



OVAKO

**THE SAFE CHOICE FOR
SUB-ZERO PERFORMANCE**
SZ-STEEL®

SAFETY COMES IN MANY SHAPES AND SIZES

Arctic pipeline bolts. Hydraulic parts. Offshore lifting devices. When the temperature drops, steel parts need to rise to the occasion with safe and reliable performance around the clock. There is no room for brittle fracturing or cracking. The price of human safety and environmental risks is simply too high.

Some of our most demanding customers tell us that safety in cold climates is increasingly becoming an urgent priority. Many are under pressure to comply with demanding oil and gas or shipbuilding standards. Nobody wants to see an accident or unscheduled maintenance when temperatures drop to -40°C and below.

Extreme sub-zero performance

So how do you know whether the quenched and tempered bar or tube you've been using for years can withstand -60°C? Or what about -100°C? And what about those ISO, EN, ASTM, DIN and JIS certification requests in the process of meeting API, DNV and other standards for the fabrication of steels with guaranteed impact and toughness properties at low temperatures?

SZ-Steel for cold climate

This is where SZ-Steel can help. The abbreviation SZ, which means sub-zero, refers to "cold climate" steels that are proven to retain their material properties at -40°C in relation to size and yield. Many are tested to withstand temperatures down to -100°C and beyond.

How can we serve you?

Although we can't legally guarantee fabricated parts, we can ensure that SZ-Steel will retain the favorable properties you need. Our service team can also advise you on application suitability, mechanical data, materials supply and logistics. All to live up to our promise that SZ-Steel is the "safe choice for sub-zero performance."

SZ-STEEL BENEFITS

- Enables the application of high-strength solutions at sub-zero temperatures.
- Enables design that creates safety for workers, service crews and the environment.
- Retains key material properties and offers reduced risk of embrittlement and fracturing.
- Meets key global safety standards.



HARNESS THE HEAT...


Can heat defeat cold? Yes, it can. Although it might sound somewhat counter-intuitive, sub-zero safety starts with the right metallurgy, the right heat treatment and the right control over steel microstructure. It's a delicate balancing act between ductility and strength. Wrong heat treatment

and you end up with a hard material that could risk brittle fracturing. Too ductile a material and you may not have the high strength required. Low impurity levels and controlled grain size give the edge you need.

...TO THRIVE IN THE COLD

It's a simple fact that cold temperatures complicate a steel's ability to remain ductile under heavy loads and stress. Whether it's a pressure valve, hydraulic tube or connector, you want a material that remains ductile at sub-zero temperatures. Sadly, threaded fasteners, nuts, washers and

other key parts have a tendency to become embrittled and shatter at just the wrong times. With human lives and the environment at stake, skimping on costs or materials is simply not an option.



“To verify the ultimate safety and reliability of our high-performance engineering steels, we used a proprietary ‘freezer box’ that goes down to -101°C. To our knowledge, we are one of the few steelmakers that backs sub-zero claims with proven in-house testing at this level.”

Ilkka Lahti
Metallurgical Expert, Ovako

IMAGINE LIFE AT -101°C. OUR STEELS DO.

We can’t help ourselves. As curious steelmakers, we’re always asking questions. Like what happens to a 200-millimeter-thick round bar at -101°C? Would it shatter upon impact? How would the mechanical strength, impact resistance and ductility be affected? To find out, we invented one of the world’s toughest sub-zero tests for engineering steels.

Actually, the whole point of creating the Ovako Big Freeze Test Facility was not just to satisfy our own curiosity. We wanted to provide customers with empirical evidence that our steels hold their beneficial properties in extreme cold. We wanted to base our claims on fact rather than extrapolations or simply referring to our “zero-complaints” track record. Sure, that’s all fine, but nothing beats the persuasive power of an experiment that is verified against industry standards.

Located in Imatra, Finland

So we set up our own sub-zero test facility at our Ovako Imatra Steel mill in southeast Finland near the Russian border. Is this unusual? Yes. Unlike other cold test facilities within Ovako, this one would test our low-alloy bar at -101°C using cryogenic liquid nitrogen and methanol as a cooling media. It had never been done before. At such temperatures, even some of the best materials become brittle and fall apart.

