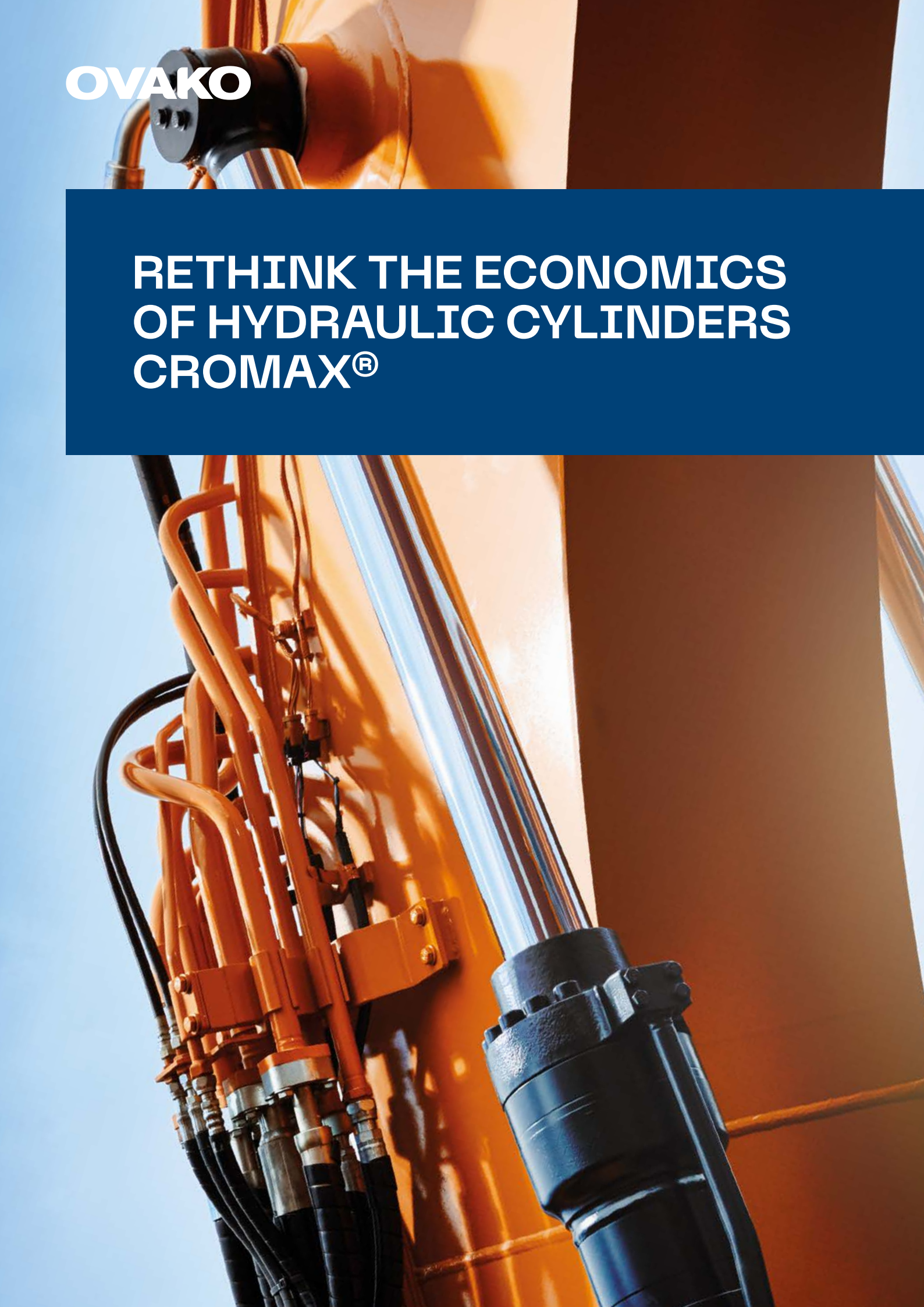
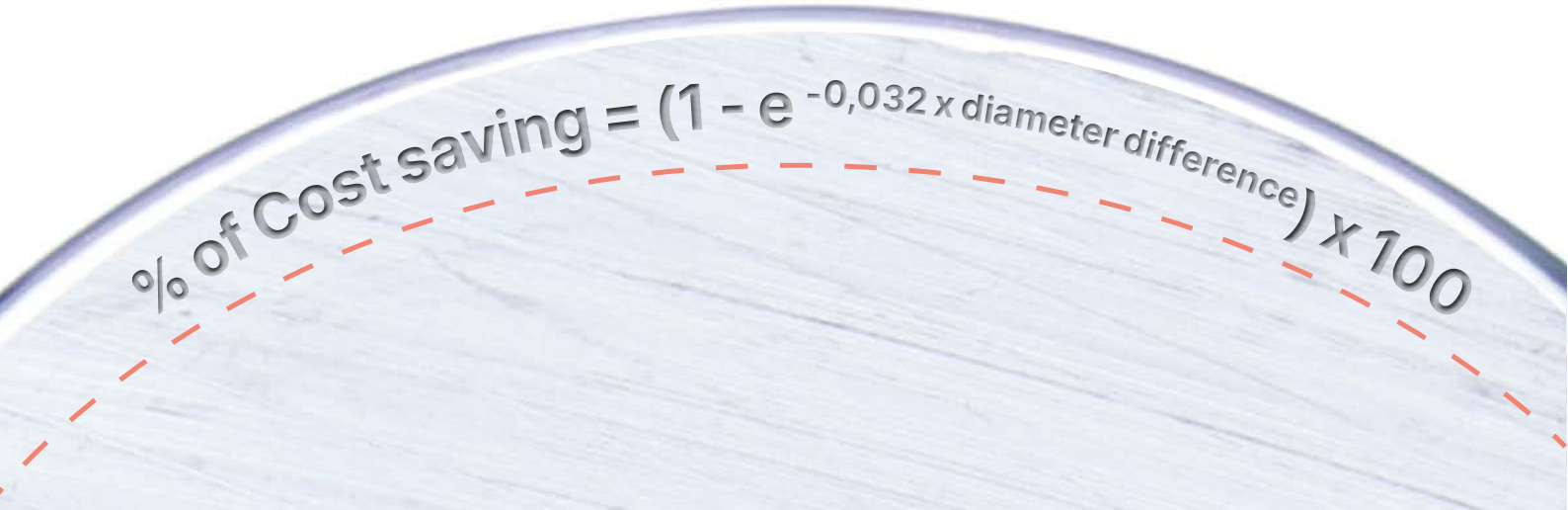
OVAKO

