamfering and radius according to agreement.

Size range: 20 to 105 mm diameter

Lengths: 35 to 1,900 mm

Center-hole drilled blanks

Blanks with sawn end surfaces, center-drilled to the 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.

Advantages of buying pre-components from Ovako

- 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

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, center-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 radius. We deliver precision-cuts within close tolerances and with a high consistent product quality. Our length tolerances are +/- 0.05 mm. To be compared with 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, 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 cut to exact length
- Chamfering
- Machining of radius
- Center-hole machining

Why not take advantage of our just-in-time delivery or ensure flexible delivery amounts suitable for you. Ordering amount ranges from one piece to an unlimited amount. We deliver within 48 hours with logistic agreement.

Chamfered blanks

We offer chamfered blanks that are sawn off and chamfered according to your specifications. Standard chamfered angle is 45°, or according to your demand.

Size range: 10–105 mm diameter

Lengths: 25–1,800 mm

Center-hole drilled blanks

We offer blanks with sawn end surfaces. Center drilled to your specifications

Size range: 10–105 mm diameter

Lengths: 25–1,800 mm

SR-100 WIRE

Surface removed and 100 % tested

Ovako's SR-100 Wire is a surface removed and inspected wire that increases 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 make a 100 % automatic inspection of the surface. Ovako offers wire that meets most requirements for high-grade structural steel and bearing steel. The steels we use for our wire are characterized 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
- Fewer quality complaints



SEAMLESS TUBE AND HOLLOW BAR

Our tube products are characterized by uniform properties, close tolerances and small machining allowances. Ovako's tubes and hollow bars are used when there are stringent demands on the material, such as within the rolling bearing, automotive, hydraulic and general engineering industries.

Standard items and stock program

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

Ovako has two such standard programs; both have the 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 steel program

This program covers roughly 350 tube sizes from OD 30 to 250 mm.

Ovako 280 hollow bar program

This program covers carbon hollow bar in grade Ovako 280 based on the standard EN 10294. We keep roughly 350 dimensions in stock from OD 50 to 243 mm.

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

Hot-rolled tubes and cold-worked tubes by Ovako offer cleaner components for smaller machining allowances, tighter tolerances and superior surfaces – all delivered on time and with bespoke markings.

HOT-ROLLED TUBES, COLD-WORKED TUBES

Machining allowances

In most cases we sell a 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 OD. For longer parts an extra allowance is calculated.

Tolerances

The level of a 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.

OD/Wall 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

Tubes can be delivered with random manufacturing length or to fix 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

Outer diameter and wall tolerance

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

Delivery executions

Tube ends

All tubes are supplied with clean, square cut ends. De-burring and/or chamfering can be carried out on request.

Tube surface

Tubes are supplied normally without anti-corrosive treatment, but anti-corrosive treatment is available and can be carried out on request.

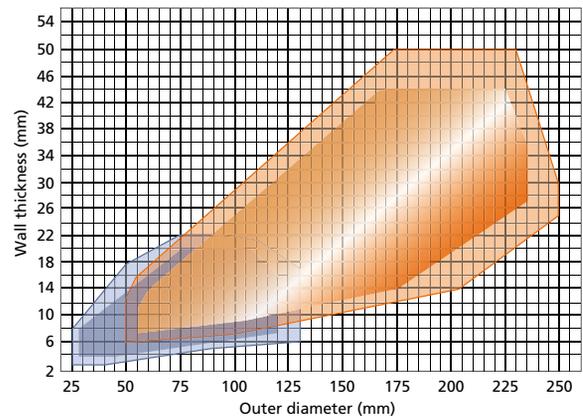
Packaging

Tubes are bundled as standard, with steel straps enclosing hexagonal bundles with one end flush. Length sorting can be carried out on request. Tubes can also be bundled in multiples. Bundle weights are adjusted as requested by the customer. Each bundle contains tubes from a single cast/heat only.

Marking

Each tube is marked with tube type, heat number, steel grade and size. Information is repeated along the whole length of the tube. Other markings, such as stamping, can be made on request. Bundles are also labeled with a tag having info both alphanumeric and by bar code. We also supply hot-rolled peeled tubes, as well as cold-rolled or drawn centerless ground tubes. Tubes can also be cut according to customer requirements.

Size ranges



PRE-COMPONENTS FROM TUBE

An ever-increasing trend in industry is to buy pre-machined or completely finished components. Ovako has recognized this and invested in the resources required to manufacture components, in particular the supply of cut blanks and pre-components such as chamfered blanks and sleeves.

Our production systems are designed to respond to both short lead times and product optimization to satisfy our customers' requirements. The equipment is flexible and able to handle small quantities of short runs as well as long-run mass-production batches. With wide experience in different types of applications, and a thorough knowledge of our products, Ovako is uniquely able to find an alternative solution best suited to meet individual requirements.