Charpy V-notch testing

After immersing steel parts in the Freeze Box, we then take them out and apply the Charpy V-notch test, a standardized high-strain test to determine the amount of energy absorbed by a material during fracture. If the material breaks on a flat plane, the fracture is regarded as brittle, and if the material breaks with jagged edges or shear lips, then the fracture is considered to be ductile.

Meeting global standards

The results are then measured in accordance with the Standard Methods for Notched Bar Impact Testing of Metallic Materials, as specified by ASTM E23, ISO 148-1 or EN 10045-1. Needless to say, the results were superior. But more than just providing us with “bragging material,” they serve as a basis for guiding our customers to choose the right materials for axles, bolts, gear wheels, connectors and other steel parts.

FREEZING OUT RISK IN REMOTE LOCATIONS

Risk. It's a nasty word. Especially in remote workplaces where sudden impacts can affect the safety and reliability of steel components at sub-zero temperatures. Personal injury and operational downtime are just too costly to be left to chance.

The problem is that steel tends to become brittle and susceptible to cracking at low temperatures and under high pressure or torque. In other words, the performance you need may decline in cold climates. That is, unless you're using SZ-Steel.

Critical components

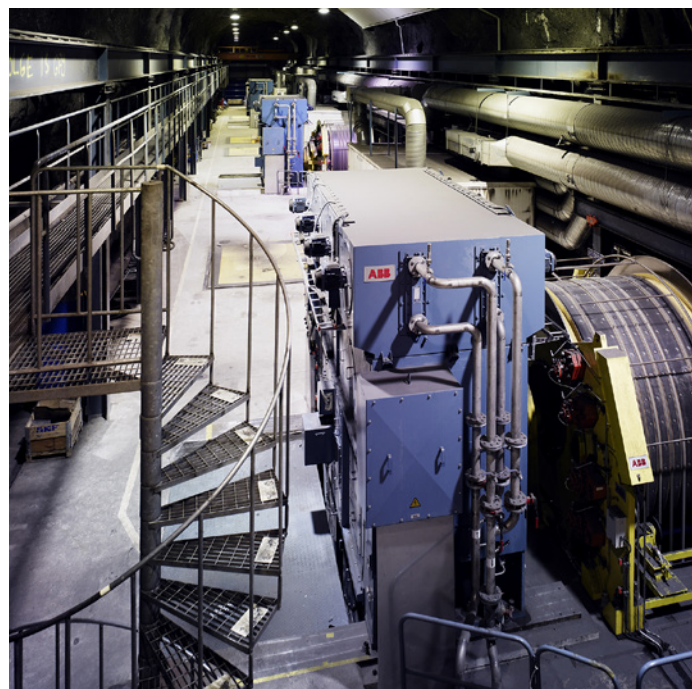
One customer that turned to us is ABB Oy Motors and Generators Helsinki, a leading supplier of power equipment to industries working in extreme conditions. For many years, the company has been sourcing SZ-Steel for their rotor shafts, one of the most critical components in their electric motors.

Designed for -55°C

Why Ovako steel? Because the rotor shafts are critical to the reliability of the electric motors in extreme conditions, including in sub-zero temperatures. Normal working conditions for ABB motors range between -20°C and +20°C, but they are designed to plunge as low as -55°C.

Demanding customers

Together, the shaft and rotor serve as the backbone of ABB's AC motors, delivering the mechanical power that drives the winches, compressors, conveyor belts and milling machines that, in turn, support the mining and oil and gas operations safely and reliably. In other words, failure is not an option.



Certain ABB motors, whether variable speed drive (VSD) or direct online (DOL), boast rotors with heads weighing up to 130 tons and spanning four to eight meters in length. Enormous torque loads in cold conditions are brought to bear on the Ovako-sourced shafts throughout their speed range.

"For our purposes SZ-Steel is the ideal choice due to its excellent toughness and resistance to cracking in extremely low temperatures, which other steels cannot match. Components made from this steel have been an important factor in the reliability of our motors in day-to-day operations, even in the most extreme conditions."