RETHINK THE ECONOMICS OF HYDRAULIC CYLINDERS CROMAX®




% of Cost saving = (1 - e -0,032 x diameter difference) x 100

THINK SMALL FOR BIG GAINS

What if you could significantly reduce your production costs with only a minor design update? In our daily work with leading equipment manufacturers around the world, we've seen first-hand a close correlation between rod diameter and cost. While it might sound hard to believe, a 5 mm reduction in rod diameter can lead to a 15% cost saving. "But what about the structural integrity?" you ask.

Glad you asked. This is where being the world's largest chrome plating company with in-house steel production – operating three high-quality steel mills – has its advantages. To compensate for the small design change, we op-timize the chemical composition of our bars and tubes to safeguard the structural integrity and eliminate slag inclusions. It's a small metallurgical improvement that results in a stronger hydraulic steel with a significant economic gain for you.

Same performance, bigger savings

But don't just take our word for it. We encourage you to have a look at the graph to the right, and see for yourself what a small reduction in diameter would mean in terms of percentage cost savings for you. Because bar diameter affects a wide range of costs – from handling and cutting to machining, grinding, chrome plating and other surface operations – it's easy to see how the savings increase exponentially as diameter decreases. In fact, compared with the most commonly used piston rod steels, a stronger material such as Cromax 280X can potentially reduce costs by as much as 30%.

The three keys to lower costs

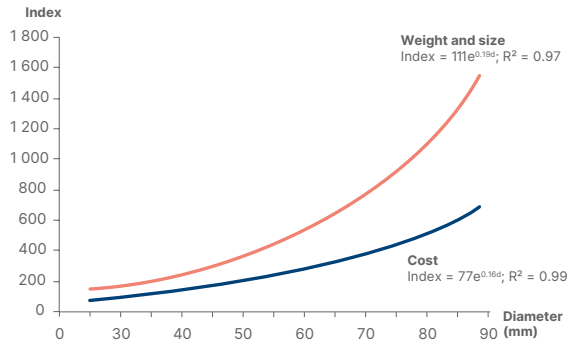
At Ovako, our mission is to reduce the cost and capital required to enable a hydraulic cylinder to supply a specific force throughout its economic life, and wherever in the world it operates. This is why all Cromax and Nikrom products have been specifically formulated – from raw material to finished product – only for high-quality hydraulic piston rods. With full control over the entire value chain, we're able to tailor your delivery to minimize costs, capital and risks in three key areas:

The right material makes it possible to minimize the diameter of the rod to your specifications, without additional risks for fatigue, buckling or impact damage. Ovako steel is also ideally suited for efficient chrome plating, machining and MAG/friction welding.

