BOLTED

A MAGAZINE ABOUT BOLTING TECHNOLOGIES

ISSUE 1 - 2020

THE PATH TO GREEN STEEL

From the raw material to the product end life, we look at how to make steel sustainable throughout its life cycle

OFFSHORE FLOATING WIND
Discover the latest trends in wind power

IN THE SPOTLIGHT
Meet Elena Moral, award winning railway engineer

A BRIDGE NOT TOO FAR
An innovative solution for a new bridge in Stockholm

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NORD-LOCK GROUP

MANAGING EDITOR
Alexander Wennberg
alexander.wennberg@nord-lock.com

LANGUAGE COORDINATION
Nord-Lock Group

CONTENT PRODUCTION
Nord-Lock Group

ART DIRECTION & DESIGN
Gabriel Jacobi

PRINT
Exakta

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Fredrik Meuller
CEO Nord-Lock Group

Steel is a material used in more or less everything we and our customers produce. From offshore wind farms to high-speed trains, bridges and rocket engines...

At Nord-Lock Group we want to make a difference by saving lives and safeguarding customer applications with our critical bolted solutions. With sustainability more or less on everyone's lips now in 2020, and only ten years away from the Agenda 2030 development goals – it is time to review, reflect and take action.

As we as a group decide on our focus areas and set targets for ourselves on how we best can make a difference, we thought what better way to contribute and inspire our customers than to look at the raw material we all use? The steel industry has a fairly dark history from an environmental perspective but has made impressive progress in terms of both emissions and reuse. With several innovations in the pipeline, this is an industry that can inspire everyone.

This year we are upgrading three of our six production sites. We are doing this partly to meet future demands, but also to further improve the working environment for our employees and enable more sustainable and efficient manufacturing — from energy consumption to waste minimization.

Speaking about energy, we talked to industry experts about Offshore Floating Wind Turbines. It is very exciting to follow the developments and enormous potential offshore wind energy may be able to offer. We also traveled to Spain to meet engineer Elena Moral, award winner for her role leading the construction of the ambitious Medina-Mecca railway project. While in Spain, we also visited PLD Space who use Nord-Lock washers in their rocket engines.

That's not all, you can also read about "Slussen", a massive construction project in our beautiful capital Stockholm, and we look into how we solved a problem for Japan Steel Works.

Enjoy your reading!

The upper atmosphere can be tough on equipment. Developing a rocket engine for this environment is a huge challenge. If there are complications in the process, the engine and its associated parts might be damaged.

TAKE IT TO THE LIMIT

Spanish aerospace company PLD Space develops launch vehicles and offers suborbital and orbital commercial launch services dedicated to small payloads and small satellites. Since its foundation in 2011, the company has gone from a small start-up to a flourishing company of 42 employees.

Choosing high-quality materials and components has been essential in the design and construction of the company's MIURA 1 and MIURA 5 launch vehicles.

"The materials that we use are very specific. For example, the bolts that join the components need to be extremely robust and reliable. This way, nothing moves out of place during a high-intensity flight," says Raúl Torres, CEO & Co-founder of PLD. Ismael Gutiérrez, Head of Propulsion, agrees:

"Quality is key as we push every single part to the limit of its capacity."

He continues: "We must test different scenarios that might occur to ensure that we comply with strict regulations and can ensure safety. If we don't have the maximum properties that we can specify, such as ultimate strength, wear rate, all these type of parameters, we cannot comply with our test."

This is particularly true for the propulsion department, where compromised base material could lead to premature failure due to the high demands of the application.

In a highly vibrational environment like outer space, maintaining the preload in the bolt is a top priority. As the traditional locking wire couldn't offer a viable solution, the PLD Space team started looking for another type of retention mechanism and came across Nord-Lock.

"We did a good assessment between different types of technologies and decided to go with Nord-Lock as their wedge-locking washers offered incredible robustness," says Torres.

Nord-Lock wedge-locking washers are now used for most of the bolted joints in PLD Space's rocket engines, as well as on the rocket launch platforms.

"We have successfully used their washers for basically every bolted connection in the engine, and they've worked really well," Gutiérrez says. "The preload is kept in our firing testing, and we haven't seen any loosening of the bolts."

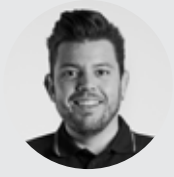
By being able to rely on quality materials, PLD Space is now preparing for their first commercial launch of MIURA 1.

Text Maria Reilly **Photos** Jörgen Lindström and PLD Space

CUSTOMER	LOCATION
PLD SPACE	ELCHE, SPAIN
BUSINESS	**APPLICATION**
AEROSPACE	LAUNCH VEHICLES

CHALLENGE
MAINTAINING THE PRELOAD IN THE BOLTS UNDER EXTREME CONDITIONS IN OUTER SPACE

SOLUTION
NORD-LOCK WEDGE-LOCKING WASHERS KEEP THE BOLTS FROM LOOSENING



Raúl Torres
CEO & CO-FOUNDER

Ismael Gutiérrez
HEAD OF PROPULSION

OFFSHORE FLOATING WIND ENERGY STARTS MOVING INTO HIGH GEAR

Imagine producing 11 times more electricity than the entire world needs, using only offshore wind turbines. This may well be possible, reports the respected International Energy Agency, IEA.

Text Hugh O'Brian
Illustration Getty Images

The enormous potential that offshore wind energy may be able to offer has been making headlines around the world. In late 2019 the Norwegian energy giant Equinor confirmed that its massive investment in the 88 MW Hywind Tampen Offshore Floating Wind (OFW) farm was going ahead. A few days later the International Energy Agency, IEA, released a major report with astonishing news. It concluded that offshore wind, not just floating but also including fixed-bottom structures, could generate 11 times more electricity than the world needs and attract $1 trillion in capital investments by 2040. Clearly, things are happening in wind power.

Three wind subsectors, based on location

As a background, today's modern wind power sector can be roughly divided into three categories, depending on where the turbines are located, and the design used to hold them up. These are: Onshore (with land-based support fixture), Near offshore fixed (with support fixed in the seabed), and Offshore floating (mounted on a platform floating above the seabed) — See Figure 1 on next page.

Offshore Floating Wind (OFW) technology involves a turbine mounted on a buoyant structure, giving it the very important advantage of allowing it to generate electricity in water depths greater than 60 meters — where bottom-mounted structures fixed to the seabed are no longer feasible.

While both onshore and offshore fixed wind power generation capacity has grown enormously over the past decades, many industry experts believe that OFW may hold the greatest potential for future growth. This is due to its ability to be located in deeper water farther from shore where more consistent high wind speeds reduce fluctuations in electricity generation. A secondary driver that may help accelerate OFW is the growing public resistance to wind turbines being placed where they can be seen or heard.

Low-hanging fruit has been harvested

OFW is also getting more attention due to the simple fact that the "low-hanging fruit" that many onshore and near offshore wind sites offer has already been harvested. Of course, there are potentially thousands of other onshore and near offshore wind locations that still can be developed, but the growing resistance to seeing and hearing the turbines is also having an impact. It's the "NIMBY" syndrome, meaning Not In My Back Yard, which refers to infrastructure installations that society generally needs, such as power plants or garbage dumps, but that nobody wants to have located near to where they live.

Equinor CEO: 80% is in deep waters

This combination of drivers has turned greater attention to OFW, which can be used in deeper waters. When announcing Equinor's final decision to go ahead with the 88-MW Hywind Tampen project, involving an investment of around USD 550 million, company CEO Mr. Eldar Sætre was very clear about the company's decision:

"About 80 percent of the global resource potential for offshore wind is in deep waters" says Equinor CEO Eldar Sætre.

"And floating offshore wind may play an important part in the energy transition toward more sustainable global energy supply," he continues.

A key motivator for Equinor to undertake this project is that the electricity generated will be used on the nearby Gullfaks and Snorre oil platforms, directly reducing the use of gas and thereby CO_2 emissions by 200,000 tons per year.

Steppingstone to 1,000 MW

Arne Eik, Equinor's Lead Business Developer for Offshore Wind, explains that Tampen is just one step on the company's path to utility-scale projects with high cost effectiveness.