Production program

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

Outer diameter: 30 to 254 mm

Lengths: 10 to 5,000 mm

Cut rings can be delivered shot blasted on request.

Chamfering can be done at fixed lengths: max length 350 mm, max OD 130 mm and max weight 3.5 kg.

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

Deviations from square cut are to be maximum 1.0 % of OD.

Deviations from square cut determine the tolerance when the deviation exceeds the tolerance.

Delivery execution

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 direct from our mill is labeled in accordance with automotive standard, including with both alphanumeric and bar code information. Customer specific data can be added on request.

HARD-CHROME PLATED TUBES

The starting material for Cromax tube is either hot-finished or cold-drawn tube in a microalloyed, low-carbon weldable steel of 20MnV6 type. Cromax tube exhibits a good combination of strength and toughness along with excellent machinability and weldability.

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 according to the same principles as our bearing steels, which result in a steel with a very high degree of cleanliness and 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 tubes or eliminate heat treatment during component manufacturing. Due to the technology used for the production the Ovako 280 hollow bar gets an inherent strength thanks to accurate monitoring of chemical composition and high degree of cleanliness.

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

Smoother production

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

Higher quality steel structures

Ovako 280 hollow bar carries a very low risk of failures caused by detrimental inclusions. Fatigue strength is of decisive importance for the safety and life of steel structures. Ovako 280 has achieved its high fatigue strength due to maintaining the same requirements on cleanliness of the steel as we have on steel for rolling bearings.

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

The cleanliness and high surface finish of the Ovako 280 hollow bar gives the best conditions for hard-chrome plating. The excellent straightness is also valuable for producers of hydraulic cylinders or long slender components.

Mechanical properties in hot-rolled condition

Wall thickness mm	Yield stress ReHmin MPa	Tensile strength Rmmin MPa	Elongation A5 min %	Hardness Approx. HB	Impact strength at 20°C min Joule
≤ 25	500	670	20	225	27
> 25	470	640	20	220	27

Straightness

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

Ovality

Maximum ovality is 65 % of the total tolerance of the OD.

Finished dimensions

Finished dimensions are guaranteed for clean up of part lengths of maximum 3 x OD.

Advantages that gives Ovako 280 hollow bar added value

- Versatility in properties cover many of the customer needs
- Availability – 250 sizes in stock at mill of service centers
- Low risk of failures caused by detrimental inclusions
- Good machinability
- Good weldability without the need for preheating up to wall thickness of 25 mm
- Cleanliness of steel and high surface finish gives the best conditions for hard-chrome plating
- Better production economy thanks to higher yield which leads to reduced raw material and machining costs

ROLLED AND FORGED RING

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. 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 ring producers can match our commitment to consistent quality from delivery to delivery.

As a result of our quality control, manufacturers can simplify their production processes and reduce their costs because the rings are not only predictably consistent from batch to batch, but also easy to process further. Ovako produces 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, Ovako can offer shot blasted rings of diameters up to 4,000 mm and weights up to 5,000 kg.

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



Rolled and forged rings by Ovako reduce your needs for further machining and associated maintenance costs and material waste, with longer lifespans and higher wear and corrosion resistance.

RINGS TO MEET THE INDUSTRY'S NEEDS

Ovako has long experience with seamless rolled rings characterized by cylindrical or profiled geometry that are very close to the final shape of the finished component.

Our reputation for precision is well earned, whether it concerns the physical geometry of the ring or the composition and homogeneity of the steel. The bulk 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 the heavy vehicle, automotive and machine tool manufacturing industries.

The 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.

Parting of rings

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

Machined rings

Ovako has relationships with several 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, US testing.



Advantages of Ovako's 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 an even quality level speeds up production and cuts costs by enabling customers to focus on finishing and/or assembly

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. Some surfaces may require no further machining at all. Our roll rings also demonstrate the expertise that Ovako has that few other manufacturers can match.