Jukka Laaja

Project Manager, ABB Oy Motors and Generators, Helsinki

YOUR LIFELINE FOR SAFE LIFTING OFFSHORE

High winds. Rough seas. Sub-zero temperatures. Not exactly the optimal conditions for lifting heavy containers from a ship's deck or oil platform. Yet this is the typical environment faced by offshore crews in the energy sector every day, placing a constant test on safe and strong materials.

For many years, Ovako has been providing bar, ring and other products to the offshore energy sector. Customers use our steel for sub-zero applications ranging from the hydraulic cylinders in windmills to anchor chains. Their components need to withstand high shock loads and fatigue on the high seas.

Exceeding tough DNV requirements

Supplying many of these offshore players is Gunnebo Industries, a leading global manufacturer of lifting and lashing equipment, which uses SZ-Steel. Their chain or wire rope slings, shackles and master links are then sold in compliance with DNV (Det Norske Veritas) 2.7-1 certification, meaning that they're approved to function safely in cold climates. Gunnebo Industries prides itself on certifying their products to perform down to -40°C and lower.

No inclusions, excellent documentation

To achieve this, they place very specific demands on the chemical composition and heat treatment process used by Ovako for its SZ-Steel. Such requirements include the level of non-metallic inclusions, grain size and impurity levels.

Detailed and helpful documentation

The details of each heat treatment are included in mill certification tests that Ovako delivers to Gunnebo Industries, providing traceability and assurance about the steel quality and process. The certification includes the results of tests that measure the heat's toughness, tensile strength, elongation and hardness.

"Ovako supplies us with the quality steel required to produce the high standards we deliver and that our customers expect. We highly value our collaboration with both our suppliers and our customers, and we have had a lot of benefits being able to get Ovako's support with both technical and logistics issues."

Lennart Nilsson

Vice President of Operations, Gunnebo Industries

UNMATCHED QUALITY UNSTOPPABLE STRENGTH

Designing and manufacturing hydraulic cylinders and other steel parts to handle heavy loads is certainly a challenge. Making sure they retain their favorable properties under stress at sub-zero temperatures is quite another matter.

Yet another example is a manufacturer of concrete pumping equipment for construction sites. Since the end of an articulated delivery boom can often extend dozens of meters from the pump location at considerable height, it increases the gravitational pull and stress on the cylinders. This, in turn, increases the risk of malfunction, human injury and property damage. In short, the equipment’s ability to securely and effectively deliver the concrete pour, even in temperatures

as low as -20°C, is critical. According to the subcontractor providing hydraulic cylinders for these systems, it was a logical choice to use SZ-Steel since the characteristics of our tube exceeded their sub-zero requirements by more than 100%.

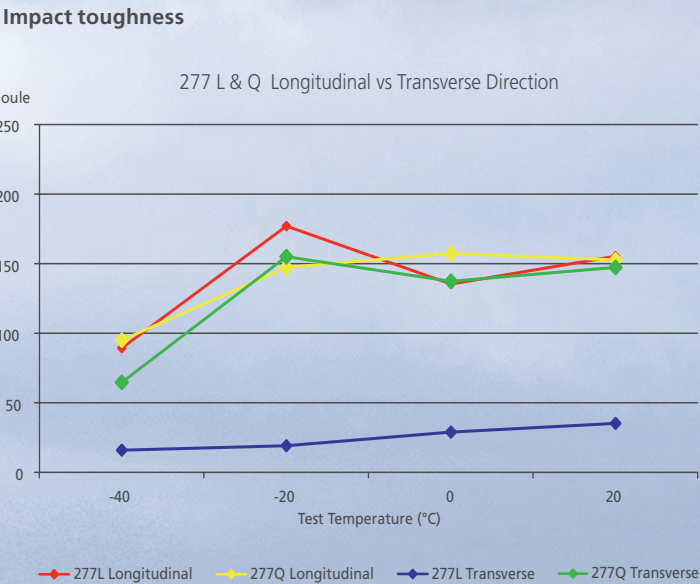
SZ-Steel combined with IQ-Steel

For concrete pumping and other applications, hydraulic cylinders are critical components that must stand up to a

three-dimensional load. This means they must be able to handle high levels of impact strength in both the longitudinal and transverse direction. It is not uncommon for steels with normal levels of sulphur and other nonmetallic inclusions to show excellent impact strength in the longitudinal direction, while the transverse impact strength is dramatically lower. This is clearly a detrimental factor for a three-dimensionally loaded component such as hydraulic cylinders.