"The existing 30 MW Hywind Scotland proved that floating offshore wind works, and the 88 MW Hywind Tampen will be almost three times as big," says Eik. "Within a few years, we hope to realize a 200-400 MW project, and then be on our way to utility-scale projects of more than 1,000 MW.

"I should add that we are achieving cost reductions of around 40% from Hywind Scotland to Hywind Tampen. Looking further out, we are very confident we'll continue to get significant cost reductions as we scale up on the next project after Hywind Tampen. So Hywind Tampen is clearly a technological and industrial development project, a steppingstone to building an industry of great importance which creates value by producing clean energy and at the same time reducing CO_2 emissions."

Rapid pace from infancy to massive investments

Erik Rijkers, Director of Market Development & Strategy at the market intelligence group Quest Floating Wind Energy, says that although only five years ago floating wind energy was in its infancy, and meeting more naysayers than believers, it has now come a very long way in terms of delivering new floater designs, scaled demonstrators, pre-commercial projects and new players.

"The entry of companies such as Equinor, Repsol, SBM, Aker Solutions and, most recently, Shell has led to a step-change for this young industry's viability and ultimate capability to produce 50 or 100 Floating Turbine Units (FTU) on a serial manufacturing basis," Rijkers explains.

"Floating wind energy is a fast-moving market," he continues, "and Europe has been the global 'test bed'. The success of recent projects like Hywind Scotland and Windfloat Atlantic will drive export of this technology to the USA and Asia well before 2025. This move to large-scale projects, aided with ample financial backing, will help to improve efficiencies and lead to significantly reduced costs. We see this trend, in turn, making further European projects more feasible, buoyed by additional government support of long-term Floating Wind Energy developments."

Many countries only have deep sites available

Charlotte Obhrai, an Associate Professor in offshore wind research at the University of Stavanger in Norway, is confident that floating wind energy has a bright future.

"To meet future energy targets, wind is essential" says Charlotte Obhrai.

"And in many countries the easier-to-reach near-offshore sites are already taken. Some countries such as Japan simply have no or very few shallow sites. Thus, deeper sites are the future and that means floating."

Also, she says, wind speeds are generally higher further out and the amount of power you can produce goes up to a power of three with increasing wind speed.

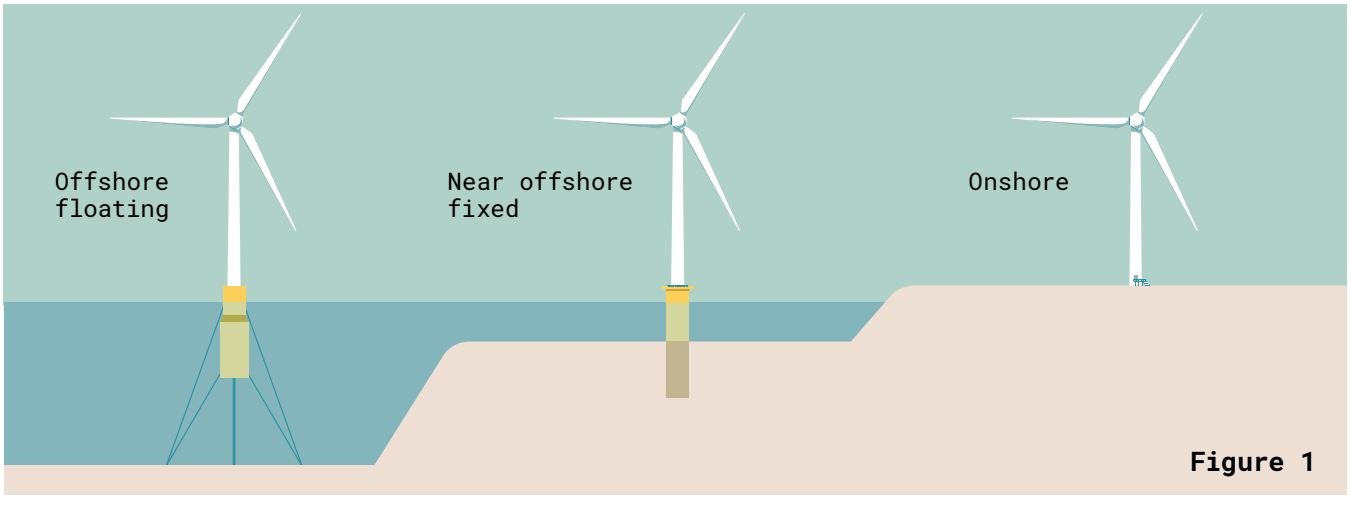
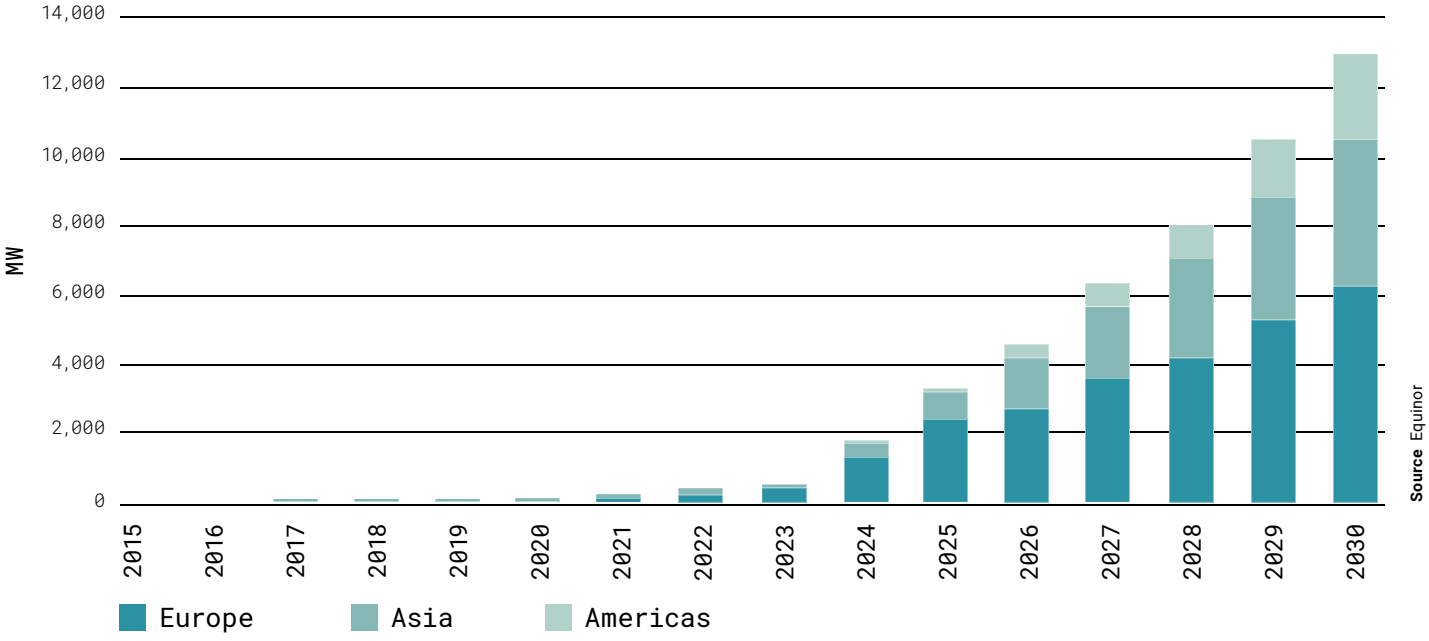


Figure 1

Arne Eik
LEAD BUSINESS DEVELOPER
FOR OFFSHORE WIND
EQUINOR

Erik Rijkers
DIRECTOR OF MARKET
DEVELOPMENT & STRATEGY
QUEST FLOATING WIND ENERGY

Floating offshore wind market outlook



So even a small rise in average wind speed makes a big difference in power output and technology is clearly developing to tap that potential.