The right surface treatment minimizes costs and coating thickness while guaranteeing that the cylinder is resistant to premature failure due to surface damage, field handling, corrosion or excessive seal wear.

The right service minimizes your working capital while ensuring low overall costs and consistent supply availability. This is assured thanks to Ovako's multiple independent plating units and steel mills, which guarantee short delivery times and flexible delivery formats – whether long bars, cut-to-length or machined/ welded rods.

Cost and weight development of a piston rod



BRING US YOUR TOUGHEST HYDRAULIC CHALLENGES

What is your system pressure? What are your design specifications for hydraulic cylinders? Whether you've got a complex system or a more straightforward need, we love hydraulic challenges. For more than 35 years, we've been working with some of the most demanding end users and cylinder manufacturers all over the world to ensure the highest performance.

At Ovako, we have the broadest selection of surface executions available, ranging from very thin single-chromed surfaces to multiple layers of chrome- and nickel-chromed surfaces, the latter with corrosion resistance on par with chrome-plated stainless steel. Whatever your requirements, we can adapt the surface to guarantee your cylinders will last their economic life at the lowest possible cost.

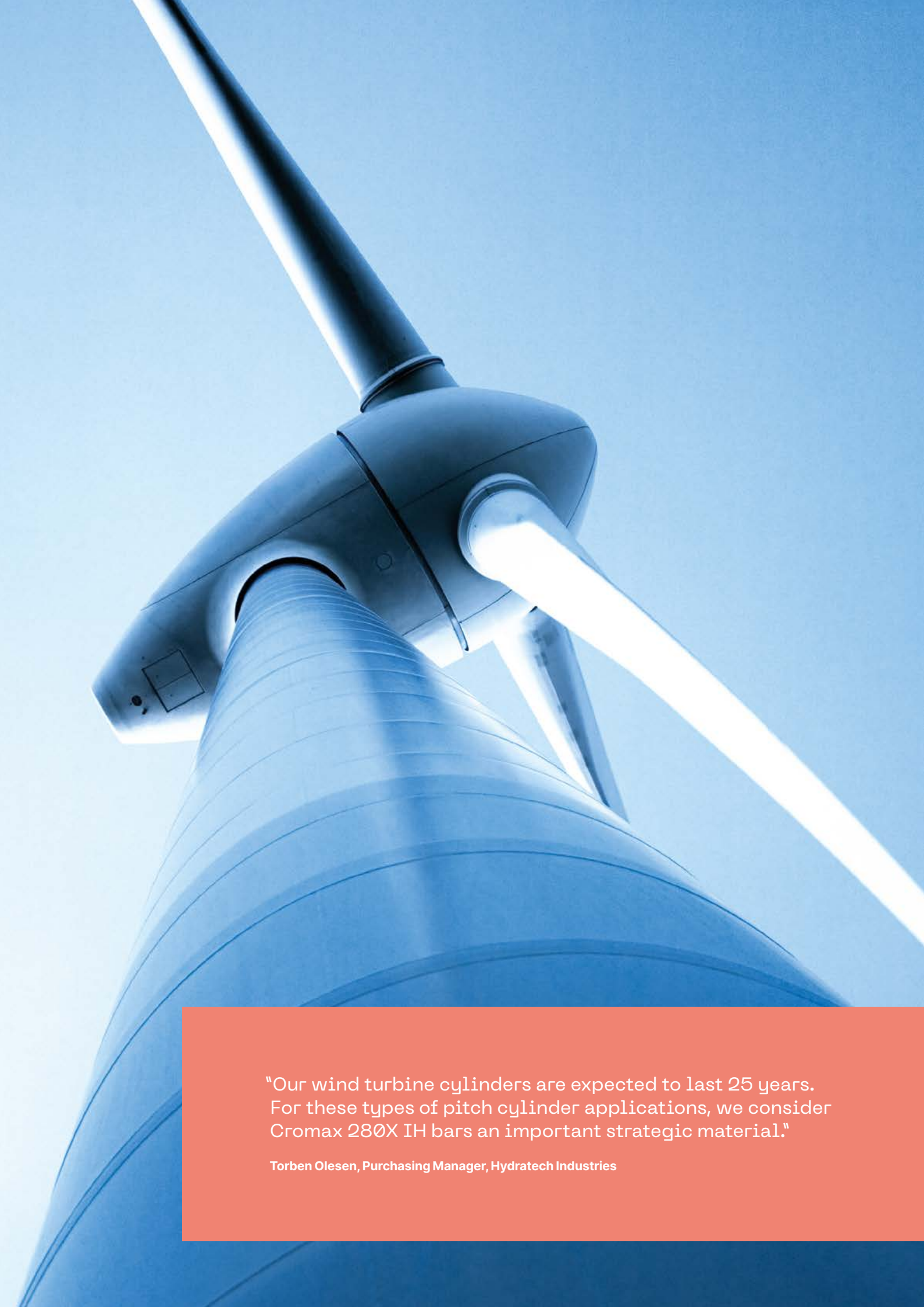
Engineered for the world's toughest customers
For more than three decades, we've worked closely with the world's leading companies in hydraulic systems manufacturing to develop a line of base steels uniquely suited for piston rods. This close collaboration has resulted in higher-strength materials and induction hardening processes that enable superior resistance to buckling, fatigue and external impact. In addition, we've been able to minimize the thickness of chrome or nickel-chrome coatings according to the specific demands, applications and designs of customers like you.