Handling loads in all directions

However, the ability to handle loads in all directions is sometimes overlooked since most standards only specify impact strength in the longitudinal direction. By combining the properties of our SZ-Steel with the isotropic properties of our IQ-Steel, we ensure a very high level of strength in the transverse direction as well. See the following graph showing SZ-Steel 277L with a normal sulphur level versus SZ-Steel 277Q with IQ-treatment.



“We’ve enjoyed a very good relationship with Ovako because they understand exactly what is required from our customer. They meet all the specifications and because they have stocking capabilities nearby they can deliver quickly and in low as well as high volumes.”

Mr. Jürgen Hahn
Klingel Hydraulik GmbH

WE MEET API AND OTHER STANDARDS BUT THE TOUGHEST ONE IS YOURS

No matter how many “certificates of approval” we mount in our reception areas (and there are many), you’re likely to shrug. The fact is that most of our customers have needs that go beyond the obvious: unique delivery demands; special formats; or they just want someone to talk to who actually understands their needs.

If you’ve been in the steel business as long as we have (read: 400 years), you’re fully aware that technical specifications are one thing and reality is another. Many steel suppliers are good at ticking off all the boxes, but lack the depth of expertise needed to combine metallurgical insight with practical advice. Nor can they provide you with a direct line into their mills for traceability, quality questions, service and more.

Demanding sub-zero requirements

But let’s start with technical specs. When it comes to sub-zero steels in demanding industries like shipbuilding, offshore oil and gas and others, we understand the scope. Many of our SZ-Steel grades are tested to meet demanding sub-zero fabrication requirements such as the DNV offshore standards and other international standards.

Bolts, fasteners and fittings

When it comes to sub-zero steel bolting materials, we’re required to follow ASTM A320 L7 standards as well. This includes steel bolting materials for pressure vessels, flanges and fittings for low-temperature service. The list goes on, particularly when it comes to the demanding American Petroleum Institute (API) standards, which are on everyone’s minds.