Of course, there are challenges to be met, especially regarding construction and installation costs, for the floating substructure. "There are numerous concepts being used and tested," continues Obhrai. "There will likely continue to be numerous designs, since the right one for a particular location is based on several factors such as depth of the nearest harbor, local manufacturing skills and capabilities, etc."

Outlook positive, but trends difficult to extrapolate at this point

Matthew Hannon, a Senior Lecturer at the University of Strathclyde in Glasgow Scotland, states that while it is probably prudent to be somewhat cautious about how fast OFW will develop, the trend is clear and positive.

"Although the long-term outlook is optimistic, at this time OFW has a very small installed base so it's difficult to extrapolate with confidence. And any failure of a project to materialize can have negative effects on confidence," he concedes.

"Nonetheless, taking all factors into account, we are projecting very steady growth in the global capacity of floating wind power by 2030. The important point is that this growth is closely mirroring the growth rates that the near-offshore-fixed wind industry experienced. So we think that during the 2030s, barring unforeseen issues, OFW will really kick into high gear from a solid base. Floating wind will be viewed, like near-offshore wind today, as a legitimate low-risk energy investment with similar dynamic growth rates."

Exciting times ahead

Exactly how fast offshore wind will grow is clearly open to numerous interpretations. But the trend is unmistakable, and it will obviously be interesting to see how both the market and the technology will develop in the coming years.

Are bolted joints the weak link?

"Life assessment of bolts is something the wind industry struggles with, as it is the weakest point on the tower life calculation. There seems to be a blind spot in that area as the bolts aren't considered as part of standard life calculations, which are all based on aero elastic codes."

David McMillan at the University of Strathclyde in Glasgow

"Predicting the performance and reliability of bolted connections throughout the lifetime of a floating asset is a challenge, both because of their physical size and the harsh environments where they are being deployed."

Tomas Svendsen – Nord-Lock Group Norway

Charlotte Obhrai
ASSOCIATE PROFESSOR IN OFFSHORE WIND RESEARCH
UNIVERSITY OF STAVANGER

Matthew Hannon
SENIOR LECTURER
UNIVERSITY OF STRATHCLYDE

Elena Moral has spent almost two decades as an engineer within the railway industry at Talgo, a Spanish manufacturer of high-speed trains. During that time, she won the 2019 Women in Construction and Engineering (WICE) prize for European Railway Engineer for her role leading the construction of the ambitious Medina-Mecca railway project.

Text Gonzalo Atienza **Photos** Brian Hallett

How has your role evolved since you first joined Talgo?

I have spent my entire professional career of almost two decades with Talgo, so I have worked with many different departments of the company. I coordinate all the various functional areas such as engineering, sales and manufacturing. It is essential to distribute the necessary resources through our many projects, which allows us to meet the objectives of all our efforts worldwide.

My deep technical experience gives me a vantage point from which to have a close collaboration with each team to resolve any problems. They're long projects, spanning multiple years and, given the size of Talgo, it means that directing the projects has to be very hands-on. Everyone feels personally involved, and when speaking to my colleagues, I frequently refer to them as "my trains". We have the privilege of working in an industry that contributes to improving the wellbeing of people, which makes the work very rewarding.

Why do you think you were awarded the WICE prize for European Railway Engineer?

To a large extent receiving the prize was thanks to the Medina-Mecca project. It's one of the most complicated railway projects ever undertaken: the construction of the first high-speed rail line operating in desert-like conditions. Over 1,000 people worked on this incredibly ambitious project, so it's important to underline that any prize is the product of collaboration. I don't consider myself the sole winner. The team that I led developed solutions in-house as well as through collaboration with other industries so that we could operate at temperatures of over 50 degrees Celsius, with powder that penetrated the finest cracks, and sand that when traveling at speeds of above 300 km/h becomes an extremely efficient abrasive – quite literally sandpaper. The line now has 1.3 million cumulative operating kilometers since last year, and the positive results make us very proud of our work.

ELENA MORAL

What did embarking on such an ambitious project teach you?

Developing a train so that it can travel at high speed through a desert is a fascinating engineering puzzle, which can throw up lessons which we can apply to many other contexts. Hermetically sealing the train to stop dust particles from entering could find applications in sub-zero temperatures to stop snow or other elements. Developing paint which doesn't chip when traveling through sand can teach us sustainable alternatives to what we currently use. At Talgo, we take pride in the wealth of our experience collaborating with clients to pioneer high-speed railway solutions tailor-made for their specific needs.

Why do you think prizes like WICE are necessary?

WICE seeks to give visibility to the contributions of women in different sectors of engineering, to make these roles more attractive and help address the gender imbalance in our industry. In many countries, less than 20 percent of engineering professionals are women. Having role models that young girls can see and want to emulate can make them more likely to pick similar careers in the industry. Ultimately, the numbers speak for themselves. Women make up half of our society and therefore make up half of the potential talent pool for the industry. Forward-looking companies can't afford to ignore this when thinking about their future. In an ideal world, hopefully in the near future, these types of prizes will disappear, and such a gender distinction will no longer be necessary.

Name

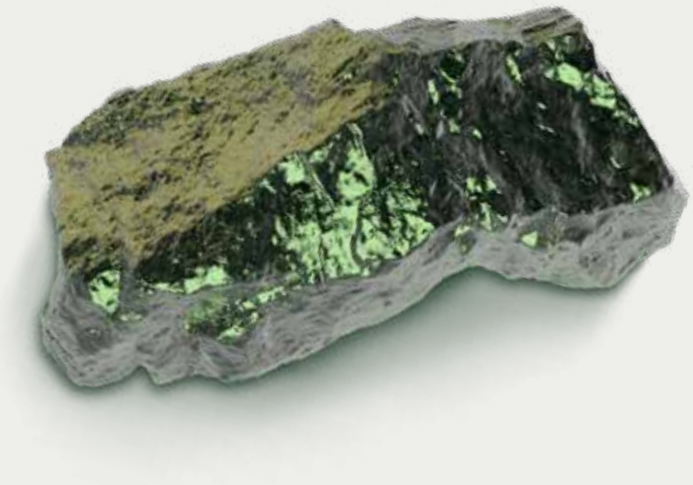
Elena Moral

Title

Project Execution Director, Talgo

Professional Background

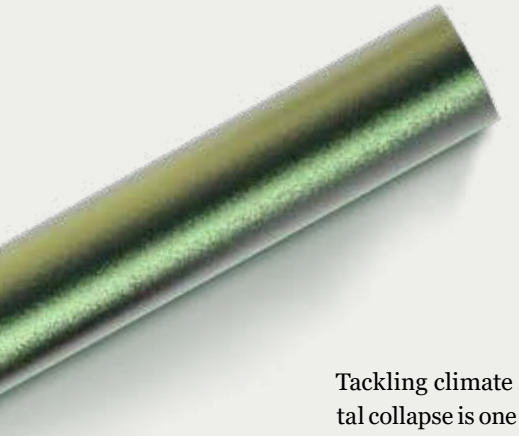
Project lead for Talgo high-speed railway projects: engineering, design, manufacturing and testing. Talgo is one of the world's leading passenger train manufacturers, specialized in the design, manufacturing and maintenance of regional, intercity and high-speed trains.



THE PATH TO GREEN STEEL

The production of steel is one of the world's major polluters. With the ever-sharper focus on the climate crisis and sustainability, things had to change. And they are, through innovations and circular thinking. But it's a long road that will require new thinking throughout the product life cycle, from design to end-of-life solutions.

Text Brian Cloughley



Tackling climate change and environmental collapse is one of the greatest challenges humanity has ever faced, and the steel industry has a major role to play. The International Panel on Climate Change estimated in 2014 that steel production was responsible for 5 percent of all greenhouse gas emissions. To put that into perspective, aviation accounts for 2 percent of global emissions.

Clearly, steel producers and the countless industries that utilize steel have a responsibility to address sustainability overall and climate change in particular. Fortunately, there are opportunities to do so.

Innovations in steel production

There are a few reasons for optimism in the industry. Firstly, steel is produced far more efficiently today than ever before. The energy used to produce steel has fallen dramatically over the last 50 years, and there remains some room for further improvement. There has also been an increase in the amount of steel produced from scrap – over a third of the steel produced globally now comes from recycled materials.

