BOLTED

A MAGAZINE ABOUT BOLTING TECHNOLOGIES

ISSUE 1 - 2022

THE OBVIOUS BUSINESS CASE FOR SUSTAINABILITY

SECURED BY
How can smart products redefine bolt maintenance?

INDUSTRY INSIGHT
Reducing the carbon footprint of mineral mining

NORD-LOCK GROUP

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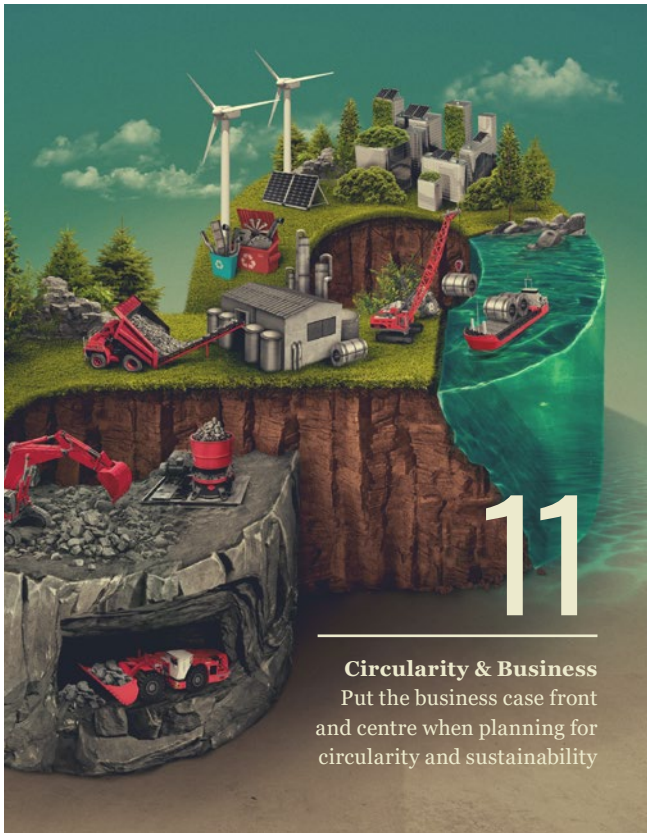

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Fredrik Meuller
CEO Nord-Lock Group

40 years shaping the industry, and industry 4.0.

Traditional engineering has long been at the core of our expertise, now we're adding digital bolting to our toolbox.

With three upgraded Nord-Lock Group facilities officially inaugurated in the past year, our enhanced production is now more sustainable, more accurate and more efficient than ever before. We're proud to have this solid operational platform to build upon. At the same moment, we are also celebrating forty years since our original wedge-locking technology was first developed out of a small red barn in Mattmar, Sweden.

Nord-Lock washers are still manufactured in this small village, today in a state-of-the-art production facility with less waste, less chemicals, and a lower environmental impact. It's important to us that our products are not only the best locking solutions on the market from a technical perspective, but that they also continue to build on our DNA as the original manufacturer of the best wedge-locking technology on the market.

Year-round cold water from the adjacent Indal river is channeled into the facility's cooling system, reducing the need for electricity. One hundred percent of production heat is recovered to heat the building, plus all incoming energy is from renewable local sources including wind and hydropower.

Sustainability is high on everyone's agenda, and every industry will impact the transition to net zero emissions. In this issue of Bolted magazine, we share insights from those who are building circular economies and highlight initiatives for climate-smart mining.

Elsewhere, what if you could automate the monitoring and maintenance triggers of critical but remote infrastructure? Our partnership with Revotec is a smart example of Superbolt LST, an industry 4.0 bolting technology, being used to innovate railway maintenance with reliable, remote preload monitoring.

We speak to an expert in crane track maintenance about the 'arteries of industrial production', as well as sharing our own findings about bolted joint security on offshore painted surfaces. Also, do you know what the connection between animals and big bolts is?

Plus, read about a Las Vegas tourist attraction that's taking no gambles on safety. Find out about all of this and more bolting applications inside the issue.

Enjoy reading!

LOOSE FASTENERS CAN DERAIL ENTIRE TRAINS

Vibrations, dynamic transverse forces, and high speeds require the highest safety standards in rail transport.

Worst case: loose bolts can lead to deadly accidents. Dinghan SMART Railway Technology relies on fastening expert Böllhoff and Nord-Lock wedge-locking washers to fasten auxiliary power converters.

Text Tomas Lundin
Photos Andrea Berg/Shutterstock and Dinghan SMART Railway Technology

Dinghan SMART Railway Technology is a global supplier of onboard converters for rail transport. The company's site in Kassel, Germany, supplies the world market with devices such as air-conditioning converters and onboard converters for a wide variety of train types.

The company's so-called SMARTconverters transform the voltage of the traction current to suit auxiliary applications, such as air-conditioning systems or onboard lighting. They find use throughout the entire field of rail transport, from long high-speed trains to metros, urban railways, and commuter trains that run continuously in metropolitan areas.

Dinghan SMART's onboard converters have been trimmed for light weight while maintaining high efficiency. They meet all European safety standards, but their modular design means they are also adaptable to the special needs of fast-growing markets outside of Europe. Moreover, there are practically no limits to the placement and mounting of the systems, which weigh up to 700 kilograms. They can be supplied as roof-mounted, underfloor, or "open-frame."

Dinghan SMART's onboard converters can weigh up to 700 kilograms

Junkers test sealed the deal

For the third generation SMARTconverters, Böllhoff, a German manufacturer of connection systems, has developed a solution that focuses on reliability and absolute safety. Various securing methods were discussed with Dinghan SMART in advance, and on-site tests were carried out with a mobile Junkers vibration test stand. For example, under-head bolts were tested meticulously. The results were unambiguous.

"The tests confirmed what we have known for a long time. Nord-Lock's wedge-locking washers are the safest and most universal locking method for such safety-critical projects," says Christian Haase.

Haase is the Certified Fastener Engineer DSV® for the ECOTECH application technology at Böllhoff , a family-owned company founded in 1877.

The decisive factor in this case was that the bolt connections that should be secured in the SMARTconverter are made of stainless steel. And there are hardly any solutions in this area that ensure sufficient anti-loosening under dynamic load.

"For example, underhead-toothed bolts made of stainless steel would be too soft to guarantee a durable tight fit," Haase says. "That is why we chose Nord-Lock's stainless steel wedge-locking washers for Dinghan SMART's auxiliary power converters."

Loose bolts pose a severe hazard

In rail transport, the challenges are particularly significant. High loads caused by vibrations and dynamic lateral forces must be mastered, and absolute safety must be guaranteed. After all, many people are transported around the clock, and heavy goods are driven through sometimes densely populated areas. Failures due to material fatigue or loose connections can be disastrous.

"In the worst case, there is a danger to human life," warns Haase. "For example, if components such as winding material of the auxiliary converter come loose due to loosened fastenings and fall onto the rails, there is a risk that the train will derail. Therefore, you should never underestimate the importance of the inverter fastenings."

And the danger is not just theoretical; it has been shown in real life. For example, in 2010, a door came loose on a Deutsche Bahn high-speed train. It happened during the passage through a tunnel when the fasteners could not withstand the negative pressure. As a result, the door was torn loose and crashed into an oncoming ICE (Intercity Express) train.

Safety requirements have always been high at Deutsche Bahn but have since been tightened even further. As one of the world's leading rolling stock manufacturers for rail transport, they now only use Nord-Lock safety devices in Germany for connections of size M10 and larger with the corresponding safety class according to DIN 25201-4 in outdoor applications.

When safety is decisive

Dinghan SMART Railway Technology, a long-standing Böllhoff customer, focuses exclusively on international rail transport. For example, SMARTconverters are used in Alstom's Metropolis trains in Barcelona, Deutsche Bahn's double-decker trains, Dutch ICM trains, and the Naples metro.