Seamless production for optimal performance
All of this is made possible through our total control of production from initial melt to finished product. Unlike other suppliers or distributors, which use many different sources of steel, we optimize our network of three mills to ensure batch-to-batch consistency, optimal chemical composition and processing characteristics for your exact requirements. No compromises. No unnecessary costs or risks.

Experience design freedom with maximum productivity
This fully integrated production – including customer-focused R&D and knowledge networks – guarantees that every Ovako product is tailored specifically for your toughest hydraulic challenges. The result? New design possibilities. The most economical formats. And the most productive manufacturing processes. Whatever your application and wherever in the world you're located, our entire production chain is seamlessly geared to deliver to your needs.

"Our specialized cylinders are used in power steering systems for tractors, and our customers expect Ognibene components to withstand corrosion caused by exposure to mud, dust and dirt as well as to absorb dynamic loads, wear and tear, and extreme temperature fluctuations."

Vittorio Nobili, Purchasing Manager, Ognibene SpA



"Our wind turbine cylinders are expected to last 25 years. For these types of pitch cylinder applications, we consider Cromax 280X IH bars an important strategic material."

Torben Olesen, Purchasing Manager, Hydratech Industries

CROMAX THE TOP CHOICE FOR TOP MANUFACTURERS

Cromax bars and tubes from Ovako have become the ideal choice for hydraulic components for a large number of companies worldwide. Ovako's deep metallurgical know–how and extensive R&D have resulted in hard chrome–plated products that excel in corrosion resistance and mechanical properties, while delivering unmatched quality consistency with professional technical support. Ovako is one of the largest producers of hard chrome–plated bars and tubes in Europe with production units in Sweden, The Netherlands, France and Italy.

Performance you can trust
The Cromax range of low-carbon and micro-alloyed steels is known worldwide for combining high strength with excellent machinability and weldability. Prior to delivery, every product is controlled to ensure optimal micro-crack distribution with high crack density. These properties, together with specially adapted finishing procedures, guarantee superior corrosion resistance, verified by salt-spray testing following ISO 9227 standards (or equivalent).

Raising the bar in next-generation hydraulics
For companies like Denmark-based Hydratech Industries, Cromax bars are critical to handling the enormous dynamic loading faced by next-generation wind turbine cylinders. At ten million strokes per year for a minimum lifetime of 25 years, the failure of even a single piston rod is simply not an option. Combine this with constantly changing loads, dirt, salt and extreme temperature fluctuations, and it's easy to see why one Hydratech purchasing manager considers Cromax 280X IH bars a "strategic material" for his company.