For Max Åhman, senior lecturer at Environmental and Energy Systems Studies at Lund University, Sweden, these developments are positive but not sufficient to meet the environmental challenges we face. He argues that breakthrough technologies are required for steel to become a genuinely sustainable resource.

"We can and we will increase the amount of recycled steel," he says. "If it's melted in an electric arc furnace with renewable electricity, then emissions are close to zero. That's okay, but we can't completely rely on recycled steel. Firstly, because the demand for steel globally is growing so we'll continue to need more virgin steel. Secondly, there are quality issues. It's not always possible to manufacture specialty steels and other steel grades using only recycled steel.

"It's nice to talk about energy efficiency and carbon footprints," Åhman says.

"But we also need to take the long-term challenges seriously, and that means focusing on the hard-to-achieve things."

"Do we need to replace all blast furnaces and if so, with what?"he asks.

Close to zero emissions

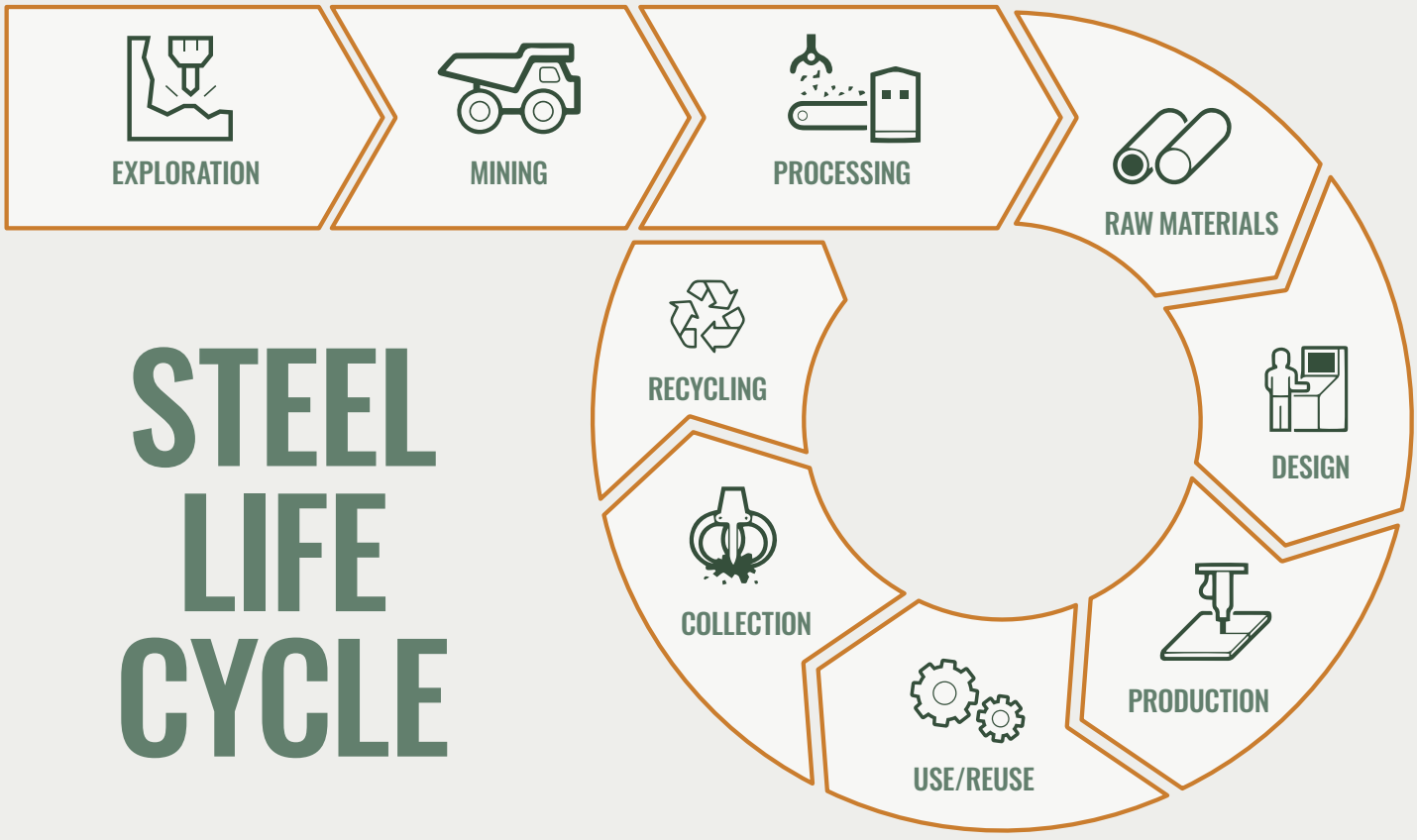
The technological innovations in the steel industry that are most likely to succeed, Åhman suggests, are based around replacing coal-fired blast furnaces with methods based on renewable fuels.

This approach is being piloted in public-private collaborations in both Sweden (HYBRIT) and Germany (SALCOS). Both these projects have devised methods of using electricity from renewable energy to produce hydrogen, and then using that hydrogen to replace coking coal in the reduction stage of steel-making. This method produces water as a by-product rather than CO_2, so it can theoretically produce steel with zero or close to zero emissions.

"There are no technical unknowns here," says Åhman. "We've done direct hydrogen reduction, and electrolysis is there. What needs to be verified is that it can be done at scale cost-effectively, and in an integrated fashion."

One thing that looms over all of this is that long term decision-making has to be done soon. Given the long investment cycles in this industry, investors will soon have to take the decision about where they want to be in 2050.

"If you want to replace blast furnaces with direct reduction from hydrogen, you basically have to decide on that by 2025. That's the timeframe we're talking about," concludes Åhman.



STEEL LIFE CYCLE

Source EIT – Raw Materials

Max Åhman
SENIOR LECTURER
ENVIRONMENTAL AND ENERGY SYSTEMS STUDIES
LUND UNIVERSITY

Karin Östman
SENIOR POLICY ADVISOR
JERNKONTORET

Life cycle assessment

Steel is everywhere in modern society, so focusing exclusively on its production would not give a full account of its role in a sustainable future. Karin Östman, senior policy advisor at Jernkontoret (the Swedish Steel Producers Association), advocates life cycle assessment (LCA) as a better way of understanding steel and sustainability.

LCA is about getting a truer measurement of a product's impact from cradle to grave. By evaluating a product's entire life cycle, it is argued, you can understand its environmental performance and make better decisions about sustainable pathways. Moreover, advances in production mean that steel can have a positive role in delivering sustainability.

"One example would be the development of high-strength steel grades," explains Östman. "When high-strength steel is used in cars, their weight is reduced, and they become more fuel-efficient. So, in this way steel is helping to reduce energy use throughout the entire system."

It can also be easy to overlook that sustainability covers more ground than just cutting emissions.

Sustainability is about maintaining a liveable planet or, as the UN explains in a description of their Sustainable Development Goals, "to protect the planet and improve the lives and prospects of everyone, everywhere." This perspective is shared by many in the steel industry, according to Östman.

"The vision we at Jernkontoret have set for ourselves is that by 2050 the steel industry in Sweden will not produce anything that doesn't create value for society," she says. "That means zero emissions and no waste, but it's also about contributing to a better society. Providing good careers and safer, fairer workplaces is a big part of that."

Using steel sustainably

Although it will be a number of years until the 'green steel' described by Max Åhman is commercially available, there are still sustainable options for manufacturers and mechanical engineers. Jernkontoret's life cycle approach to sustainability can help identify sources of improvement.

Making life cycle analysis a central part of the design process is key. Many countries, inter- and non-governmental organizations maintain life cycle inventories to quantify the impact of products and their inputs. The datasets in these inventories aim to be all-encompassing, and cover the environmental impact of raw materials, manufacturing, transport, end-use, and much more through to end-of-life.

This data allows for comprehensive life cycle assessment for a wide variety of goods, but there are some basic considerations that are relevant to almost any application requiring steel.