When secure bolted connections are required, the company consistently relies on Nord-Lock washers, even when there are lower-priced fasteners available on the market. Because at the end of the day, what counts most is safety and durability under heavy loads.

In particular, this goes for the third generation of SMARTconverters, which are primarily used in public transport, whether for long or short distances.

Strong focus on customer satisfaction

"Safety was the decisive reason for choosing the wedge-locking safety washers from Nord-Lock," emphasizes Christoph Engemann, Group Manager Mechanical Engineering at Dinghan SMART. "As a supplier of onboard power converters, Dinghan SMART is also concerned with customer satisfaction."

Putting the focus on customer needs, Engemann concludes that, "To exaggerate a bit: if fewer bolts come loose in daily train traffic, fewer bolts subsequently need to be retightened. And you can minimize the maintenance work and the associated vehicle failures."

The need for renewable energy is seemingly mutually exclusive to increasing demand for mineral extraction. Mining is crucial to build green technologies including solar panels, wind turbines and lithium-ion batteries, but the industry itself must decarbonize to meet global sustainability targets.

ELECTRIFICATION IN MINING

SPARKS OF A LOW-CARBON FUTURE

Text Ulf Wiman **Photo** Roman Korotkov/Shutterstock

As you read this, the world's population is racing towards the 8 billion mark, described as the estimated sustainable population on our planet. Predictions put the number at 9-10 billion by 2050. To satisfy the growing demands of this, we will need to significantly ramp up production of almost everything you can think of.

This places the mining industry firmly in the spotlight. Because, as it is sometimes put: if it's not grown, it ultimately comes from mining. So, for example, when the growing global middle class drives an accelerating demand for products such as mobile phones and cars, it consequently drives a massive demand for metals and minerals.

This demand is multiplied by sustainability and circularity trends, and the so-called clean energy transition aiming at a net-zero emissions future. Today, energy consumption and production account for two-thirds of global greenhouse emissions, and 81 percent of the worldwide energy mix remains based on fossil fuels. So if we are to meet the Paris Agreement targets, such as limiting the global average temperature increase, things will have to change.

Exploding demand for clean energy

It will be challenging to meet the future demand for clean and renewable energy. The World Bank Group estimates that the production of graphite, lithium, cobalt and other minerals may increase by an extraordinary 500 percent by 2050.

These minerals are needed to manufacture equipment such as solar panels and wind turbines, but also lithium-ion batteries which are essential for the clean energy transition, powering electric vehicles for example.

While recycling and re-use can go some way in meeting the demands, we need to ramp up the mining of the required minerals and metals significantly. And here is the thing: the mining industry doesn't exactly have an environment-friendly track record. So, the seemingly inevitable future convergence of clean energy and mining might seem like an odd pairing.

Minimizing climate and material footprints

However, things are changing in the mining industry. Along with safety and productivity, sustainability and social responsibility are critical drivers for change. With growing environmental and climate change awareness, the pressure from governments, investors, the public, and other stakeholders increases.

Many initiatives support positive development, such as the World Bank's Climate-Smart Mining (CSM) Initiative. It champions "the responsible extraction, processing and recycling of minerals needed for low-carbon technologies by minimizing their climate and material footprints, from extraction to end-use, by scaling up technical assistance and investments in mineral-rich developing countries."

CSM has devised twelve climate-smart building blocks, divided into four groups:

They complement several of the United Nation's sustainable development goals (SDGs). Especially SDG 7, "access to affordable, reliable, sustainable and modern energy for all," and SDG 13, taking "urgent action to combat climate change and its impacts."

Covering the entire supply chain

However, in an interview with *mining-technology.com*, Riccardo Puliti, Global Director, Energy and Extractive Industries, World Bank, says an across-the-board global shift to clean extraction techniques will be difficult. There are simply too many variables.

Still, he says, "There is a need to look at the whole mineral supply chain to minimize the impacts and promote best practices. While innovation is happening, it is often concentrated in isolated corners of the world."

"We need a much faster and wider spread of knowledge about best available technologies in this space, and widespread adoption of these by the mining industry globally."

Aiming to reduce their carbon footprint and become more sustainable, an increasing number of mining companies are acting, both regarding their operations and throughout their value chain. Initiatives such as turning to low-carbon renewable energy and using innovation to improve efficiency and productivity in the extraction are essential, but so are, for example, water and forest-smart mining, innovative waste solutions, and adoption of a more circular business model.

Climate-smart mining building blocks

Source: Climate-Smart Mining (World Bank)

Strong governance and adequate regulatory framework

CLIMATE MITIGATION	CLIMATE ADAPTATION	REDUCING MATERIAL IMPACTS	CREATING MARKET OPPORTUNITIES
Integration of renewable energy in the mining sector	Forest-Smart Mining with landscape management	Adoption of a circular economy for low-carbon minerals	De-risking investment for low-carbon minerals
Innovation in extractive practices	Resource efficiency in mineral value chain	Reuse and recycling of low-carbon minerals	Leverage carbon finance instruments
Energy efficiency in mineral value chain	Innovation waste solutions	Low-carbon mineral supply chain management	Robust geological data management

Gender and multi-stakeholder engagement

Expected to make a positive contribution

Australian BHP Group Limited was one of the pioneers in this area, setting emission targets as far back as 1996. BHP's Climate Transition Action Plan 2021 outlines their "strategic approach to reduce greenhouse gas (GHG) emissions to net-zero within our operations by 2050 and to work with customers and suppliers to support their own emissions reductions, consistent with the ambition of pursuing net-zero in our value chain."

Other industry giants, such as Anglo American and Rio Tinto, also have comprehensive sustainability plans. The former writes, "Our industry must address critical challenges of safety, productivity, and the way we use land, energy, and water."

"Modern society rightly expects the mining industry to make a positive contribution to socio-economic development in a sustainable way by reducing its environmental footprint and supporting biodiversity."

That's all good, you might say, but how is the daily operation changing?

The electrification of mining

Riccardo Puliti mentioned the spreading and adoption of the best available technologies. More environment-friendly equipment is a way to change, and many mining companies are turning to electric instead of diesel vehicles. There are many benefits.

In fact, electrification has been described as one of the decisive technology shifts in mining, together with automation and digitization.

The reduced carbon emissions benefit the environment. But electrification can also significantly lower operating costs when the need for elaborate ventilation systems in underground mining is reduced. Especially as underground mines continually need to dig deeper to reach new deposits.

Operator health and well-being also improve considerably when the working environment is devoid of diesel exhaust fumes. And generally, battery electric vehicles (BEVs) are smaller sized for the same loading capacity.

Working together for change

As autonomous and battery electric vehicles increasingly become the norm — linking back to the clean energy transition — equipment manufacturers rely on innovation and partnerships to meet their own and their customers' needs.

Partnerships and collaborations seem likely to increase in number. For example, Caterpillar announced in August 2021 that they would work with BHP to develop zero-emission battery-powered large mining trucks.

Caterpillar writes that, "BHP will have early access to the Caterpillar-developed zero-emissions equipment and will provide input to the developing and testing processes. The resulting collaboration will shape the processes, technology and infrastructure that will ultimately support zero-emissions machines and mine sites of the future."

A future benefitting everyone

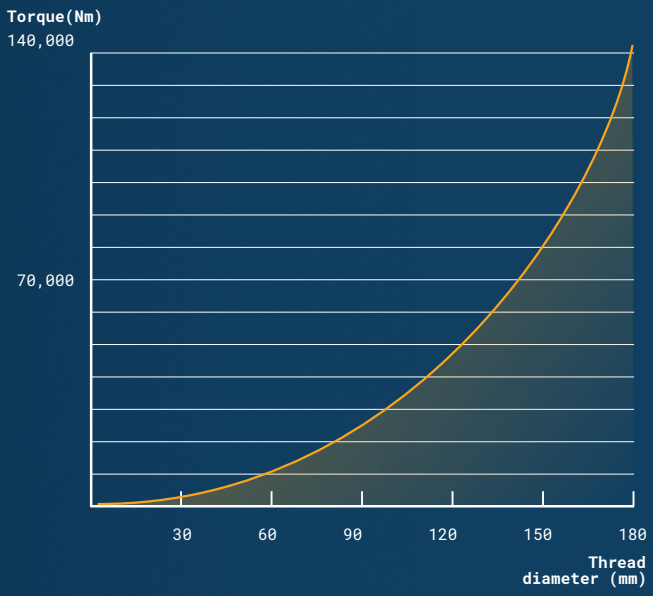
So, while the development and adaption of climate-smart mining are beginning to gain momentum, there is still a long way to go. But, hopefully, the various industry initiatives and those of individual companies will keep the ball rolling.