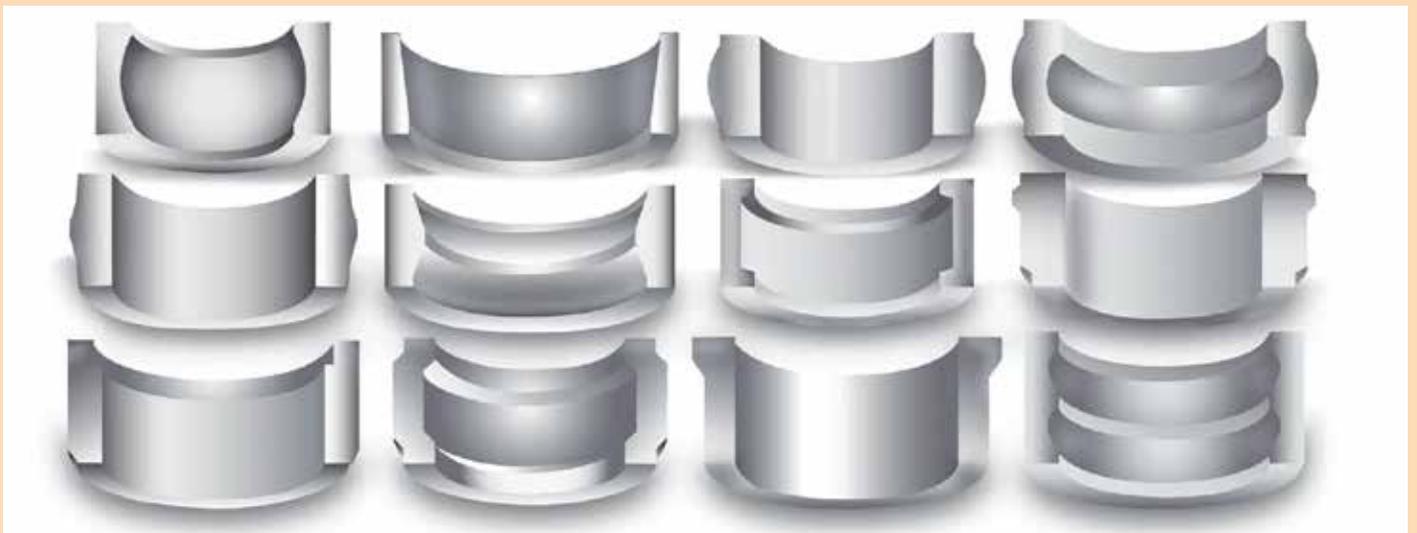
Size range

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 Ovako’s profiled rings

- Near-net-shape rings substantially lowers the cost of machining
- Very small allowance
- Tight tolerances
- Lower weight
- Less machining
- Less waste
- Stable quality with test 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



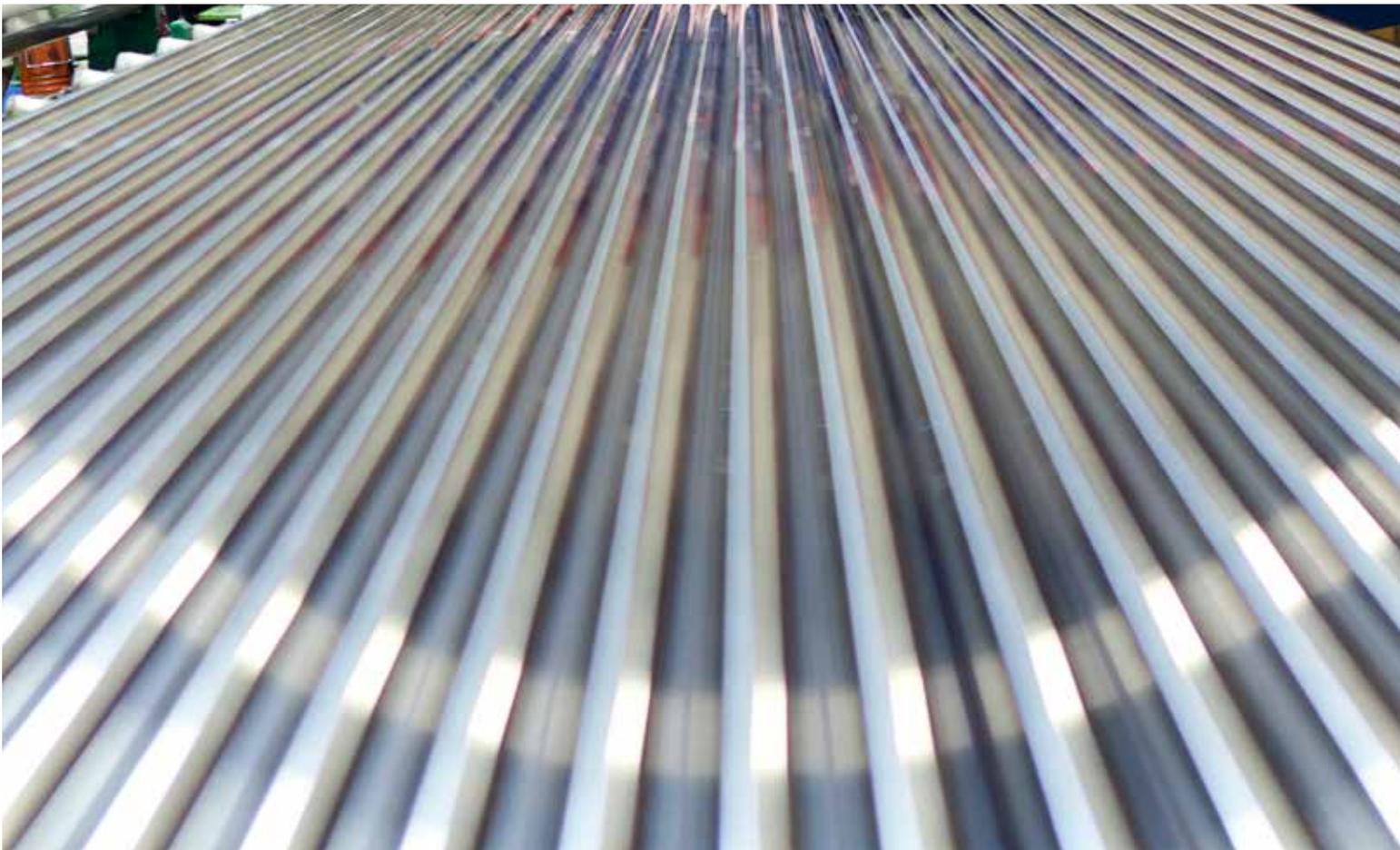
Ovako can manufacture virtually any profile shape required. Where the shape is based on the customer’s products shape, there is an additional, comparably small machining allowance.