Three levels of corrosion-resistance
Depending on the intended use of your Cromax products, three levels of corrosion resistance are available:

- Standard Cromax – with a single chrome layer, subjected to a special surface finishing process.
- Cromax C – with a double chrome layer for increased protection against environmental penetration and corrosion of the underlying steel.
- Nikrom – nickel-chrome plated products for aggressively corrosive environments such as marine, offshore, mining, agriculture and many more.

CROMAX C TWICE THE PROTECTION, HALF THE RISK

Having served hydraulic systems manufacturers in a range of industries, we know that no two operating environments are exactly alike. Many demand components that can withstand harsher conditions that risk penetrating even a high quality single chrome layer. This is why we created Cromax C, a range of double–chromed, ready–to–use bars that provide twice the protection against penetration and pitting of the underlying steel.

The hydraulic components produced by PMC Cylinders AB face some of the most punishing conditions imaginable – folding massive farming planters from 6.5 to 3 meters in width at the push of a button, with constant exposure to dirt and corrosive fertilizers. One Swedish manufacturer of farm machines, forklifts and mobile cranes purchases some 28,000 mobile hydraulic cylinders from PMC Cylinders for exactly this purpose – every year.

When there's no room for risk

At the heart of these cylinders are double-chromed Cromax 280X bars from Ovako, a Cromax C product designed specifically for superior corrosion resistance. Thanks to their double layer of chrome, they are able to operate under extreme pressure while ensuring twice the resistance to corrosion otherwise caused by micro-cracks that result from regular wear and tear.

Reaping big benefits

These properties, according to Peter Blomquist, Supply Manager for PMC Cylinders, are precisely why his company relies on Ovako to provide more than 500 tons of Cromax 280X bars every year. "The base material of 280X has higher mechanical properties and tensile strength than average," says Blomquist. "Because of this, Cromax 280X is ideal for smaller-sized piston rods that we build into our hydraulic cylinders for the mobile sector, such as those used for critical and high-performance functions in harvesters and agricultural equipment."

Maximum strength with minimal weight

For Blomquist, it is the combination of superior corrosion resistance, low weight and high strength that makes Cromax C rods uniquely suited for the demands of mobile hydraulics systems: "The 280X rods in our mobile hydraulic cylinders are smaller and lighter in weight but just as strong as larger ones – qualities that our customers, like Väderstad, absolutely require for their harvesters' cultivat-ors, drills, planters and other applications." In short, it's a win-win for cylinder manufacturers and end customers who demand lightweight, reliable hydraulics that withstand years of demanding operation in the field.

"In our opinion, Cromax 280X is one of the few hard-chromed bars in the world that meets the highest standards in terms of corrosion-resistant surface treatment and the quality of the steel grade."

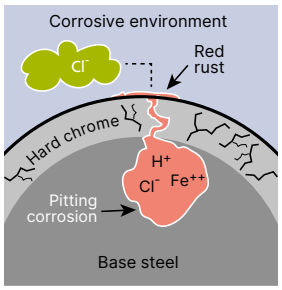
Peter Blomquist, Supply Manager, PMC Cylinders

NIKROM GUARANTEED CORROSION RESISTANCE IN AGGRESSIVE ENVIRONMENTS

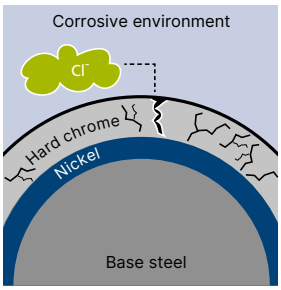
In the most aggressive environments, chrome-plated hydraulic components may not be sufficient. Highly corrosive conditions with exposure to marine environments, fertilizers, chemicals or road salt can pose extreme challenges for hydraulic systems. Even a piston rod that remains extended for long periods of time in a moderately aggressive environment may be at risk. This is where Nikrom bars can provide a crucial advantage.

Superior corrosion resistance
Because hard chrome is naturally micro-cracked, species can penetrate the layer. In corrosive environments or safety-critical applications exposed to risk of mechanical damage, the oil film alone is insufficient for protection in the field. This is especially true if the piston rod remains extended for long periods of time, causing the oil film to dry out. By combining chrome plating with an underlying layer of nickel, Nikrom dramatically improves corrosion resistance regardless of the piston rod's overall oil film protection.