Because, as the demand for minerals and metals continues to grow — to a great extent driven by the needs of the clean energy transition — the mining industry must resolve the sustainable road forward.

In his foreword to the 2020 CSM report Minerals for Climate Action, Riccardo Puliti concludes that, "by working together to reduce the carbon and material footprints of minerals, we can support the large-scale deployment of renewable energy and battery storage technologies required to meet ambitious climate targets and achieve a low-carbon future that benefits everyone."

HOW MUCH FORCE IS REQUIRED TO TIGHTEN A BOLT?

Torque curve for 310 MPa bolt stress



$$T = (c)D^3$$

T = Torque
c = Constant
D = Bolt diameter

Thread size [mm]	M24	M30	M48	M64
Preload [kN]	145	214	700	1,270
Torque [Nm]	615	1,134	5,937	14,362
Force needed* [kg]				
	62.6	115.4	604.0	1461.0

*Force needed with a 1-meter lever

Did you know that there's a connection between animals and big bolts?

That's right! It's possible to compare an animal's weight with the force it takes to achieve a specific torque. Clever, isn't it? The weight of a cow, for instance, is the force it takes for a torque of 5,937 Nms using a 1-meter lever!

Torque force grows exponentially as you work with larger bolts, but it's not always easy to understand just how much power is needed to achieve said torque force, so the animal's weight gives us a useful comparison. By comparing against an elephant, it becomes clear that if you're working on really large bolted connections then you need to work extremely hard to generate the required torquing force.

Luckily, there is an easier way to tighten large bolted connections than using the force of an animal — and that's by using tension instead of torquing. Depending on your application, Nord-Lock Group has two distinct and innovative solutions:

The first: Boltight hydraulic tensioners
Boltight has been at the forefront of hydraulic bolt tensioning for over a decade. Our tensioning tools provide fast, accurate and safe solutions to tighten and loosen multiple bolts safely and simultaneously, with less effort. Using high-pressure hydraulics, bolt tensioners stretch the bolt before the nut is wound down under no preload, ensuring extreme accuracy, speed and uniformity.

The second: Superbolt multi-jackbolt tensioners
Superbolt was the world's first to revolutionize nuts and bolts with multi-jackbolt tensioning (MJT) technology. The technology has been proven in tens of thousands of successful installations and continues to develop a multitude of solutions to solve the next generation of bolting challenges. Superbolt MJTs take the high preload requirements in large diameter bolting and break it down into manageable torques using the jackbolts threaded through the nut body.

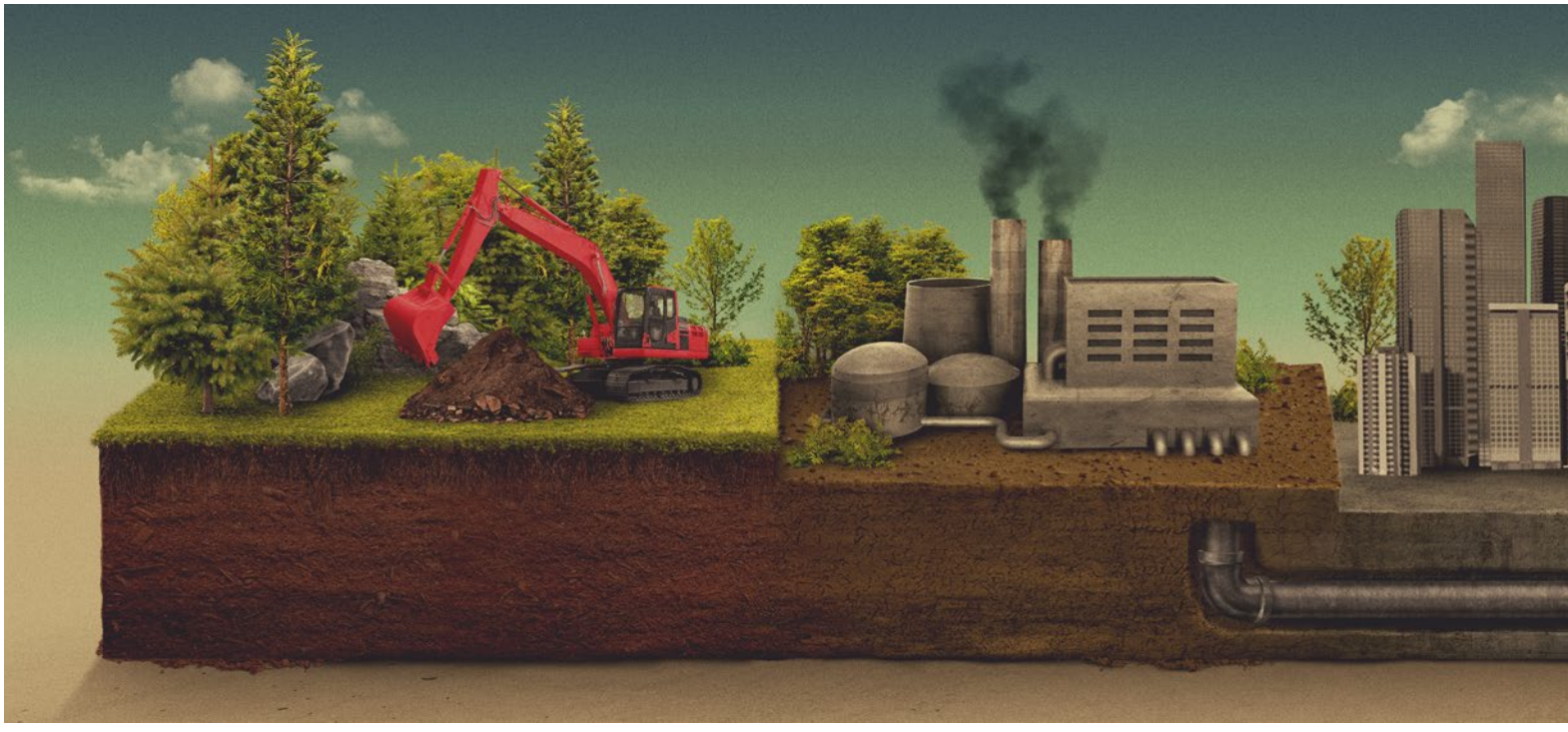
Previously in Bolted #1 2020, we reflected upon the need for more sustainable use of industrial raw materials in 'The Path to Green Steel'. In this issue, we develop that focus into a theoretical overview and practical example of the circular business strategy.

For an introduction to the fundamentals of the circular economy and circular design, go to: **www.nord-lock.com/circular**

THE OBVIOUS BUSINESS CASE FOR SUSTAINABILITY

Sandvik is a global engineering group specializing in the manufacture of tooling systems for advanced industrial metal cutting, mining equipment, construction equipment, advanced stainless steels, and special alloys. The company also has a deep history of social responsibility.

We spoke to Mats W. Lundberg, Head of Sustainability, about the group's ambitious sustainability goals and how, in his opinion, any organization can make the shift to a circular economy.



Let's start at the very beginning. How does a multinational engineering company begin to think about circularity?

Well, at least when I think about circularity, it's about business possibilities. When you talk about sustainability in general, you need to put business front and center. Because what is the purpose of sustainability? It's to make money, save money, reduce risk and have a positive impact on the environment. That's the big scope of what you are trying to do.