CROMAX® – HARD-CHROME PLATED BAR AND TUBE

Cromax supplies chrome plated bars and tubes for hydraulic applications. The steel grades are developed and produced by Ovako and further processed within Ovako's four chrome plating plants in Sweden, the Netherlands, France and Italy.

There are three executions for the protective chrome coating depending on demand for corrosion resistance. With increasing guarantee of corrosion resistance we can supply Cromax with one chrome layer, Cromax C with two chrome layers and NiKrom with one nickel layer and one chrome layer.

All our Cromax products can be supplied with an induction hardened surface layer of the steel. This promotes excellent resistance to mechanical damages. It can also in combination with our own developed steel give excellent resistance to bending forces.



Cromax 280X

Cromax 280X is based on a low carbon, micro-alloyed steel combining high strength with excellent machinability and weldability.

For diameters up to 90 mm, yield and tensile strength are 20 % higher than is normal for hard-chrome bars based on low-carbon weldable steel. This improvement is achieved without detriment to machinability or weldability. In comparison with standard products based on grade 20MnV6, the superior properties profile of Cromax 280X offers a number of potential advantages in the design and manufacture of fluid-power cylinders. One advantage is the possibility to downsize piston rods without loss of load-bearing capacity, thereby reducing not only weight but also cost.

Chrome layer

For diameters more than 20 mm, the chrome layer thickness is 20 µm min. For smaller sizes, the minimum thickness is 15 µm.

Surface roughness

The surface roughness (Ra) is always less than 0.2 µm and normally in the range 0.05–0.15 µm. Rt (ISO) is always less than 2.0 µm and normally in the range 0.5 to 1.5 µm.

Surface hardness

The chrome layer hardness is a minimum of 850 HV_{0.1}.

Straightness

For diameters smaller than 30 mm, the maximum deviation is 0.1 mm/0.5 m. The maximum deviation for larger diameters is 0.1 mm/m.

Roundness

The out of roundness is maximized at 50 % of the diameter tolerance interval.

Diameter tolerance

ISO f7 is standard. Other tolerances can be supplied upon request (narrowest range is ISO level 7).

Delivery lengths

Production lengths are between 3.6 to 7.6 m. Standard is 6.1 +0.1/-0 m with the following exceptions.

- For diameters below 20 mm the production length is varying between 3.0 and 3.6 m +0.1/-0 m depending on diameter.
- For diameters 20 and 22 mm, the standard production lengths are 5.0 +0.1/-0 m and 5.5 +0.1/-0 m respectively.

The "unchromed length" of each bar, i.e. the distance at each end over which the chrome-layer properties and tolerances can not be guaranteed, is at most 0.15 m per end (i.e. 0.3 m in total per bar). Fixed, cut lengths can be supplied if required.

Corresponding standards

The table shows the closest equivalent standard for steel in Cromax 280X.

Ovako grade	EN	DIN	BS	AFNOR	ASTM
Ovako 280X	20MnV6	20MnV6	55M	E420	A572

Average chemical analysis Cromax 280X

C %	Si %	Mn %	S %	V %	C.E. % (*)
0.18	0.35	1.55	0.025	0.11	0.55 max

Advantages of Cromax 280X

- Weight and cost reduction without loss of load-bearing capacity

Cromax IH 280X

Cromax IH 280X is the induction-hardened version of Cromax 280X. Apart from improved resistance to damage from external impact, this product offers increased buckling strength. In many applications the material enables downsizing of piston rods, resulting in cost and weight savings.