Effective protection barrier
The ductile nickel layer, free from pores and cracks, acts as a barrier and protects the base steel by sealing it off from the surrounding corrosive environment despite micro-cracks in the outer hard chrome layer.



Corrosion mechanism of hard chrome plated bar



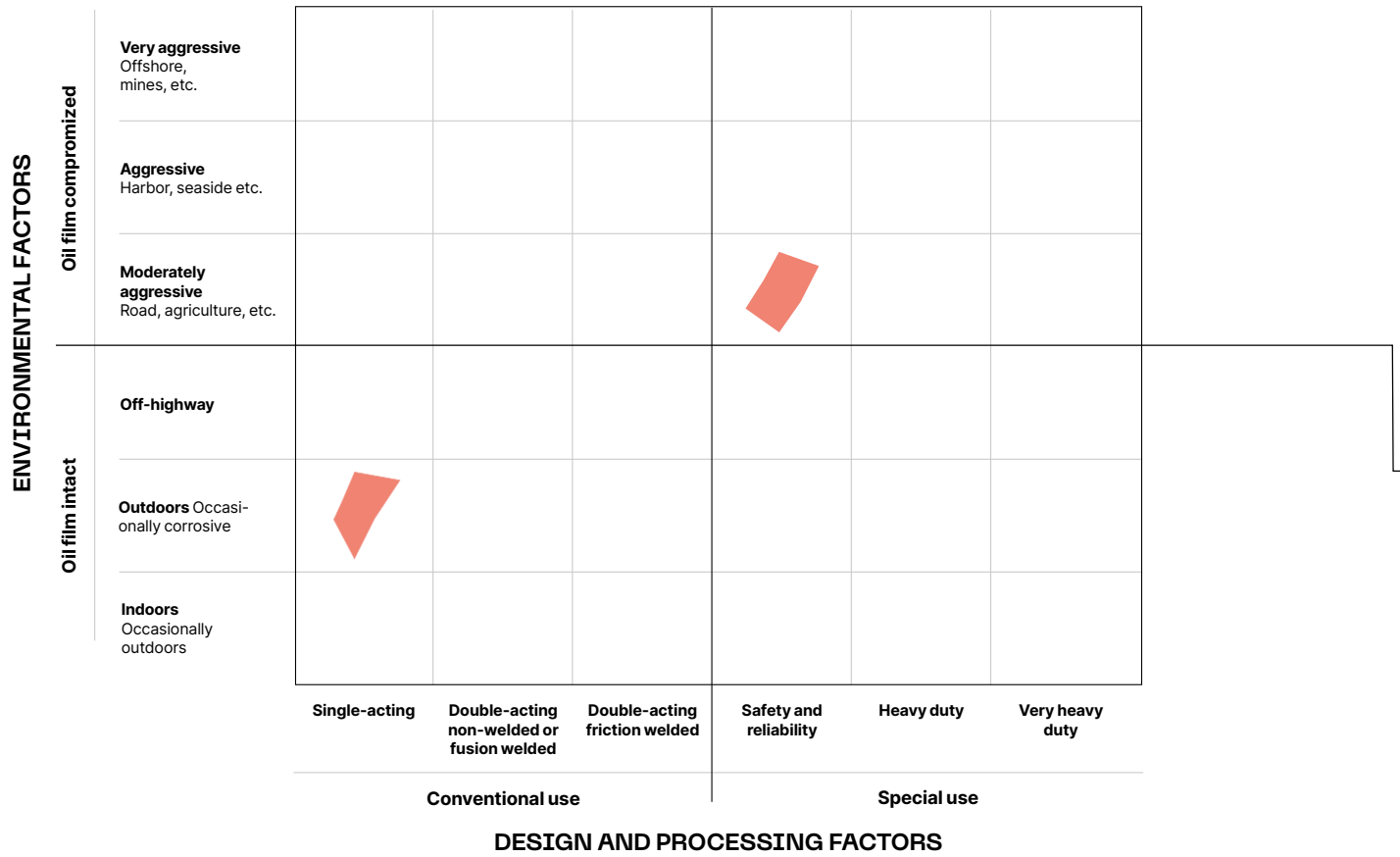
Barrier protection of the inner nickel layer

Durably withstands stress and impacts
Extensive field tests and salt spray tests confirm Nikrom's excellent corrosion resistance even after external impacts. The nickel's high ductility also ensures that these superior corrosion properties are maintained over time, with no aging effect or weaknesses in the outer layer of hard chrome due to cyclic compression loading in service.