You might start by looking at risk and raw materials, for example. Depending on your industry, there can be a limited number of suppliers and there's a variance between the levels of quality control in different countries. Your suppliers may pose a risk to the core values or even the reputation of your own company, so you sometimes must handle and mitigate risk.

One way to do so can be to make suppliers sign and comply with codes of conduct. But it's not always a perfect scenario. One benefit of introducing circularity is that you replace virgin raw material with circular material by recycling from products that have already been in use. Then you become less dependent on a risk associated area.

Let's take it another step. Suppose I sell a mining machine or metal tube to a customer, but I also offer to buy that product back when it has reached end-of-life. From a customer point of view, the product has become scrap at its end of life, but instead of selling it to a scrap dealer they can be incentivized to sell directly back to Sandvik. The material can then be reused as raw material once again.

To be able to buy back a used product from a customer is also an advantage for Sandvik as we know the exact content and chemistry, maybe even the batch number, of our own products. Instead of random scrap, we can use those tubes in a new melt and know that we already have almost the exact composition for what we want to produce. You need a small amount of virgin material at the very top to calibrate the perfect mix - in the same way you might add a little salt and milk to a shake-and-bake bread mix to get the taste right.

At Sandvik, we call this secondary raw material, not scrap. Secondary raw material is also less expensive than virgin raw material and it has a smaller environmental footprint. This is a benefit for both Sandvik and our customers. By designing a closed loop system together, we help customers handle scrap, and with less demand for virgin raw material the environmental impact is smaller.

From a financial perspective, a closed loop system like this is helping us to save money on raw materials and mitigate risk at the same time as we are increasing sustainability. In short, a perfect example of how circularity is also beneficial for business. This is an example that can be used as a guide to start thinking in new and more circular ways to find other business cooperations or product lines where a similar approach could work.

You present circularity with such a strong business case. Why would an organization not already be pursuing it as a sustainability goal?

The problem is that the traditional linear economy is built on multiple transactions. You look at whether your inputs are expensive on one end and calculate your earnings at the point of sale on the other. But when you're building a circular economy, you're figuratively bending that straight line so that the two ends meet, suddenly your raw materials buyer and the sales teams will start to cooperate because one needs to buy product back from the other.

It has to be a transition, so that's why we call our sustainability strategy, 'make the sustainability shift'. The infrastructure needs to be implemented, production facilities might need to be adapted and business models redesigned.

There's also a mental shift away from 150 years of a linear economy, so you can't transform an entire company in one go, it will probably take 10 or more years of iteration to get everything in place. That's why it's important to realize there is a business case, we're not doing sustainability only to tackle climate change, it's about both.

Circularity works when you build the business case. Some raw materials, like plastic, are too cheap to implement a buy-back. That's a limitation, but steel is an expensive raw material, so circularity makes a lot of sense for us in mining and steel manufacturing.

The more circular you get, the more savings you will realize because you might have missed some possibilities before moving to a new business model. If I have a tube, why should I sell it? Why shouldn't you rent the tube instead?

What happens if you go over to the 'rent instead of sell' mode?

Well, then I would like to develop sustainable tubes that never break, because I want you to rent it forever, right? From a sustainability point of view, that is great because then less material is out in circulation. That's great for the environment and from a business point of view, I get paid every month.

Your product might become more expensive to make, but now it's designed for 'forever' use and guarantees you a monthly income. When the customer no longer needs it, we get our raw material back and can use it to produce a new product.

It takes thinking outside of the linear box that we've been locked into. Ultimately the circular economy is what we did before money: we traded, repaired and reused.

Extreme linear supply chains only arrived because things became so cheap to manufacture. There isn't the same financial pressure to be resourceful with consumption when you can throw things away. But now we're realizing the business benefits of the circular economy; high resourcefulness is back on the table.

Convinced by the business case, and knowing that change could take a decade, what can you do in the first year to move in the direction of circularity?

Five years ago, I started to look at: where is it easiest to change? Don't fight against impossible odds with the grand notion that everything should be circular overnight. Instead, go where you can build the business case.

Forcing sustainability on people will only make the organization frustrated, then you've lost hope of gaining momentum. Despite Sandvik being a business-to-business company, the first thing I did was to look at our products closest to the consumer market.

Sandvik is manufacturing strip steel that our customers are then using to produce kitchen knives and razor blades, for example. Consumer research concluded that, on average, women are the main purchasers of household goods in Europe. Women were also more likely to buy an ecological product. Then you see an opportunity to brand a 'green' razor blade or 'eco' kitchen knife as it will be appealing to your customer.

The opportunity to collaborate with the manufacturers and repackage the same product by adding sustainability as 'value' improves their product portfolio. By also offering to buy back the strip steel that is otherwise scrapped when they're making these razors or knives, gives them double points — green steel and a circular economy.

With a good business case, you're no longer just the person who's preaching about the environment. I'm not telling you that the world is burning, I'm telling you how to make more money and tackle climate change.

Then you're opening people's minds to it in a positive way and that will influence decision makers in other departments to also look for those simple entry points.

When you talk about business-to-business, how do you convince a mining machine customer to think about circularity?

First, I would make sure that we're not talking about surface mining, we're talking about the underground, because that is where you have the interesting business case to begin with.

If you go with a battery powered electric vehicle instead of a combustion engine, you generate less emissions in the mine. Lower emissions require less ventilation, so it's cheaper to run an electric powered mine than a diesel one — and the deeper you get, the more ventilation costs you're now saving. Switching to electric also reduces the carbon footprint of the ore you are extracting. So in selling the idea of an electric mining machine, you also get the customer thinking about how they will brand their new, greener ore.

Metals and minerals power mobile phones, so you get the mining company talking to a manufacturer who wants to market phones with a lower carbon footprint, because your raw material is now extracted using less CO_2 and less water.

You help your customer to connect the dots and find a toolkit for driving a higher price from what they are manufacturing, based on the new added value passed on to their own customers.

And this works, companies are buying green steel at a higher price because they recognize the added value and consumer demand. From a consumer perspective, it's empowering to buy and use environmentally friendly products. People are buying organic bananas, why wouldn't they also buy an organic Volvo? The difference in price between a green steel car and its regular model is negligible, so it works financially and morally for the customer.

You have stated that Sandvik wants to be 90% circular by 2030. What impact will 90% circularity have?

Many people misunderstand the circular economy as using less material. It's actually about being more responsible and not wasting material that is in circulation. You could build bigger machines, but when it comes to end of life you have to take care of and reuse the materials.

I use the Swedish phrase, "resurssnål", which can translate to being stingy with your resources, mindful of how you use them and avoiding waste.

Throwing things away is too passive and ignores the reality that waste ends up in a physical place, it doesn't disappear from the planet. Circularity uses materials in a more mindful way, reduces landfill and shows responsibility.

For our part at Sandvik, I think by signaling that we want to be 90% circular by 2030 sends a strong message. We want to achieve a change, which means our suppliers need to think differently, our customers need to think differently and certainly, most of all, we need to think differently.