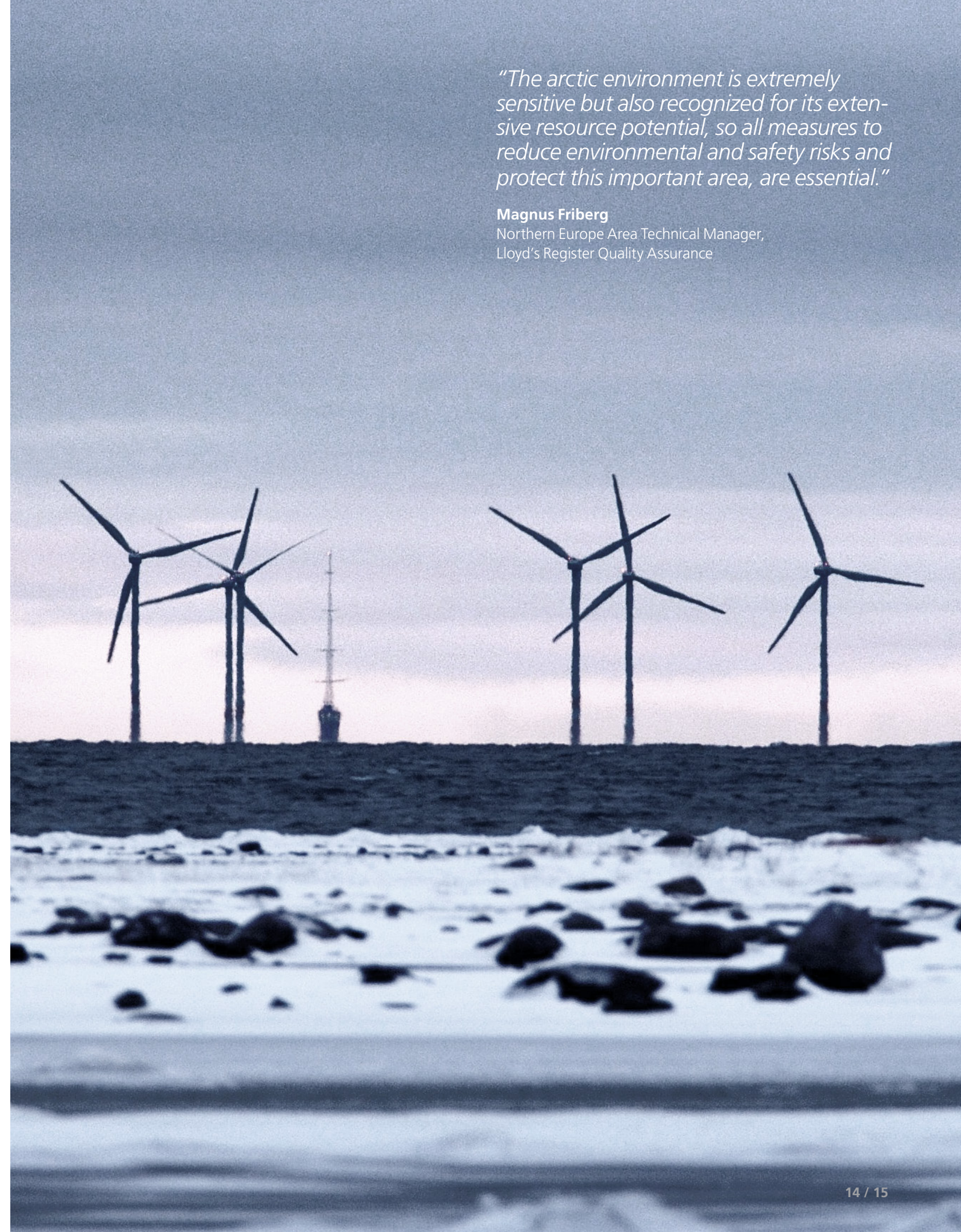
Coming back to you

Beyond all the standards, we always come back to you and your specific needs. How can we help you reduce maintenance costs? Improve service? This might involve everything from providing full technical advice on application suitability, mechanical data, batch production, material supply and logistics.

“The arctic environment is extremely sensitive but also recognized for its extensive resource potential, so all measures to reduce environmental and safety risks and protect this important area, are essential.”

Magnus Friberg

Northern Europe Area Technical Manager,
Lloyd’s Register Quality Assurance



WE DON'T HAVE POLAR BEARS BUT NOT FAR FROM IT

One of our experts in cold-climate steels made the comment: “We don’t need an attitude to be cool – nine months of the year we have no choice.” It made us chuckle, but we also realized it was more than true. Perched on the northern rim of Europe and located close to the Arctic Circle, we have our origins in a “cold” steelmaking tradition that dates back more than 400 years.

You could say that working safely in cold environments is in our DNA. In fact, we expect nothing less from our products, especially for the oil and gas, shipbuilding and other demanding industries. And while we may not have the world record of -89.2°C (Antarctica), we have witnessed temperatures dip to -51.4°C in Kittilä, Finland (Lapland) and -53.0°C in Malgövik, Sweden. Even the polar bears were keeping away those days.