High added value
Every lot we ship is quality tested to ensure zero surface defects and no risk of flaking. The corrosion resistance is also guaranteed by daily tests. In moderately to highly corrosive environments, Nikrom ensures years of trouble-free service with minimal maintenance. Nikrom has corrosion resistance on par with chrome-plated stainless steel and is a cost-efficient and reliable alternative for most applications.

OPTIMIZE PERFORMANCE FROM EVERY PERSPECTIVE

Single or double-acting cylinders? Aggressive environments, risk for abrasive wear, or maybe a combination of both? Whatever your needs, Ovako's R&D is always striving to extend the limits of performance. From your most stringent design requirements in relation to buckling or fatigue resistance to your particular manufacturing constraints, we ensure the optimum balance between field performance and production economy – well beyond the capabilities of the standard steel grades used for piston rods.

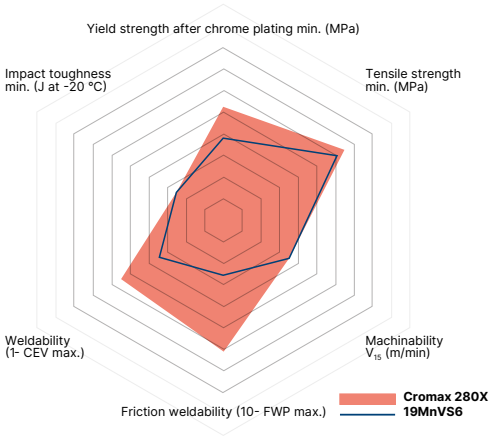


Selecting the right steel
Your specific design and processing requirements are the keys to determining the optimum steel selection for the application at hand. Conventional uses cover a wide range encompassing single- and double-acting cylinders. These include piston rods manufactured by machining only, via machining and arc welding or even friction welding. In more demanding applications, such as those involving heavy duty or particularly stringent requirements on safety or reliability, a steel with special properties may be needed. The aim is to mitigate risks for brittle failure, as weel as undesirable consequences from external impact or unfavorable side loading.

Choosing the right surface
The ideal surface for your application is determined by a whole matrix of field-life considerations. In many cases, a single chrome layer in combination with a continually replenished oil film is sufficient to protect the underlying steel from corrosion and, to some degree, negative effects from contact with abrasive particles. However, in harsher conditions such as those encountered in marine/off-shore environments or in some agricultural or mining applications, there is a decisive benefit to be gained from a sub-layer of nickel. This not only imparts an enhanced overall corrosion resistance, but it also compensates for loss of protection under circumstances when the oil film is compromised or even absent.

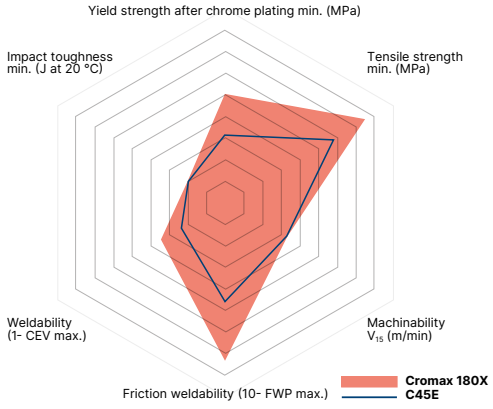
The tables and diagrams below represent just two examples of how a Cromax product can be tailored to meet the requirements of a specific situation. Whatever the demands may be, rest assured that we can offer the optimum combination of steel and surface to meet your needs.

Safety and reliability	**Cromax 280X**	**19MnVS6**
Yield strength after chrome plating min. (MPa)	520	390
Tensile strength min. (MPa)	650	600
Machinability V15 (m/min)	350*	350*
Friction weldability (FWP max.)	3.84	7.35
Weldability (CEV max.)	0.55	0.65
Impact toughness min. (J at -20°C)	27	27*



Single-acting	**Cromax 180X**	**C45E**
Yield strength after chrome plating min. (MPa)	500	305
Tensile strength min. (MPa)	750	590
Machinability V15 (m/min)	320*	320*
Friction weldability (FWP max.)	2.78	5.38
Weldability (CEV max.)	0.65	0.77
Impact toughness min. (J at 20°C)	20*	20*

*Measured / indicative value, no guarantee



FULLY TAILORED DELIVERIES, ZERO COMPROMISES

Which material, surface and service options are right for you? Choose from our wide range of standard products, or contact us for customized materials and surface treatments specified exactly to your demands.