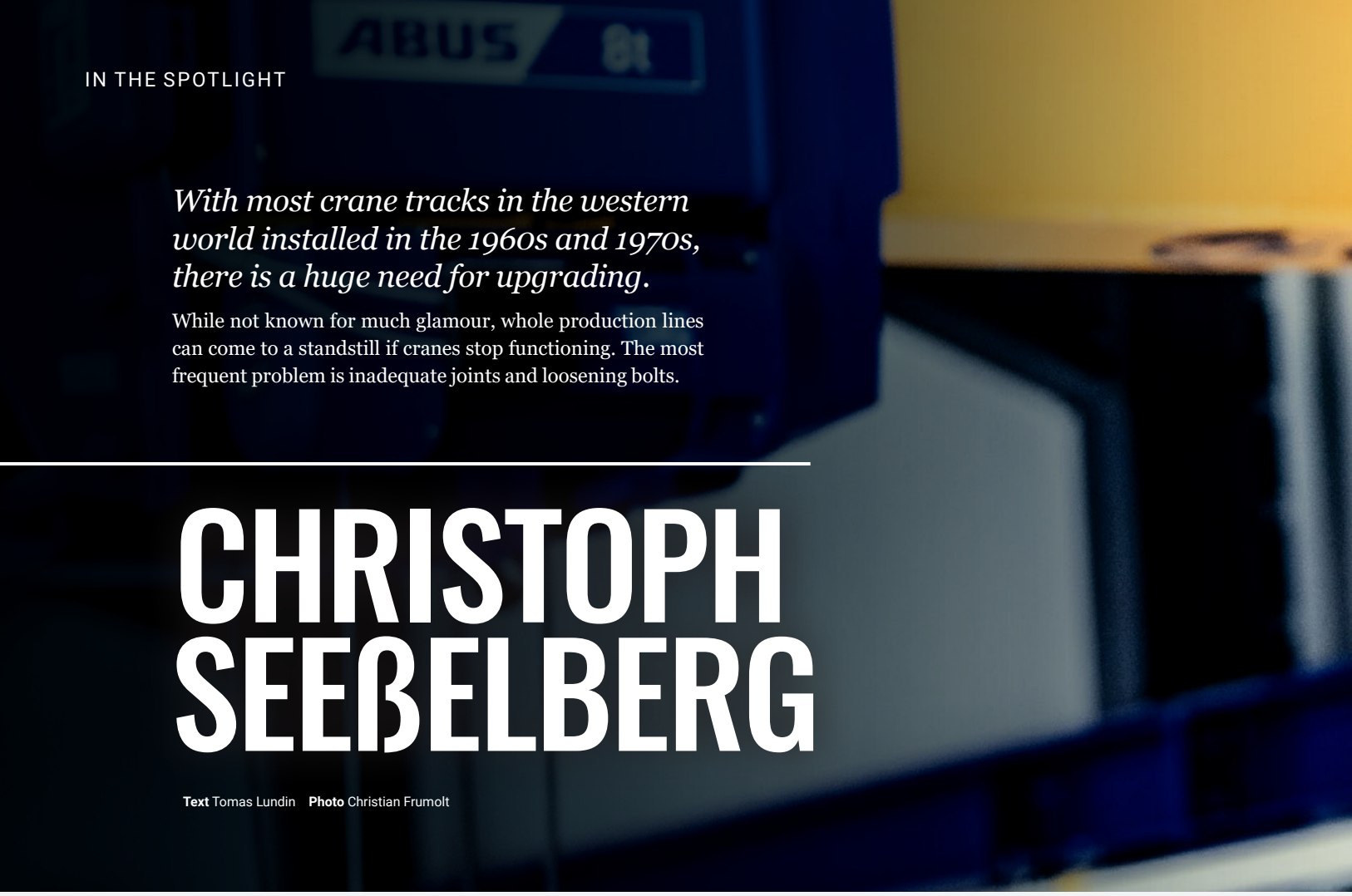
The upside of our ambitious target is phenomenal from an economical point of view, we're talking hundreds of millions if you do this right. Then from an environmental point of view, everything you do right in circularity contributes to tackling climate change. The two are in symbiosis.

And that's sort of it really. Sandvik's purpose is 'We make the shift — advancing the world through engineering'. From my point of view, it's quite difficult to advance the world without making it more sustainable.

Making It Circular: Mining Machines and Manganese Steel

To find out how Sandvik's sustainability strategy materializes at the project level, go to **nord-lock.com/circular**

Text Kelvin Slesser-Marriott **Illustrations** Ju Sting



With most crane tracks in the western world installed in the 1960s and 1970s, there is a huge need for upgrading.

While not known for much glamour, whole production lines can come to a standstill if cranes stop functioning. The most frequent problem is inadequate joints and loosening bolts.

CHRISTOPH SEEßELBERG

Text Tomas Lundin **Photo** Christian Frumolt

You're a renowned expert on crane tracks, and you've had an esteemed career in structural engineering and steel construction. Where has this taken you?

As an officer in the German Army, I studied Civil Engineering at the University of the German Army in Munich. In my spare time, I prepared my thesis. After leaving the Military, I finished my studies with a Doctor of Engineering (Dr.-Ing.) at RWTH Aachen University.

My first job was with the German aerospace company Dornier, which was an unusual place to be for a civil engineer. But I worked on durability and resilience in dynamic constructions, such as bridges and windmills, and then I got hooked on crane tracks. For the last 26 years, I've been teaching and researching at the Munich University of Applied Science, writing books, and advising private companies about crane tracks.

What is so fascinating about crane tracks? At first glance, it doesn't appear to be cutting-edge technology.

You're right. At first sight, crane tracks are pretty boring and not very "sexy". Essentially, there's just a steel beam reaching over one, two, or more fields. But if you look closer, it's really thrilling. It's all about critical infrastructure and ensuring long-term security and durability.

Recently, I advised a German company in heavy industry. They reported a loss of one million euros every day that the crane track was down, and they needed to keep it working while at the same time investing in new cranes. So we found a way to keep the crane running by using a "minimally invasive" parts replacement. It was a fascinating project.

It's just one example of how essential the crane tracks are for almost every industrial sector. Be it heavy industry like steel production, automotive assembly, or light mechanical industry, lifting heavy components is essential.

I like to compare it to an artery. When it's clogged, the production breaks down. When it happens in a blast furnace, it's a catastrophe. It's one of the most underestimated dangers in many industries — nobody is interested as long as they function.

Many installations around the world are aging. How serious is this problem?

In Germany, more than 50 percent of the crane tracks were installed in the 1950s, 1960s, or 1970s. By now, they exceed their technical lifetime of around 25 years by far and need regular maintenance and upgrading. So the question is, should they be replaced, or is it possible to save them for another couple of years while planning for a replacement?

We must be aware that the industry has changed a lot. The lifting loads are getting heavier. And today, the technical norms before 1980 are not adequate anymore. It's a real problem. But I wouldn't say it's a ticking bomb because there are solutions.

What are the primary deficiencies?

Every crane track which is older than 25–30 years will have defects. The main problems are cracks in the steel construction and loosened bolts, or even empty bolt holes. In regular inspections, problems with joints and bolts are the most frequent problem. In my experience, they account for 80 percent of the reported faults. So it's a significant problem.

Unfortunately, the German norm regulating the inspections, the VDI 6200, is not very well known and not consistently applied. If we don't use the norm, there's a risk that problems get so massive that components fall and cause severe accidents.

When it comes to securing joints, what is your preferred solution?

With preloaded bolts, we need to ensure that they don't lose the preload. A perfect way to do this is to use Nord-Lock wedge-locking washers. But regrettably, I receive almost daily proposed solutions with lock nuts or pall nuts, which are entirely unsuitable. This is because many construction engineers are not familiar with dynamic load.

But cranes always produce dynamic load, which means that even perfect preload will lose preload over time. It's amazing how fast this happens. Even I was shocked when Nord-Lock demonstrated the different locking solutions at the Munich University of Applied Sciences. The lock nuts and pal nuts loosened within seconds when exposed to vibrations. Only the wedge-locking washers remained tightened.

Do you foresee any significant developments in the future of crane tracks?

I expect changes in the electronic control systems of cranes, making it possible to adapt to different loads at various parts of the crane tracks. This would make it possible to use older crane tracks longer. Another trend is that we're moving from S235 steel to S355 steel. Finally, the trend is to use wider flange profiles for the beams, which improves stability.

In your view, what is the role of future engineers?

Engineers tend to focus on purely technical matters without asking what it means for society. We must take a broader view and think outside the box. For example, at Munich University of Applied Sciences, the students must study at least two subjects without any relation to engineering topics. Sometimes people deride this as unnecessary, but as engineers, we must get more sensitive and more responsible.

"ALEXA: HOW CAN SMART PRODUCTS REDEFINE BOLT MAINTENANCE?"