Reduce, reuse, recycle

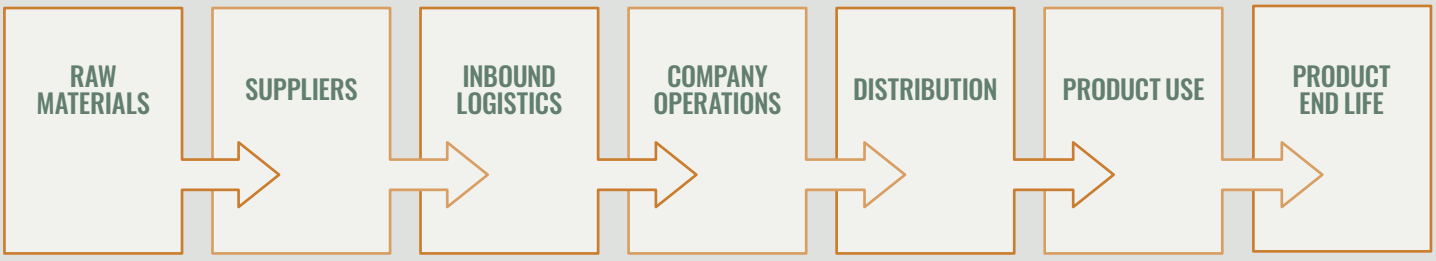
The first consideration involves material efficiency and overdesigning. Life cycle assessment begins with the extraction of resources, and overdesign – making a product stronger, bigger or more complex than its end use demands – is by definition an inefficient use of materials.

The use of steel from recycled materials can be a way to reduce raw material usage but, depending on the application, higher grade steel might be a better way of optimizing design and reducing a product's impact throughout its lifetime.

It's always advisable to consider the end of a product's life at the design stage to enable a circular model.

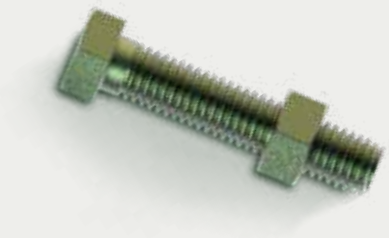
Steel is endlessly recyclable, however contamination with other metals — especially copper — often limits the usefulness of recycled steel. Recyclability varies massively according to the type of product but ensuring easy disassembly and minimizing the welding of steel to other metals are design considerations applicable in any industry.

Increasing positive impact on the value chain



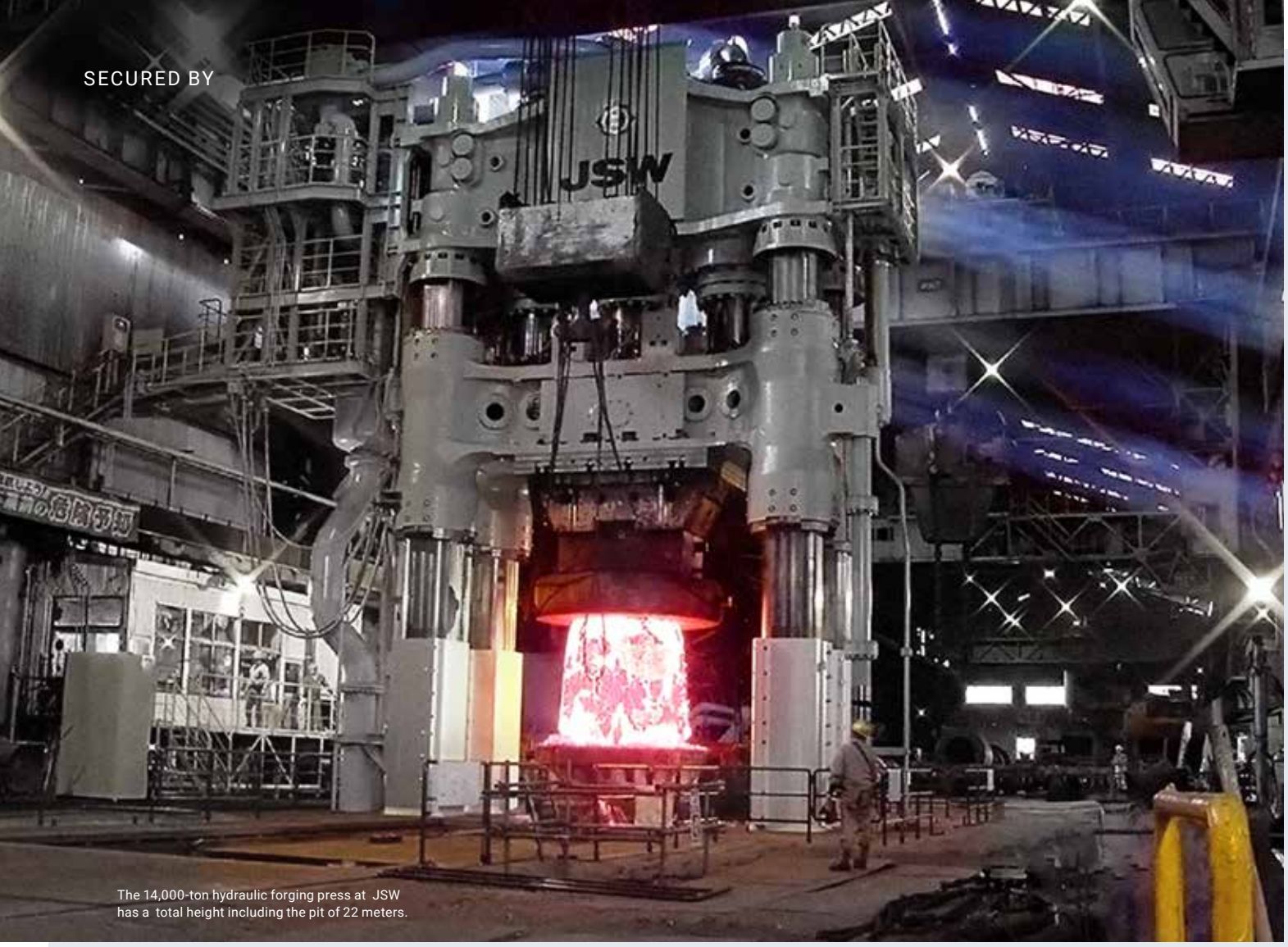
A holistic approach — i.e. taking into account the entire key chain — is key to achieve a sustainable development.

Source GRI, UN Global Compact, and WBCSD



IMAGINING THE SUCCESSFUL SOLUTION IN YOUR MIND

Like a winning athlete, can a maintenance manager see the perfect fix in his mind before actually doing it? Japan Steel Works might have the answer.



The 14,000-ton hydraulic forging press at JSW has a total height including the pit of 22 meters.

Text Hugh O'Brian **Photos** Keisuke Okada and Japan Steel Works

The Japan Steel Works, Ltd. (JSW) in Muroran on Hokkaido island operates one of the world's largest forging presses, capable of handling enormous steel ingots weighing up to 670 tons. The company, founded in 1907, is today a well-established manufacturer of large-size cast and forged steel products, sheet steels and industrial machinery parts. With 3 plants in Japan, and 18 offices around the world, JSW uses advanced technologies to manufacture pressing machines, turbine shafts and even Japanese swords. As part of their after-sales service, the company has recently started offering maintenance services for pressure vessels, pressing machines and other pieces of heavy equipment.

A major maintenance challenge that JSW has faced in its operation for many years has involved the tightening and untightening of the giant bolts on its hydraulic forging presses and on the massive water pumps that drive them. This includes M180 size bolts securing the "balancer rods" on the 14,000-ton hydraulic forging press and M64 bolts on the water pump which tighten its cover and main structure to withstand the enormous pressure needed for the hydraulic forging press.

The problem was that it was difficult to achieve accurate and uniform tightening of these big bolts. JSW had traditionally used hammering or a hydraulic torque wrench, which were the only available methods. However, this led to inaccurate tightening, and even sometimes to bolt failure due to the variation in preload.

A very frustrating, and costly, problem

Mr. Takumi Kawauchiya, who has been responsible for JSW's Manufacturing Division facility maintenance for over 30 years, says that this problem had been very frustrating, both for him and for the company.