Cromax materials and critical design parameters

STEEL GRADE	TECHNICAL DATA						
	Dimension	Yield strength	Tensile strength	Elongation	Hardness	Impact toughness	Surface hardness ih
	Diameter (mm)	reH/rp0.2 (mpa)	Rm (mpa)	A5 (%)	HB	kv (j)	hrc
C35E	< 20	≥ 345	≥ 590	10	–	–	≥ 55
	20-90	≥ 345	≥ 590	19	165-220	–	
180X	20-90	≥ 500	≥ 750	16	230-280	–	≥ 55
280X	20-90	≥ 520	650-800	19	200-240	≥ 27 at -20°C	≥ 45
	91-125	≥ 440	550-700	19	180-230	≥ 27 at -20°C	
	> 125	≥ 350	500-700	19	180-230	≥ 27 at -20°C	
482	< 125	≥ 580	850-100	14	250-300	–	≥ 55
42CrMo4	< 40	≥ 750	1000-1200	11	295-355	≥ 35 at 20°C	
	40-95	≥ 690	900-1100	12	265-325	≥ 35 at 20°C	≥ 55
	> 95	≥ 550	800-950	13	235-295	≥ 35 at 20°C	
TUBE		≥ 450	550-800	20	160-240	≥ 27 at -20°C	≥ 45

Customer specific steel grades and/or mechanical properties are available upon request

Cromax surfaces

EXECUTION	CORROSION RESISTANCE ACCORDING TO ISO 9227			TECHNICAL DATA			
	AASS	NSS	CASS	Surface roughness		Chrome thickness	Chrome hardness
				Ra (µm)	Rt (µm)	µm	hv0.1
CROMAX	Up to 40 h R10	Up to 120 h R10	Up to 64 h R9	≤ 0.2	≤ 2.0	≥ 20	≥ 850
CROMAX C	Up to 80 h R10	Up to 240 h R10	–	≤ 0.2	≤ 2.0	≥ 20	≥ 850
NIKROM 150	Min. 150 h R10	Min. 500 h R10	–	≤ 0.2	≤ 1.6	Ni ≥ 10, Cr ≥ 20	≥ 850
NIKROM 500	Min. 500 h R10	Min. 1500 h R10	–	≤ 0.2	≤ 1.6	Ni ≥ 30, Cr ≥ 20	≥ 850

All surfaces can be modified to meet customer specific requests

Cromax delivery and service options

EXECUTION	MANUFACTURING FORMAT				
	Max. length	Diameter min.	Diameter max.	Hardening	Packing
CROMAX EXECUTIONS	7800 mm	10 mm	150 mm	Continuous/Skip	Plastic/Cardboard
NIKROM EXECUTIONS	7300 mm	18 mm	160 mm	Continuous	Plastic/Cardboard
LOCATION	SERVICE OPTIONS				
	Warehousing	Kan-Ban	Cutting	Machining	Friction welding
Hallstahammar, Sweden	√	√	√	√*	√*
Twente, The Netherlands	√	√	√	√*	√*
Molinella, Italy	√	√	√	√*	√*
Redon, France	√	√	√	–	–
Shanghai, China	√	√	√	–	–
Pune, India	√*	√*	√*	–	–

* In co-operation with external partners

WE'VE GOT YOU COVERED ALL OVER THE WORLD

Need specific rod lengths? Machining? Or friction welding? No problem. In addition to our operations, Ovako Cromax is continually investing in warehousing and cutting facilities on several continents to ensure high-quality piston rods — wherever you are based.

Many of our customers have production facilities throughout the world. To meet their demands, we take great pride in our ability to guarantee short lead times and flexible delivery formats from our multiple independent chrome-plating units and steel mills. This built-in flexibility – with the same products available from different plants, and most types of steel supplied by any of three mills – also protects all of our customers from any unforeseen supply chain disruptions.

Whatever your individual requirements for delivery format, lead times or logistic concepts, we can tailor the most cost- and capital-efficient solution for your needs. In short, we've always got you covered.

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

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

Discover more about our innovative solutions at ovako.com, sanyo-steel.co.jp, and nipponsteel.com

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