Michael Reiterer co-founded Revotec as an international consultancy with expertise in the field of structural dynamics and structural health monitoring.

Text Kelvin Slesser-Marriott **Photos** Jörgen Lindström

Since 2014, the company has been on a mission to achieve status in the development of smart products for engineering structures. "We already developed a reputation for analyzing vibrations and preventing fatigue damage," says Michael. Revotec uses software to make dynamic calculations and evaluate the impact of, for example, vibrations of railway bridges due to train crossing.

This capability resulted in a contract with the Austrian national railway company, ÖBB in 2016. Revotec were tasked with investigating the impact of aerodynamic loads on the railway's noise barriers.

Specifically, Michael recalls "they wanted to know how the fasteners are affected when trains pass at high speed, how does the service life of fastening elements change when preload force is lost and is it possible to continuously monitor preload in those fasteners?"

Aerodynamic load is the force acting on noise barriers when trains pass. Its amplitude depends on the train speed, shape, height of the barrier and its distance from the track axis. It's a pressure wave that forms a maximum amplitude in fractions of a second, creating a shock load that results in fatigue damage to the noise barrier's steel structure.

Unfortunately, the rising speed of trains during the early 2000s has exaggerated this issue. Below 160 km/h you don't really get problems, but Michael tells us "German and Austrain trains now regularly exceed this speed, with some even surpassing 300 km/h". Noise barriers have also been heightened to six or seven meters, multiplying the impact of dynamic vibrations.

Research & Development

"Our main challenge has been to continuously monitor preload force in the fastening elements," adds Michael. Revotec employs a small team of graduate mechanical, electrical and civil engineers. Joachim Muik is one of those colleagues, assigned to a four-year research project developing two prototype solutions for preload detection on bolts, the REVO m-Bolt and REVO e-Bolt.

Joachim found the continuous monitoring that ÖBB were looking for to be a particular challenge, telling us "there's a huge amount of knowlegde behind engineering a nut or bolt that can actually measure the preload force, but it's way more difficult to connect the internet to that bolt."

Was there a solution already out there?

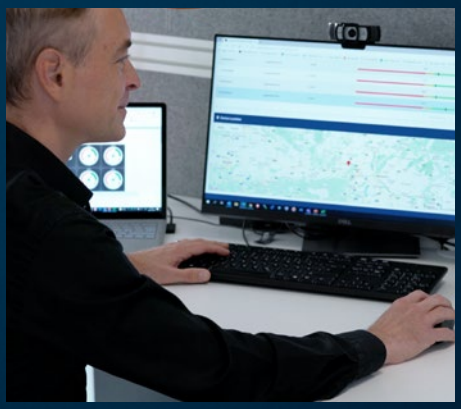
Revotec's core business is consultancy, so as much as Michael has a thirst for innovation, that would never compromise finding the right partner to collaborate with. Besides their own development, Michael learned of Superbolt Load-Sensing Tensioner (LST), Nord-Lock Group's industry 4.0 solution for continuous preload monitoring, thanks to a connection with Thomas Schardax, Nord-Lock Group Sales Engineer in Austria.

After some conversations and a knowledge sharing meet at Nord-Lock Group's office in Lauchheim, Germany, the two parties agreed to tackle ÖBB's problem together. At first Joachim was surprised that Superbolt LST didn't look like a conventional nut, but he quickly saw the benefit upon installation.

Superbolt multi-jackbolt tensioners (MJTs) take high preload requirements and break them down into manageable torques, using the jackbolts threaded through the nut body. For example, to tighten a regular M16 bolt to 80 kN of preload, you'd need 200 Nm of torque. Joachim says that with "Superbolt LST it was only 12 Nm on each jackbolt, which meant I could stand on a ladder and work in tight spaces."

The future of preload monitoring

Installation is simple, but the main innovation is how smart technologies completed this project. Pierre Kellner, Nord-Lock Group's Business Developer for Smart Products, along with colleague Damien Thomas in Lyon and partner Lisab from Gothenburg, supported Joachim through the first installation via a remote live stream at their desks, hundreds of kilometers away.



Joachim Muik with a pair of HoloLens smart glasses

REVOTEC ENGINEERING GMBH

THE COMPANY
EXPERTS IN THE FIELD OF STRUCTURAL DYNAMICS AND STRUCTURAL HEALTH MONITORING.

ESTABILISHED
2014

LOCATION
VIENNA, AUSTRIA

APPLICATION
RAILWAY NOISE BARRIERS

THE CHALLENGE
CONTINUOUSLY MONITOR PRELOAD FORCE IN THE FASTENING ELEMENTS

THE SOLUTION
SUPERBOLT LOAD-SENSING TENSIONER (LST)

"Despite travel restrictions, Joachim's Microsoft HoloLens smart glasses gave us an augmented reality view so that we could 'be there' with Joachim in the field. He'd never installed a Superbolt MJT before, let alone our smart solutions, but with this connection we could be 'his eyes', freeing his hands to do the work. Recording everything also gets rid of the need to take notes," says Pierre.

Once installed, the Superbolt LST provides an accurate, remote and continuous preload reading that can be viewed from a web interface, anywhere in the world.

"Using this technology, we can set trigger levels that automatically inform clients when preload has fallen below a predefined limit," explains Michael.

"We also detected a loss in preload within 72 hours of the first tightening, then another loss of preload after 1 year of monitoring," he continues. With this information, Superbolt LST users like ÖBB can set the optimal intervals for retightening and bolt maintenance, invaluable information for a company like Revotec who specialize in helping clients to avoid fatigue damage in their infrastructure.

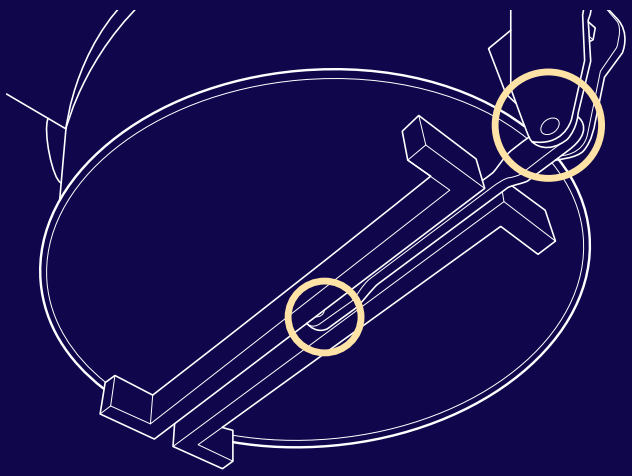
What is the potential for digital tools in industry?

"It's extremely high," says Michael, who feels that predictive maintenance will become more and more important for industrial and infrastructure companies. Part of Revotec's vision is that data recording can be done without any cables or a power supply, instead the train itself records the data of all smart products along the railway tracks and feeds a central database for train operators to plan maintenance schedules.

Joachim adds that "the opportunities are endless, it doesn't matter if it's a noise barrier with simple fasteners or a high-level application like a turbine or pressured applications — this technology can apply everywhere."

"I think, in the same way we're now connecting to home applications like TVs, heating and vacuum cleaners, industries will do the same thing with remote connections to critical components."

It makes life easier not having to be there, and at the same time achieves greater control over maintenance.



REDUCE PIVOT WEAR IN HIGH TEMPERATURE ENVIRONMENTS

Text Kelvin Slesser-Marriott **Photo** Yermolov/Shutterstock

Equipment owners in the steel industry are plagued with the problem of pivot wear, accelerated by the high temperature working environments.

Equipment breakdowns result in downtime and production shortfalls, and these breakdowns often require line boring and welding. For example, the ladles used to transfer molten steel from furnaces to casting often feature pivots in several positions. Because of the high temperatures, the wear and permanent deformation is increased. The bending deformation of the axle often results in the need for cutting, causing labor intensive maintenance.