| COUNTRY / REGION | TEMPERATURE | TOWN / LOCATION | DATE |
|---------------------------|--------------------|--|------------|
| Antarctica* | -89.2°C (-128.6°F) | Vostok Station | 1983-07-21 |
| Russia | -68°C (-90°F) | Verkhoyansk and Oymyakon, both in Sakha Republic | 1892-02-07 |
| Canada | -63°C (-81°F) | Snag, Yukon | 1947-02-03 |
| United States, Alaska | -62°C (-80°F) | Propect Creek, Alaska | 1971-01-23 |
| United States, contiguous | -57°C (-70°F) | Rogers Pass, Montana | 1954-01-20 |
| Finland | -51.5°C (-60.7°F) | Kittilä, Lapland | 1999-01-28 |
| France | -41.0°C (-41.8°F) | Mouthe, Doubs | 1985-01-17 |
| Germany | -45.9°C (-50.6°F) | Funtensee, Berchtesgadener Land, Bavaria | 2001-12-24 |
| Iceland | -37.9°C (-36.2°F) | Grímsstaíir | 1918-01-21 |
| Norway | -51.4°C (-60.5°F) | Karaskjok, Finnmark | 1886-01-01 |
| Sweden | -53.0°C (-63.4°F) | Malgövik, Västerbotten County | 1941-12-13 |

* Lowest temperature ever recorded Source: Compiled from recognized international meteorological bureaus.

OVAKO HOFORS-HÄLLEFORS
Premium-quality steel products of high cleanliness and fatigue strength. Used primarily for components in bearings, diesel engines, oil & gas, mining and other special products. New ring mill for bearing steel and other demanding applications.

OVAKO SMEDJEBACKEN-BOXHOLM
Primarily alloyed engineering steel produced using advanced rolling to very tight tolerances. Products such as bolts and fasteners are used for transport, agriculture, rail and other demanding industries.

OVAKO IMATRA
Long steel products such as bar and rod for machining and forging. Consistent high quality designed for high-productivity cutting. Forged precision parts, including bolts and fasteners, for use in mining, offshore, shipping and automotive industry.



WHAT SUB-ZERO STEEL WILL YOU LEAVE OUT IN THE COLD?

We’re sometimes asked how our steels perform in the cold. “Will this IQ-Steel maintain its isotropic properties on a pipeline in Alaska at -60°C?” “We love our M-Steel, but can it handle -101°C offshore?” To guide you, we’ve gathered examples of applications and how our steel measures up to standard – often setting a standard within the standard.

EXAMPLES OF SUB-ZERO STANDARDS FOR DEMANDING APPLICATIONS

| | | | | Standard requirement | | | | |
|---------------------------------|----------------------|--|---|----------------------|------------------|-----------------|-------------|------------------|
| Application Area | Example of Standards | Scope of Standard | Standard Specifics | Yield Strength | Tensile Strength | Impact Strength | | Sample Direction |
| | | | | MPa (min) | MPa (min) | Temp (C) | Joule (min) | |
| Oil & Gas | API 6A | Spec for Wellhead and Christmas Tree Equipment | Temperature classification L through V PSL 1 to 4 75K | 517 | 655 | -46 | 20 | L |
| | API 6D | Spec for Pipeline Valves | | | 689 | -29 | 34 | L |
| | API 16A | Spec for Drill-through Equipment | Temp Rating T-20 75K | 517 | 655 | -29 | 20 | L |
| | API 16C | Spec for Choke and Kill Systems | Temp Rating A, B, P and U 75K | 517 | 655 | -29 | 20 | L |
| Construction | EN ISO 898-1 | Bolts, screws and studs with specified property classes | Property class 10.9 | 940 | 1040 | -20 | 27 | L |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | EN 10269 | Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties | 25CrMo4 | 440 | 600 | 20 | 60 | L |
| | ASTM A320 | Spec for... Bolting for Low-Temperature Service | Grade L7 | 725 | 860 | -101 | 20 | |
| Mobile cranes & Lifting devices | EN 13001-3-1 | Cranes General Design - Limit States and proof competence of steel structures | S355 | 315 | 490 | -40 | 27 | L |
| | | | | | | | | |
| | EN 17115 | Steels for welded round link chains and components | 23MnNiMoCr5-4 | 1060 | 1180 | 20 | 60 | L |
| | | | | | | | | |