Advantages of Cromax IH 280X

- Improved resistance to damage from external impact
- Increased buckling strength

Cromax IH 482

Cromax IH 482 is an induction-hardened product that effectively resists damage from external impact. Cromax IH 482 is based on a high-strength, medium-carbon, micro-alloyed steel.

Cromax 42CrMo4

Quenched-and-tempered Cromax 42CrMo4 is manufactured from the standard low-alloy chromium-molybdenum steel. The product is most effectively applied in situations where there is a requirement for elevated strength in combination with a defined and high level of toughness.

Corresponding standards

The table shows the closest equivalent standard for steel in Cromax 42CrMo4.

Ovako grade	EN	DIN	BS	AFNOR	SAE/ASTM
Ovako 326	42CrMo4 +QT	42Cr-Mo4V	708M40	42CD4	4140

Average chemical analysis Cromax 42CrMo4

C %	Si %	Mn %	S %	Cr %	Mo %
0.42	0.25	0.80	0.02	1.05	0.20 max

Chrome layer

The thickness of the chrome layer is minimum 20 µm.

Surface roughness

The surface roughness (Ra) is always less than 0.2 µm and normally in the range 0.05 to 0.15 µm. Rt (ISO) is always less than 2.0 µm and normally in the range 0.5–1.5 µm.

Surface hardness, induction hardening

The chrome layer hardness is 850 HV_{0.1}. Cromax 42CrMo4 can be supplied in an induction-hardened execution. In such a case, the hardness immediately beneath the chrome layer is 55 HRC min., and the depth of hardening is between 1.0 and 3.0 mm depending on dimension. However, for applications requiring a surface-hardened execution, Cromax IH 482, the induction-hardened hard-chrome bar, is recommended.

Straightness

The maximum deviation is 0.2 mm/m.

Roundness

The out of roundness is maximized at 50 % of the diameter tolerance interval.

Diameter tolerance

ISO f7 is standard. Other tolerances can be supplied upon request (narrowest range is ISO level 7).

Delivery lengths

Production lengths are between 4.0 to 7.6 m. Standard is 6.1 +0.1/-0 m.

The "unchromed length" of each bar, i.e. the distance at each end over which the chrome-layer properties and tolerances can not be guaranteed, is at most 0.15 m per end (i.e. 0.3 m in total per bar). Fixed, cut lengths can be supplied if required.

Cromax C35E

Cromax C35E is a hard-chrome plated product based on medium-carbon steel. Compared with the traditional C45E base, C35E offers improved weldability. However, by means of thermo-mechanical processing, the mechanical properties of the C35E used for Cromax products are rendered equivalent to those attainable in C45E.

Corresponding standards

The table shows the closest equivalent standard for steel in Cromax C35E.

Ovako grade	EN	DIN	BS	AFNOR	SAE/ASTM
C35E	C35E	Ck35	080M36	XC38	A572

Average chemical analysis Cromax C35E

C %	Si %	Mn %	S %	C.E. %
0.37	0.25	0.65	0.02	0.65 max

Chrome layer

For diameters below 20 mm the chrome layer thickness is min. 20 µm. For smaller sizes, the minimum thickness is 15 µm.

Surface roughness

The surface roughness (Ra) is always less than 0.2 µm and normally in the range 0.05 to 0.15 µm. Rt (ISO) is always less than 2.0 µm and normally in the range 0.5 to 1.5 µm.

Surface hardness, induction hardening

The chrome layer hardness is a minimum of 850 HV_{0.1}. Cromax C35E can be supplied in an induction-hardened execution. In such a case, the hardness immediately beneath the chrome layer is 50 HRC min., and the depth of hardening is between 1.0 and 3.0 mm depending on dimension. However, for applications requiring a surface-hardened execution, Cromax IH 482, induction-hardened hard-chrome bar is recommended.

Straightness

For $\varnothing < 30$ mm, the maximum deviation is 0.1 mm/0.5 m. The maximum deviation for larger diameters is 0.1 mm/m.

Roundness

The out of roundness is maximized at 50 % of the diameter tolerance interval.

Diameter tolerance

ISO f7 is standard. Other tolerances can be supplied on request (narrowest range is ISO level 7).

Delivery lengths

Production lengths are between 3.6 to 7.6 m. Standard is 6.1 +0.1/-0 m with the following exceptions:

- For diameters below 20 mm the production length is varying between 3.0 and 3.6 +0.2/-0 m depending on diameter.
- For diameters 20 and 22 mm, the standard production lengths are 5.0 +0.1/-0 m and 5.5 +0.1/-0 m respectively.
- Bars with length 7.6 +0.1/-0 m can only be supplied for diameters between 40–80 mm.

The "unchromed length" of each bar, i.e. the distance at each end over which the chrome-layer properties and tolerances can not be guaranteed, is at most 0.15 m per end (i.e. 0.3 m in total per bar). Fixed, cut lengths can be supplied if required, but at a higher price than production lengths.