The solution? Expander System

Pivot positions on the ladle can be fitted with Expander System, which is fixated in the lug ears by its expanding sleeves and thereby significantly reduces the bending and maintenance time to remove the pins, as well as eliminating lug wear completely. Expander System can also include removal features like a flange or threaded holes in the sleeve and pin, making it even more convenient and faster to install and remove with the use of a puller.

DON'T WASTE TIME

Stop boring and guessing how much time a service will take

To line bore and install a traditional straight pin just means that the lug wear process starts all over again, and it is just a matter of time until the same repair process is needed. Using Expander System, besides being much faster and time predictable to remove and install, also means that you do not need to repair the pivot lugs ever again.

Download your free white paper to find out more – **Solutions for the Steel Industry: Eliminate pivot wear and future line boring with Expander System**

THE RECIPROCATING COMPRESSOR

AN OIL & GAS WORKHORSE

Text Ulf Wiman **Photo** Kazutora Soma

Performing fundamental tasks across many industries, Japanese manufacturing giant Kobe Steel relies on Nord-Lock Group solutions to get ahead.

Reciprocating compressors play an essential role in many industries. Commonly applied in the oil & gas industry, they are used to compress and transport gases efficiently, for example. Another example is using them for the high-pressure hydrogen required to remove the sulfur contained in crude oil.

They are also known as piston compressors, which gives an idea of the working principle. The machine compresses or pumps gas through the reciprocating motion of pistons powered by the rotational motion of a crankshaft.

Fundamental in Oil & Gas

Japanese industrial group Kobe Steel — operating globally as Kobelco — offers a wide range of products and services. Back in 1915, the company produced Japan's first reciprocating compressor.

Hitoshi Takagi, Manager of the company's Reciprocating Section in the Compressor Division, says, "Reciprocating compressors are fundamental machines that form the basis of an oil refinery."

Kobe Steel also supplies reciprocating compressors for tankers transporting liquefied natural gas (LNG). Most conventional ships use diesel engines fueled by heavy oil. However, in recent years, dual-fuel engines that run on both heavy oil and natural gas have been put into practical use.

A greener fuel supply system

As air pollutants from ships are increasingly scrutinized, such dual-fuel engines can significantly reduce emissions of sulfur oxides (SOx), nitrogen oxides (NOx), and greenhouse gases to comply with stricter regulations.

CUSTOMER
KOBE STEEL LTD., OPERATING GLOBALLY AS KOBELCO

FOUNDED	HEADQUARTERS	APPLICATION
1905	KOBE AND TOKYO, JAPAN	RECIPROCATING COMPRESSORS

THE CHALLENGE
VIBRATION DAMPENING AND MAINTENANCE IN SMALL WORKSPACE

THE SOLUTION
SUPERBOLT TENSIONERS, BOLTIGHT HYDRAULIC TENSIONERS AND NORD-LOCK WEDGE-LOCKING WASHERS

Takayuki Tomochika
HEAD OF THE RECIPROCATING SECTION FOR KOBE STEEL'S COMPRESSOR DIVISION

Kazuo Kusaba
KOBE STEEL'S MACHINERY BUSINESS

Natural gas is a clean energy source that contains almost no impurities. It is transported in significant quantities by LNG tankers, utilizing the fact that it liquefies when cooled to 162 degrees Celsius below zero, resulting in a volume 1/600th that of gas.

However, it is challenging to prevent vaporization caused by external heat during transportation due to the extremely low temperature. As a result, the vaporized content ends up being discarded as waste. But reciprocating compressors increase the pressure of the vaporized LNG to 300 bar, so it can be used as fuel for such dual-fuel engines, providing an environment-friendly fuel supply system.

Superior vibration dampening

Although offering rugged and efficient performance, reciprocating compressors generally have a large footprint and can cause many vibrations during operation. Kobe Steel uses Nord-Lock washers as well as Superbolt and Boltight series products to tackle these issues.

Using Nord-Lock wedge-locking washers improves safety and reliability, reducing the risk that vibrations loosen bolts. In addition, unlike many other companies, Kobe Steel performs vibration analysis and acoustic analysis in-house, resulting in high analysis accuracy thanks to the accumulated on-site data.

Kobe Steel's reciprocating compressors are notably quiet. Takayuki Tomochika, Section Head of the Reciprocating Section for Kobe Steel's Compressor Division, says: "In the 15 years I have been involved in the compressor business, I have never had a customer complain about the noise."

More efficient in cramped spaces

Apart from the compressor, Kobe Steel's packaging services also include the drum, gas cooler, and other equipment, as well as piping and valves mounted on a base. This enables a compact design — a significant advantage given the limited space in LNG tankers.

These cramped conditions complicate the installation and maintenance of reciprocating compressors. Kobe Steel has found that using Nord-Lock Group tensioning solutions improves work efficiency. They use either Superbolt tensioners or Boltight hydraulic tensioning, depending on the workspace and efficiency of the fastening process.

The Superbolt series is used to fasten the piston rod to the crosshead on the other side of the piston. Previously, a geared wrench with a long handle was used, but this proved problematic in confined spaces. With Superbolt, a regular torque wrench can fasten large diameter bolts, eliminating the need for space or heavy tools.

Providing prompt technical support

Kobe Steel uses Nord-Lock Group's products in machines that must keep running. "We can never stop production because it would cause serious losses," says Kazuo Kusaba at Kobe Steel's Machinery Business.

As compressors continuously get more reliable, the maintenance intervals have lengthened. "But if you can only access the inside of the equipment once every few years, you will not be able to build up the maintenance experience," Kusaba explains. "This makes it difficult for experienced technicians to pass on their skills to the next generation. However, with Superbolt and Boltight, we are now able to quantitatively manage the torque of bolt fastening, which is very encouraging."

Kusaba adds that Nord-Lock Japan is different from other companies because they provide prompt technical support, including engineers, for all kinds of issues. He is thankful that Kobe Steel can rely on them.

With an eye to the future

Across all industries, environmentally friendly solutions are becoming the norm. The United Nation's Sustainable Development Goals (SDGs) are crucial for the future and driving this change.

Kobe Steel is shifting its focus from oil refining to hydrogen energy for the next generation. Their hydrogen compressor units (HyAC® series) are already in use at hydrogen refueling stations, and product development is in progress with an eye to the future.

YOUR BEST BET FOR SAFETY

Powerful forces of nature can potentially cause terrible disasters, and they seem to be on the rise. So, safety and resilience should always be the primary concern when designing large structures, such as bridges, or one of the tallest Ferris wheels in the world.

Text Ulf Wiman **Photo** Diana Gorita/Shutterstock

When the first forerunners to Ferris wheels were constructed — possibly in 17th century Bulgaria — no one could have imagined the sheer size of the Las Vegas High Roller in their wildest dreams. Until late 2021, it was the tallest Ferris wheel globally, rising 168 meters (550 ft) above the Las Vegas Strip towards the Nevada sky, dwarfing the surrounding buildings.

Attached to the rim, which is 143 meters (469 ft) in diameter, are 28 observation cars, each 40-passenger capacity. A complete revolution takes 30 minutes, providing a magnificent view of the surrounding Las Vegas Valley.

Reaching new heights

The name Ferris wheel emanates from the one built for the 1893 World's Columbian Exposition in Chicago by George Washington Gale Ferris Jr. It was 80 meters (264 ft) tall, which must have seemed gigantic at the time.

The 21st century has seen a race to construct the tallest Ferris wheel. Las Vegas High Roller had held the title since 2014 but is now overtaken by the Ain Dubai in the United Arab Emirates, which is 250 meters (820 ft) tall.

Nick Greco
VP ENGINEERING
AMERICAN BRIDGE

Safety is the top priority

Constructing anything of these proportions takes engineering expertise. You are dealing with massive weights and forces, from the structure itself as well as from wind and seismic activity. Regarding Ferris wheels, the safety of people taking the ride as well as people and property in the vicinity must always be the top priority for mechanical engineers and designers.

Looking for the right contractor, owner of the Las Vegas High Roller, Caesars Entertainment, turned to the well-renowned construction company American Bridge, with long experience in designing and building complex structures, such as large bridges.