EXAMPLES OF HOW SZ-STEEL MEASURES UP TO STANDARD

| | | | | Exampels of suitable Ovako grades | | Typical data of Ovako grades | | | | | |
|---------------------------------|----------------------|--------------------|------------------------|-----------------------------------|------------------|------------------------------|-------------|------------------|---------------------------|----------------------|--|
| Application Area | Example of Standards | Ovako Grade | Corresponding Standard | Yield Strength | Tensile Strength | Impact Strength | | Sample Direction | Products | Max. Dia / wall (mm) | |
| | | | | MPa (min) | MPa (min) | Temp (C) | Joule (min) | | | | |
| Oil & Gas | API 6A | Ovako 326C | AISI 4140 | 600 | 740 | -50 | 150 | L | Bars, Tubes, Rolled rings | | |
| | API 6D | Ovako 281T | 19MNV5 | 620 | 740 | -40 | 115 | L | Rolled rings | | |
| | API 16A | Ovako 322D | AISI 4130 | 620 | 730 | -50 | 100 | L | Bars, Tubes, Rolled rings | | |
| | API 16C | Ovako 322D or 322Q | AISI 4130 | 620 | 730 | -50 | 100 | L | Tubes | | |
| Construction | EN ISO 898-1 | Cromobolt | 42CrMo6 F | 980 | 1100 | -60 | 46 | L | Bars | 60 | |
| | | Imacro | 4Cr16 F | 780 | 900 | -40 | 40 | L | Bars | 140 | |
| | | SB27M12CB | 27MnCrB5-2 | 1000 | 1070 | -40 | 85 | L | Bars | 35 | |
| | | SB30M12CB | 30MnCrB5-2F | 1030 | 1090 | -40 | 65 | L | Bars | 42 | |
| | | SB29M10CB | | 1050 | 1100 | -40 | 55 | L | Bars | 50 | |
| | EN 10269 | 25CrMo4 | | 460 | 650 | -40 | 120 | L | Bars | 100 | |
| Mobile cranes & Lifting devices | ASTM A320 | Imatra L7 | | 970 | 1085 | -101 | 27 | L | Bars | 30 | |
| | EN 13001-3-1 | 520M | | 400 | 520 | -40 | 27 | L | Bars | 100 | |
| | EN 17115 | 23MnNiMoCr54 | 23MnNiMoCr5-4 | 1060 | 1180 | -40 | 50 | L | Bars | 70 | |
| | | Ovako 277 L | | 660 | 800 | -40 | 90 20 | L T | Bars, Tubes, Rolled rings | 160 | |
| | | Ovako 277Q | | 660 | 800 | -40 | 90 60 | L T | Bars, Tubes, Rolled rings | 120 | |

CHOOSE FROM MANY SHAPES AND FORMS

Demanding customers all over the world rely on Ovako to deliver safe and reliable steel in a wide range of shapes and forms. Our products are therefore characterized by durability, uniformity, close tolerances and small machining allowances. Our rigorous quality control ensures our products are consistent from batch to batch and easy to process further. This simplifies manufacturers’ production processes and helps to reduce costs.



FORGED BAR

Square forged bar in dimensions 200 – 400 mm. Round forged bar in dimensions 220 – 350 mm. Dimensions outside these ranges can be provided upon agreement.



HOT ROLLED BAR

Available in a wide range of sizes from 14 – 200 mm. Characterized by close tolerances and excellent dimensional properties and surfaces.



COLD-WORKED BAR

Ovako’s peeled bar in optional sizes in the 20 – 195 mm diameter range. Ovako’s drawn bar in the 11 – 55 mm diameter range. Ovako’s ground bar in the 12 – 100 mm diameter range.



HARD-CHROMED AND NICKEL-PLATED BAR

Cromax is Ovako’s brand for hard-chrome plated bars and tubes. Nikrom is the name for Ovako’s nickel-plated bars.



SEAMLESS TUBES

Tubes are available in hot-rolled or coldworked condition. Produced in sizes between 30 – 245 mm OD and possible to have cut to part length.



STEEL GRADES AND HEAT TREATMENT

A large number of steel grades and a menu of heat-treatment processes are available to meet your demands.



PRE-COMPONENTS

Going for pre-machined components allows customers to minimize stockholding, crosscutting and machining.



ROLLED AND FORGED RINGS

Cylindrical, profiled or machined rings with geometry close to the final shape of the product. Full dimensional range from diameter 170 – 4000 mm and weights up to 5000 kg.

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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