Advantages of Cromax C35E

- Improved weldability with retained mechanical properties compared with traditional C45E base

GRINDING MEDIA

GRINDING BALLS

Grinding balls are delivered as-rolled or in the quenched and tempered condition. The standard grinding ball steel A810 is of the type 0.83 % C, 0.8 % Mn, 0.3 % Cr.

Hardness in the quenched and tempered condition

The A810 grinding balls maintain the same wear resistance from start to finish. Grinding balls in other steel grades can be supplied upon request.

Hardness

Surface	62–66 HRC
Core	60–65 HRC
Average volumetric hardness	61–65 HRC

Nominal standard diameter

Ø mm	Weight per ball g	Theoretical weight kg/m ³	Number of ball/ton balls	Surface area/ball cm ²	Surface area/m ³ m ²
20	33	4,520	~31,000	12.6	1,738x10 ³
25	64	4,520	~16,000	19.6	1,390x10 ³
30	110	4,520	~9,100	28.3	1,158x10 ³
35	175	4,520	~5,700	38.5	993x10 ³
40	261	4,520	~4,000	50.2	869x10 ³
50	510	4,520	~2,000	78.5	695x10 ³
60	882	4,520	~1,100	113	579x10 ³
70	1,400	4,520	~700	154	497x10 ³

GRINDING RODS

Grinding rods are delivered in the as-rolled condition. Maximum out of straightness for grinding rods in as-rolled condition is 2 mm/m for diameters < 92 mm and 0.0100 x L for diameters > 92 mm. On request, maximum out of straightness 1 mm/m can be achieved by straightening. The grinding rod steel is of type CHA with 0.90 % C and 0.70 % Cr, or of type C100 with 1.0 % C and 0.75 % Cr. The dimension range is Ø 40–120 mm. The hardness range is 300–400 HBW.

Mechanical properties

Chemical composition	Condition	Bar diameter Ø mm	Hardness HBW
CHA	As-rolled	40–120	300–400
C100	As-rolled	40–100	340–400



HEAT TREATMENT

Heat-treated tubes

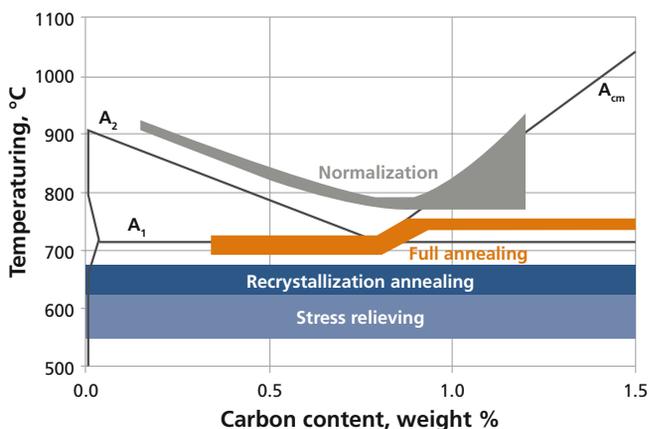
Our tubes can be supplied in the following heat-treated conditions of combinations thereof:

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

Heat-treated bars

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

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



Iron-carbon diagram with temperature ranges for different types of annealing.

Type of heat treatment/Benefits

Soft or full annealing, (Spheroidizing/globulization)	Softening the steel by offering a structure well suitable for machining and cold forming
Isothermal annealing	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
Stress relieving	Reducing stress in the steel to avoid distortion during subsequent machining and heat treatment. Also reduces risk for cracking in connection with welding
Hydrogen annealing	Reduction or elimination of hydrogen in the steel in order to prevent hydrogen embrittlement and subsequent risk for cracking
Recrystallization annealing	Restores a cold worked micro structure. Necessary for further processing involving plastic deformation. Note that the level of deformation controls the grain size and final toughness
Normalizing	Offers the steel a predictable even microstructure of fine grains, ensuring toughness and impact strength as well as improved machinability
Homogenizing	Evens out segregations in the steel. The soaking is performed at high temperature over a long time
Hardening	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 hardness or strength of the steel and is normally followed by a tempering
Surface induction hardening	Surface induction hardening offers a few millimeters deep hardened surface layer with compressive residual stresses
Tempering	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 and 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 for cracking

OVATRACK

OvaTrack is a customer web portal that enables selected Ovako users, customer and partners to view up-to-date information about the status of their orders and other business activities. Once logged in, customers can view exactly where the order is in the production process and the expected date of delivery.

Site links make it possible for the customer to access detailed information about production steps, materials analysis and charges as well order confirmations, dispatch advice, certificates and invoices are all available as PDF files. OvaTrack also provides information about production schedules for some of the production mills, deliveries to selected destination and up-to-date information on stocks. OvaTrack data can be exported from the screen to Excel or other systems for further processing.