"We were using very forceful tightening methods, hammering and hydraulic torque wrenching, which were both inaccurate and physically fatiguing for our people," explains Mr. Kawauchiya. "It was a heavy burden on the workers and at the same time it wasn't functioning perfectly. Sometimes, we would even experience bolt failures in these well-designed machines due to inaccurate preload on the bolts."

CUSTOMER	APPLICATIONS	SOLUTION
THE JAPAN STEEL WORKS, LTD.	14,000-TON HYDRAULIC FORGING PRESS AND MASSIVE WATER-PRESSURE PUMP	SUPERBOLT MULTI-JACKBOLT TENSIONERS

APPLICATION (PRESS)	APPLICATION (PUMP)
TIE-ROD BALANCER (M180)	COVER BOLT (M64, 4 PIECES AS A SET X 8 UNITS)

SIZE OF THE PRESS
GROUND HEIGHT 16.44M (TOTAL HEIGHT INCLUDING THE PIT PART IS 22M)

A mental image of the successful solution

Like a professional golfer who before hitting the ball imagines where it will go for a positive result, Mr. Kawauchiya says he likes to paint a mental image in his mind of what the successful outcome will look like for any repair challenge he is facing. "I visualize the whole work process in my mind, including examining what might be the best way to fix the problem, option A or B, and then go through it step by step. Only after I finish creating this image do I start working," he says.

The bolting challenges were a serious problem which were messing up his well-considered strategies. Normally, he continues, when unexpected incidents happened, he made an alternative plan from the experience and re-visualized the whole process. However, when an unexpected problem like bolt breakage occurred it would stop the entire operation of the facility. The longer it was stopped, the greater the monetary losses, which can amount to tens of thousands of euros for one single day. "Obviously, there was nothing more important than how quickly we could recover and restart," Kawauchiya comments.

"It had been my dream to solve this maintenance challenge."

Emotionally 'moved' by a true problem solver

Happily, his dream came true a few years ago. When Mr. Kawauchiya tightened the large-size bolts with Superbolt for the first time, he says he was pleased as he realized that this long-term, difficult-to-solve problem had indeed been solved. "When I finished tightening them, I was totally moved by Superbolt. I saw it was a true problem solver." Mr. Kawauchiya explains this was because of the ease of the operation, compared to the earlier work of hitting large bolts with a hammer.

Due to its unique design, some people initially raised doubts whether Superbolt could really tighten large size bolts or that it would be too time consuming to tighten all the small jackbolts on the nut body. When asked how he responded to these concerns, Mr. Kawauchiya answers that the other methods had drawbacks as well. "The hydraulic torque wrench requires heavy units like pumps. And hammering is very heavy work as well, meaning we get exhausted when we tighten many large bolts. Compared to those methods, Superbolt is a lot easier even though we need to tighten the jackbolts."

Flex-in & Flex-out technology makes the joint safer

The benefit delivered by Superbolt is not only the reduced workload. Safety of the bolt joint, to prevent bolt breakage and the associated dangers, is also improved. Superbolt can prevent bolt breakage due to its "Flex-in & Flex-out" structure brought about by the patented design of the jackbolt. This distributes the stress which is normally concentrated on the first and the second screw threads to the whole threads by opening the lower part outward and closing the upper part inward during tightening.

Mr. Ryu Kobayashi, who has been in charge of designing production equipment for many years at JSW's Equipment Division, considers this to be a great advantage.

"The Flex-in & Flex-out functiom is very beneficial, especially for fastening parts which are exposed to a wide variation of dynamic loads."

In fact, it is the secret to preventing the breakage of bolts, and analysis of testing data shows that Superbolt equalizes the stress on each screw thread very evenly. Hydraulic nuts may also reduce the workload of tightening, but they do not function to prevent the bolt breakage. This technology is patented by the Nord-Lock Group and products which copy the structure do not have this feature.

Mr. Kobayashi also points out other advantages of Superbolt from a designer's point of view. "The accuracy of bolt tightening by hammering varies considerably from person to person so some bolts might not be tightened well. Even if the bolt is tightened, it might not have enough preload. The repeatability of Superbolt is great and anyone can tighten the bolt to the same state, resulting in better safety of the maintenance repairs." This high repeatability reduces the risk of improper work and prevents accidents, and also helps reduce unplanned and expensive downtime.

Just like a designer at a machine manufacturer gains benefits from Superbolt, end users of the machines can also reduce their total cost of ownership. If we regard the effectiveness of maintenance expenditures as "quality", this is an improvement of the quality and can be considered as a service for the end users. This can also be an additional selling point for sales teams at machine manufacturers.

What to consider when reusing bolted joints?

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

Sonny Halberg
APPLICATION AND SALES ENGINEER
NORD-LOCK GROUP

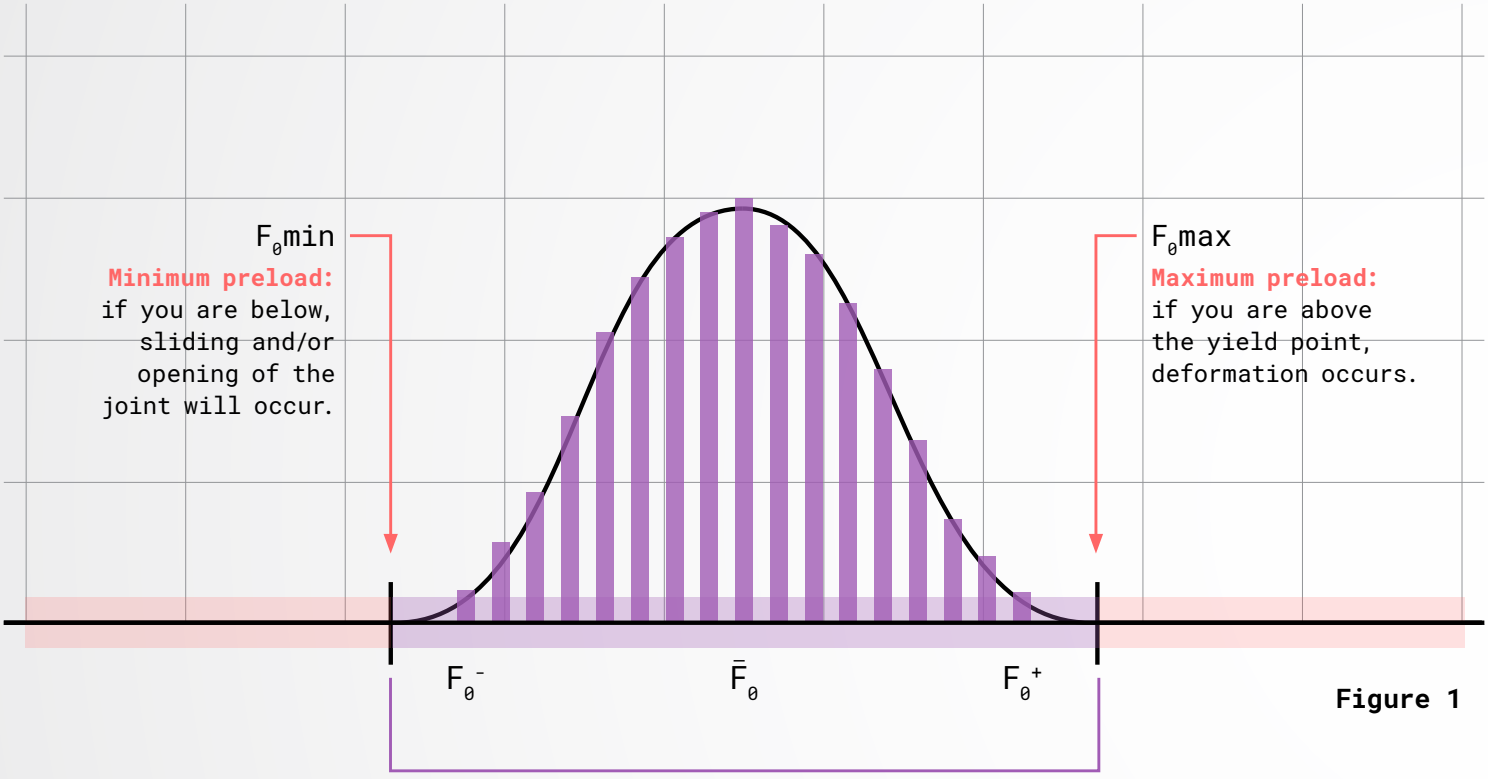


Figure 1

A bolt is installed in a factory without lubrication and everything works fine... until the first time the bolt is removed and reused. Then the problems start. Why?