American Bridge writes on their website that they have "a long history taking on challenging and unique steel erection projects, often requiring unprecedented techniques."

"A massive amount of construction engineering"

The American Bridge engineers' design features a rim connected to a rotating hub and fixed by 112 cable spokes, made from 75-millimeter diameter locked coil cables. There are four support legs but also a single braced leg for extra support.

According to American Bridge, the project required "a massive amount of construction engineering and procedure development. By project completion, over 300 drawing sheets were prepared."

Construction of the wheel started in late 2011, and Las Vegas High Roller opened to the public in March 2014.

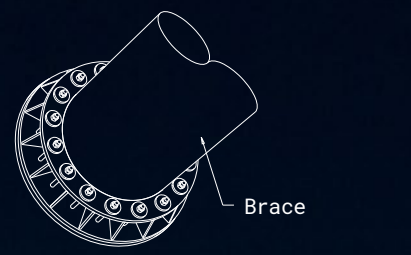
High risk of devastating earthquakes

While Nevada is not subject to earthquakes on par with Alaska or neighboring California, it is still the third most seismically active state in the USA. Large quakes in California can also be felt in Las Vegas. Researchers say that the southern part of Nevada, where Vegas is located, may also face more devastating earthquakes in the future.

The risk of large and damaging earthquakes was considered when designing Las Vegas High Roller. For example, for improved stability and safety, the braced leg attached to the east end of the spindle provides lateral support in the transverse direction.

Boltight secured the braced leg

American Bridge contacted Boltight in search of a solution for tightening 16 equally spaced anchor rods that would connect the braced leg to its foundations. The construction would have to resist any tension arising from high wind speeds or seismic activity in the area.



Boltight supplied a complete tensioning solution for tightening the 16 anchor rods that secure the braced leg. It includes custom-designed tensioners, all working at 1,500 bar pressure and capable of producing 3,115 kilonewtons (kN) of force. Apart from the tensioners, Boltight also supplied high-pressure pneumatic powered hydraulic pumps, hydraulic hoses, and hydraulic manifolds.

This solution provides double benefits. First, the equipment allowed the customer to tension the anchor rods to the pretension load required by the contract. Second, American Bridge could also perform the anchor rod pre-tensioning operation efficiently due to the equipment's compact size, weight, and ease of setup.

Many advantages for the customer

Through this solution, American Bridge was able to ensure the safety of the Las Vegas High Roller's critical structure through a custom-designed bolting solution that was also accurate and time-saving.

Nick Greco, Vice President Engineering, American Bridge, concludes that, "The biggest advantages were the ease of handling, compactness, and the capacity of the equipment to achieve the desired level of stress in the rods."

Can I use Nord-Lock wedge-locking washers on painted surfaces?

Email your questions about bolting technologies to experts@nord-lock.com

We are often asked about securing bolted connections where parts have painted surfaces, something relevant to many applications and industries. The answer depends on the type of coating used and how it's applied, though in general there are a few practical challenges to overcome.

Nord-Lock recommends using a wedge-locking washer with a larger outer diameter as it distributes the load over a larger surface area. This is gentler for sensitive surfaces and achieves a more even clamping, negating settlements to some extent.

The most common issues are a loss of preload over time due to settlements and relaxation in the paint, or corrosion problems caused due to wear at the point of assembly and breakages in the paint. The rotation caused when tightening/untightening the bolted joints with traditional fasteners can also tear up the coating.

Different industries have varying criteria for coatings, but some of the most demanding applications and the thickest paints can be found in offshore industries such as oil & gas, wind farms, solar farms, and shipping. These must preserve steel constructions in a cost-effective way and protect against the corrosive nature of harsh ocean environments.

These industries often use 'active' coatings containing aluminum and zinc, elements providing a chemical resistance to corrosion in steel structures by acting as an anode in the electric cell. Other non-active coatings create an impenetrable layer to shield the construction from the corroding elements, but when this coating breaks down, the construction is exposed and starts to weaken.

To assemble a bolted joint, you are creating a rotation of the bolt, nut and perhaps washers. This rotation can cause damage to painted surfaces. The rotational behaviour of these ingoing parts also determines the impact on the coating, so Nord-Lock Group has been carrying out tests on different bolting methods to learn more in this area.

With no washer

Assembling a bolt without any washers concentrates the rotation directly between the bolt and the painted surface, and it is evident that the high torque used to preload the bolt will damage the paint.

With flat washers

Adding a flat washer lowers the rotation against the surface but does not guarantee that all rotation takes place between the bolt and the washer. Instead, it is random and therefore hard to predict the level of damage on the coating.

With Nord-Lock washers

Nord-Lock wedge-locking washers are designed to control the rotation between the upper washer and the nut during assembly, so this keeps the painted surface more intact.

Nicholas Lundkvist
EMEA PRODUCT SPECIALIST
NORD-LOCK GROUP

The outer faces of Nord-Lock washers are also serrated to grip both the clamped parts and the underside of the bolt head — securing the joint. Impression marks from the serrations on both surfaces can be seen when untightening the bolt, verifying the wedge-locking effect that prevents bolts from spontaneously loosening.

You might expect these serrations to destroy the paint during assembly, but the tests prove several positive impacts instead. Because the serrations press slightly into the paint, settlements in the bolted joint are decreased compared to applying a flat washer — hence the desired preload will be better preserved in the bolted connection.

When exposed to vibrations, the design of Nord-Lock washers also directs movement to between the two washers, so there is no rotational impact on the coating during vibrations. The wedge-locking effect also ensures preload is kept to a high and safe level, something which is not achieved with the other solutions.

Effect of assembly on painted surfaces with different locking methods

Figure 1. Tightened Nord-Lock Washer on painted surface

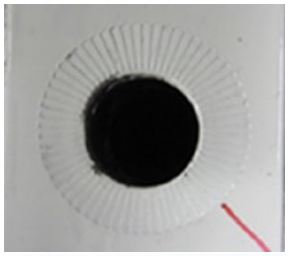


Figure 2. Painted surface after Junker Vibration test with Nord-Lock washers. Serration imprints clearly seen in the surface

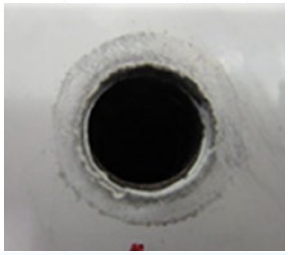


Figure 3. Painted surface after Junker Vibration test with flat washers. Random wear on the painted surface.

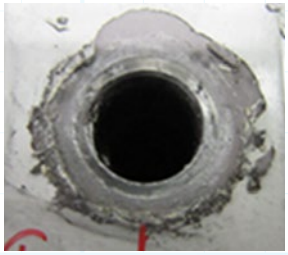


Figure 4. Painted surface after Junker Vibration test with only bolt head. Clear removal of paint, Cracks in the paint can also be seen.

Best practices

We recommend working in this order:

1. Assemble parts
2. Secure the bolted connections
3. When properly tightened, finally apply the coating

This would give a better guarantee of a secure and corrosion resistant bolted joint for painted surfaces, but sometimes this process is overlooked as it can be too expensive or impractical in the field.

As our tests find, the risk of coating before bolting is that some locking methods cannot maintain preload because of settlements and relaxation in the paint, or the paint is broken when tightening the bolt and your parts are then also exposed to corrosion.

Although there is much to consider, our findings in this test do give a reliable indication that using Nord-Lock wedge-locking washers will have a more positive impact, compared to the alternatives, on the security of bolted connections when used in these scenarios.

MAGAZINE WRAPPED IN COMPOSTABLE PLASTIC

WE WANT TO HEAR FROM YOU!

What are the most important industry trends, engineering challenges and bolting tips that you would like to be covered in Bolted?

Tell us about your reading preferences for a chance to win a Garmin Forerunner 935!

Go to survey
nord-lock.com/survey

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