OvaTrack also provides customers with daily e-mail updates known as Personalized Information Service. This service enables customers to subscribe to alerts about activities related to their order, such as production, delivery, and invoicing status.

Selected users can also use OvaTrack for entering repeat orders for specific Ovako production units.

In the past year, some 250 customers have used OvaTrack. Today, about 500 are set up to receive alerts or PDF documents. For more information on how you can set up an OvaTrack account, contact your Ovako sales representative.



SALES AND SERVICE CENTERS

Ovako is a leading provider of the highest quality engineering steels that offer operational reliability. Our goal is to provide outstanding know-how and support in developing solutions that give our customers a competitive edge.

The objective of Ovako's on-going product and process development work is to strengthen our position as one of Europe's leading producers. We do this by developing the best possible know-how and practices in metallurgy, material science, forming, machinability, heat treatment and material testing procedures.

We apply quality management systems to all company processes. To fulfill the high demands from the automotive industry, some Ovako units have included the ISO/TS 16949 requirements in their quality management systems and are third-party certified.

Steel Service Centers

Ovako understands that you require steels that are specifically developed and adapted for your needs. You also need them delivered on time to your chosen location. We provide these services 24/5 with our Steel Service Centers. Each of our Service Centers offers covered storage and the full range of Ovako's products of tube, ring and bar. The Centers also offer services such as cutting and chamfering of different pre-components – all depending on your individual requirements.

The product is packed, marked and delivered as specified by the customer. Our technical customer support gives advice on product choice, adaptability to the customer's process and other technical information.

Sales offices:

Asia Pacific:	+65 9675 9052
Benelux:	+31 546 588 360
Bulgaria:	+359 887 704 733
China	+86 21 3366 2787
Finland:	+358 40 751 5249
France:	+33 3 8054 1515
Germany:	+49 211 250 40
Hungary:	+36 30 914 1920
Italy:	+39 51 690 0332
North America:	+1 803 802 1500
Poland:	+48 22 697 6464
Romania:	+40 721 29 5298
Russia:	+7 495 228 0780
Scandinavia:	+46 591 600 00
Sweden:	+46 591 600 00
United Kingdom:	+44 138 421 3940

SERVICES THAT GIVES YOU AN EDGE

Customer value adding services by Ovako are designed to bring real value, and true competitive advantages, across your operations.

Ovako is devoted to comprehensively ensuring that you can receive the steels needed for your unique project requirements, when you want them. We are uniquely equipped to find alternative solutions best suited for your individual specifications, around the clock. Visit our homepage www.ovako.com where you can find contact details for our sales and technical support.



24 HOUR DELIVERY

Few steel producers can match Ovako's commitment to reliable delivery of products, and we have longstanding experience of supplying steel products to customers all over the world with dedicated just-in-time delivery, 24/5. Ovako continuously refines its logistics solutions for shorter lead times, more rational and cost-effective transport systems, and more purpose-driven warehousing routines. Our ultimate goal is to enable you to simplify your material handling, reduce capital costs and enjoy a better service. This is reinforced by our comprehensive total quality systems which conform to ISO 9001:2000, ISO 9000:1998 and ISO/TS 16949:2002.

SMALLER QUANTITIES CATERED FOR

As a service to our customers, Ovako standard product programs offer smaller order quantities and shorter lead times than we normally require for a production batch. These programs pull together our delivery and storage facilities. A variety of products are stocked at our mills as well as at some of our sales companies and appointed distributors. Our fully transparent services place Ovako at the forefront of meeting industry demands for smaller and lighter components, helping you to attain ever higher standards of cost efficiency.



TECHNICAL SUPPORT WITH EXPERT KNOWLEDGE

Making steel is only part of our job. Just as important is our collaboration with each individual customer, helping you to realize your technical requirements. Comprehensive technical support from Ovako draws on our comprehensive knowledge and experience in a wide range of applications and production methods, not only with regards to the properties of our steel but also heat treatment and machining. We can help you getting the most out of your chosen Ovako products and attain the highest quality end result, with the best production economy.

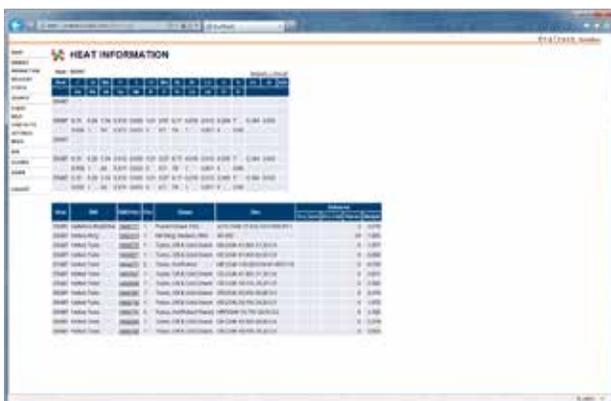


PLANNING AND WAREHOUSING TO FIT YOUR REQUIREMENTS

Logistics have always been integral to Ovako's operations, which is why you can also benefit from our infrastructure. Customers increasingly demand efficient on-time deliveries for their tube and ring products, and Ovako takes care of these requirements with the option to store their steels at our facilities and have them delivered to their chosen location. Our strategically located steel centers provide 24/7 storage services. Each center is managed by our experts, with 70 years of practical knowledge and experience to solve all your requirements.