In the designing process an engineer sets the preload range for a joint, as shown in Figure 1 — so the parts don't open or start to slide, and that the yield strength will not be exceeded on any of the parts. The friction coefficients are a part of the calculation to find the nominal torque needed to achieve the correct preload.

The bolt contact area is flattened during the first tightening operation due to the surface roughness and irregularities. What happens during reuse is that the friction increases because of the bigger contact area generated at the 1st tightening. This means you need a higher tightening torque to achieve the same preload you had during the first tightening. If, instead, you simply use the same initially-recommended tightening torque during reuse, the result is less achieved preload.

Tightening without lubrication

The graph in Figure 2 illustrates a M12 grade 8.8 bolt which has been tightened for the first time and then reused without any lubrication. The design engineer's preload range is marked in blue. The first-time tightening is clearly inside that range and everything works fine. However, because of friction effects, the first time the fastener is reused a higher tightening torque is needed to get the required preload.

An example might be a machine that has been working fine since it came from the manufacturer. Then the first maintenance overhaul is done after, for example, a year. When the bolt is reused, following the instructions from the manufacturer, and tightened to what is thought to be the correct torque, the achieved preload is below the range originally determined by the engineer.

This is when the problems occur. The preload is too low, and the parts can start to slide, meaning the joint will loosen and/or the bolt breaks.

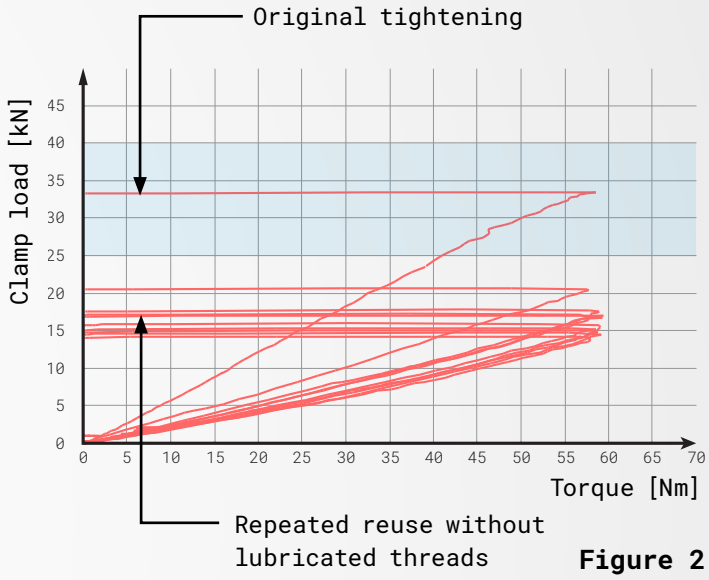


Figure 2

Conclusion

Reusing bolted joints without proper lubrication is quite a gamble. It may be tempting not to use lubrication to save time, or may not be possible due to, for example, hygiene reasons. But it's important to be aware that the drop in preload between the first time installation and the first reuse without lubrication can be very large, and also vary a lot. This means the achieved preload cannot be accurately predicted. If lubrication is not used, then it would be safer to change the fasteners each time, rather than to reuse them.

If the fasteners are to be reused, then it is strongly recommended to use a good uniform lubrication. It is very important that the bolts are cleaned and lubricated again with the same lubrication. This will restore the friction conditions to its original level, maintaining the clamp load within the predefined range (see Figure 3).

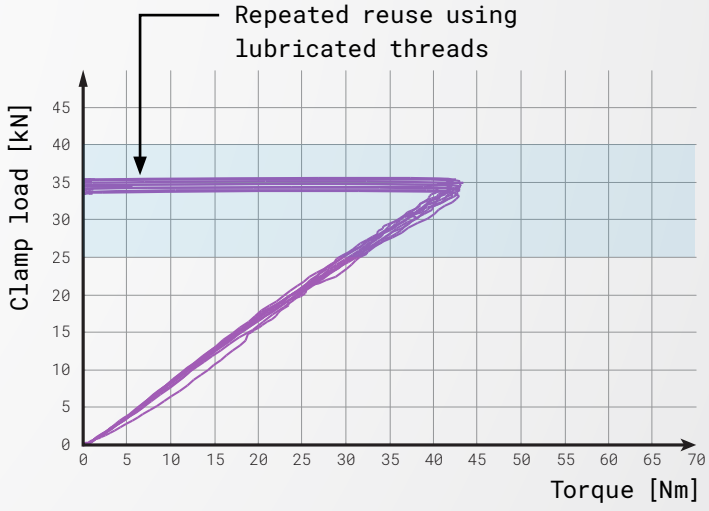


Figure 3

If you start to use lubrication, make sure that the tightening torque is adjusted to fit the new friction condition and values. If you need assistance, please contact Nord-Lock Group.

AN INNOVATIVE SOLUTION FOR A SPECIAL BRIDGE

140 meters in length, 45 meters wide and 3,400 metric tons heavy. And gold colored. The new bridge in Stockholm is definitely set to be a new landmark in Sweden's capital city. It's a project that has challenged even the most experienced design engineers.

Text Jens Kärrman **Images** Stockholm Stad and Foster & Partners

The Slussen interchange is an iconic location in Stockholm. It is a dominant feature in the cityscape and a key part of the capital city's infrastructure.

Slussen connects the Baltic Sea to Lake Mälaren and has a long history as a trade route. There has been a lock there, to adjust for the difference in water level between the sea and the lake, since 1642. The current lock is 85 years old and in a poor state of repair. The City of Stockholm has therefore decided to replace the two current bridges, that connect the city centers Södermalm and Gamla stan, with a new bridge in steel.

The new lock will increase the amount of water draining out of Lake Mälaren, thereby reducing the risk of the floods that could pose a threat to the drinking water in this densely populated region.

Due to its location at the heart of Stockholm, the Slussen redevelopment has been a hot issue for decades. All this attention is one of the aspects that makes the Slussen project so special. The setting is another key aspect. Building a new bridge in the middle of a big city without completely stopping traffic for several years is complicated.

"Hoards of pedestrians constantly need to pass by. So a temporary bridge has been constructed and is now in place, to make room for the foundation of the new bridge to be built," explains Tomas Bergström from sustainable society consultants Ramboll, the company that has been working on the bridge part of the project on behalf of the main contractor Skanska.

The time constraints, durability and weight are some of the main reasons the bridge is being constructed entirely of steel.

"If the entire bridge had been constructed in concrete, it might have taken a year longer," notes Ramboll's Chief Designer Tore Lundmark.

The thickness of the bridge varies, as does its height. The southern section of the bridge is seven meters high, while the northern end of the bridge, abutting Stockholm's well-preserved medieval center Gamla Stan, is less than one meter high.

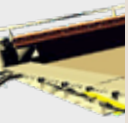
It is a complicated project, and the path to the finished bridge has tested both Skanska's and Ramboll's engineers' endurance and patience to the limit. "We've produced 550 drawings. That's more than twice as many as for our next-largest project," reports Tomas Bergström.

In order to handle the movements generated in the bridge, Ramboll has chosen to have hinged columns with Expander System axles from the Nord-Lock Group as struts.

The Expander System is most frequently used between moving parts in large machines, but Ramboll's bridge designers discovered it was a good fit for the special bridge design in the Slussen project.

"The pressure in the bearings has roughly the same force upwards as downwards. The movements were so great that we were forced to have hinged columns, with spherical bearings with an axle through, and so these axles suited our needs," says Tore Lundmark.