SPECIAL PROFILES SAVING TIME AND COSTS

You can eliminate manufacturing steps and significantly lower your costs with Ovako's special profile offerings – e.g. by opting for hot-rolled special profile bar tailored for your unique specifications. We can often 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. Ovako manufactures special profiles both in symmetrical and asymmetrical shapes. Special profile bars can also be marked with your company logo or other information.



OVATRACK – ONLINE CUSTOMER SERVICE SUPPORT

OvaTrack answers the questions – Where is my order, and when can it be delivered? Our services can ensure that you get the steels you need when you want them, 24 hours around the clock to perfectly suit your project's time scale and cost requirements. OvaTrack contains an automatic e-mailed deviation alert, claims handling function and order amendment ability.

ONLINE ORDERING FOR YOUR CONVENIENCE

Online ordering systems and interactive tools by Ovako give you quicker and enhanced access to the engineering steels you need. From Ovatrack our customers can enter repeat orders including documentation and distribution set-up. Access the Ovako bespoke online ordering services through our web site at www.ovako.com.



EASY TO INTERACT WITH OVAKO

Finding the best solutions for your needs is always our priority at Ovako. To achieve this, you can use a number of our service systems and interactive tools for developing solutions and managing orders. These tools also help us keep a close eye on the value created for our customers, and strengthen our services to you as a partner and technical collaborator.

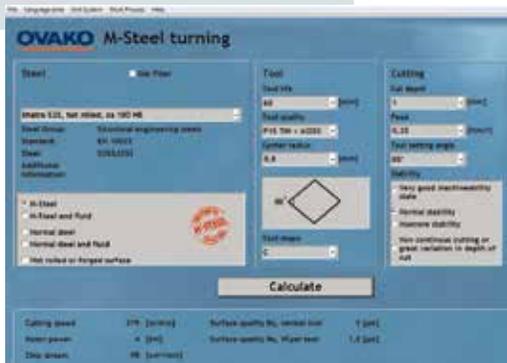
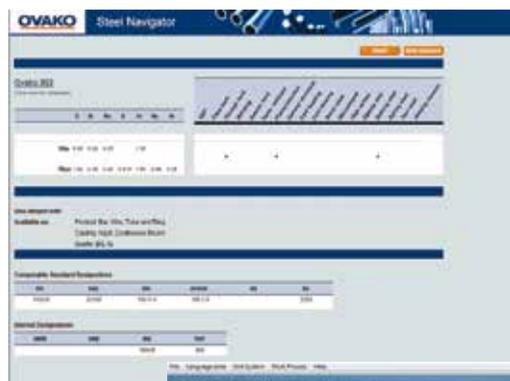
Product finder

Steel Navigator can be used to find the right steel for your needs. The tool includes approximately 200 steel grades covering Ovako's business areas.

A search can be done in many ways. Start with steel designation, chemical composition or application. The base page of the grade links to data sheets containing versatile information about the grade.

Scrap and alloy surcharges

Ovako provides monthly updated scrap and alloy surcharges on the web. Scrap and alloy surcharges are commonly used in the industry to adjust steel prices due to national and international variations in cost for scrap and alloying elements. The surcharges are generally based on published prices.



Cutting data

The M-Steel Calculator provide the cutting data for Ovako's M-Steel grades. The user enters data about the cutting conditions and the M-Steel Calculator calculates the recommended cutting speed, cutting stream and the required engine power. M-Steel Calculator provide values for turning, drilling and sawing. M-Steel Calculator can be downloaded and installed from our web site at www.ovako.com.

Online customer service support

OvaTrack is an extranet system designed to support customer service and sales activities. It provides selected customers and partners the ability to process information related to their business activities.





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 confidentially and all information, documentation, materials in whatever form disclose 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 subsuppliers 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.

Ovako is a leading European producer of engineering steel for customers in the bearing, transportation and manufacturing industries. Our production is based on recycled steel and includes steel in the form of bars, tubes, rings and pre-components. Ovako is represented in more than 30 countries and has sales offices in Europe, North America and Asia. Sales in 2014 amounted to EUR 862 million and the company had 2,925 employees. For further information please visit us at www.ovako.com

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