The bridge will be delivered in one piece by ship from China, where the 72 parts have been assembled by one of the world's largest bridge construction companies. Once it arrives in Stockholm, it will be moved to Slussen on pontoons in two channels, and then lowered down onto its supports. The new bridge will be installed during the spring of 2020 and this new landmark in the heart of the Swedish capital is scheduled to officially open in the summer of 2021.

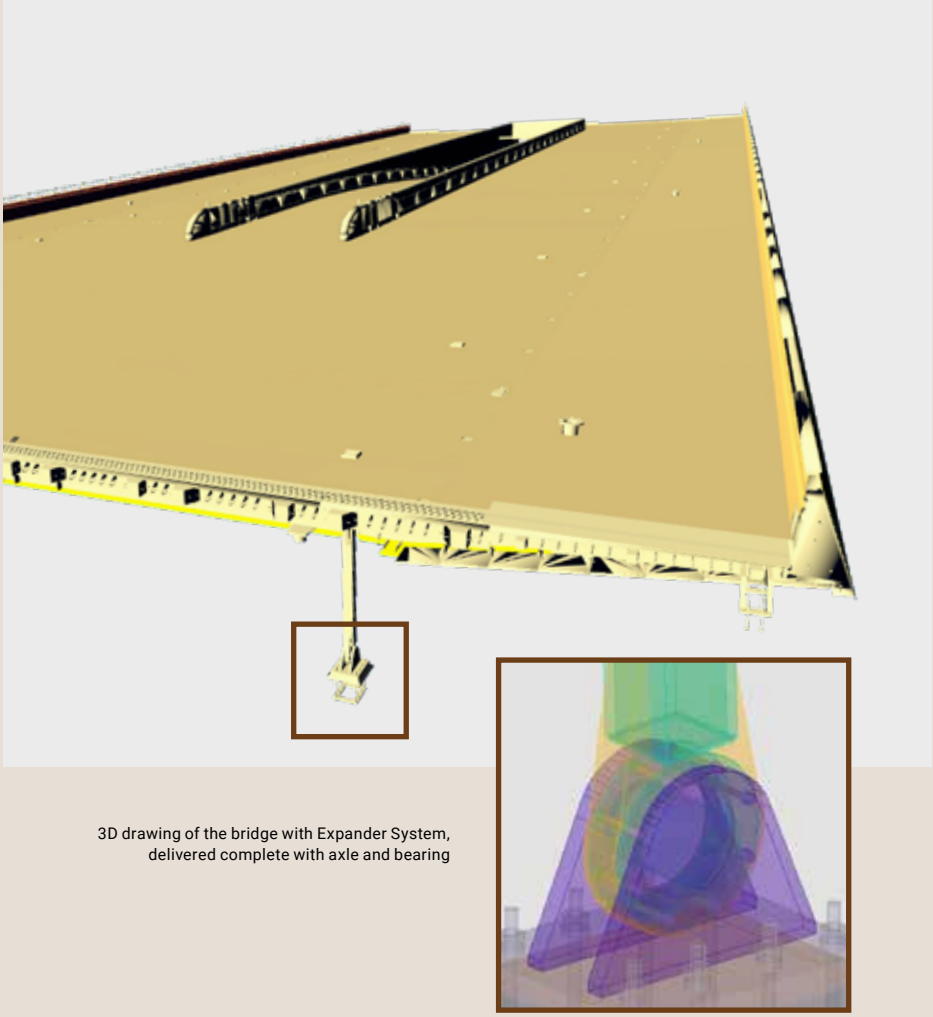


Bridge construction bucks the trend

"Bridge projects are much larger today. We seldom get the chance to build a single bridge over a river, since those bridges have already been built," says Tore Lundmark, an honorary doctor at Luleå University of Technology. He has been designing bridges since the early 1980s and during his long career he has been involved – in a variety of roles – in a number of high-profile projects.

Standardization and a module mindset are now the norm in many parts of the construction industry. But bridge construction projects are bucking the trend. They just keep getting more and more complex.

"There are rarely any straight parts and standardization is almost impossible. Most bridges curve and bend, or have varying widths. Each bridge has a unique character and personality," says Tore Lundmark.



3D drawing of the bridge with Expander System, delivered complete with axle and bearing

Tomas Bergström
SENIOR CONSULTANT
RAMBOLL

Tore Lundmark
CHIEF DESIGNER
RAMBOLL

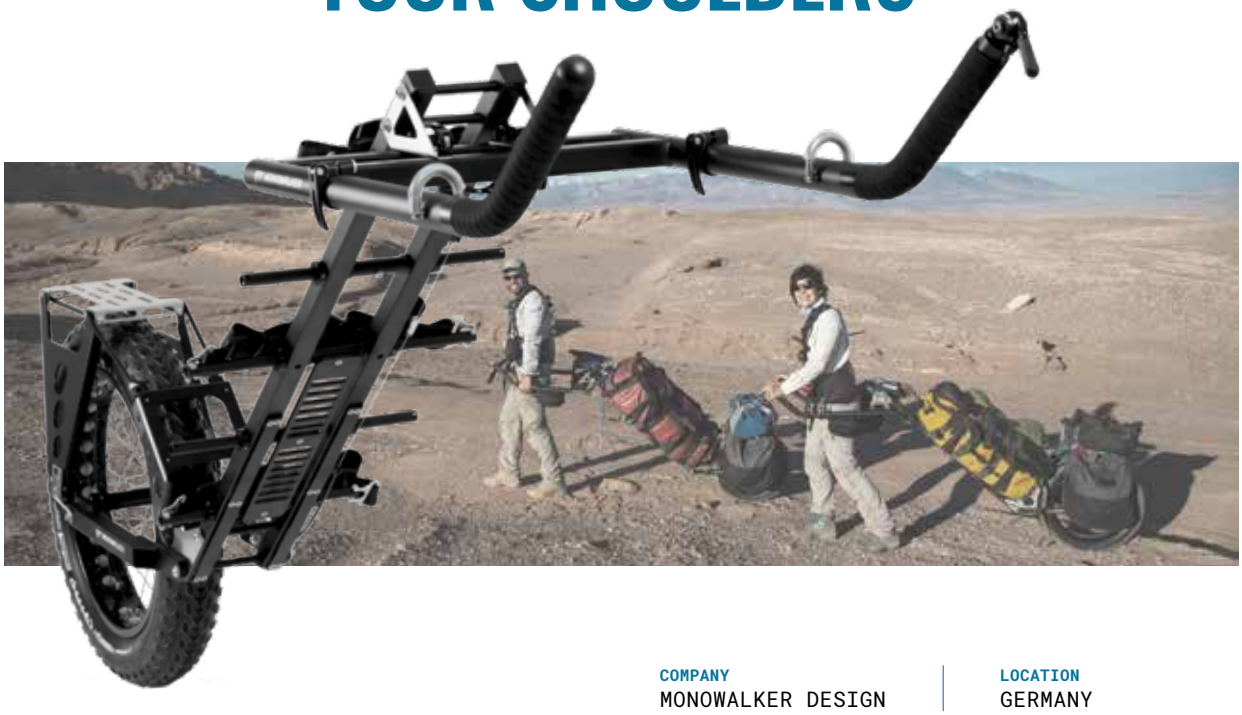
CUSTOMER	END CUSTOMER	MAIN CONTRACTOR
RAMBOLL	THE CITY OF STOCKHOLM, SWEDEN	SKANSKA

CHALLENGE
TO MANAGE MOVEMENTS IN A BRIDGE WITH GREAT VARIATION IN CROSS-SECTION HEIGHT AND VARIABLE CROSS-SECTION GEOMETRY

APPLICATION	SOLUTION
STRUTS FOR HINGED COLUMNS	EXPANDER SYSTEM

BENEFITS
THERE WILL BE NO PLAY BETWEEN THE STRUTS AND THE BRIDGE STRUCTURE

TAKING A WEIGHT OFF YOUR SHOULDERS



Braving the elements and getting close to Nature can be an enlightening experience, especially for children. But proper planning is crucial.

COMPANY
MONOWALKER DESIGN

LOCATION
GERMANY

PRODUCT
MONOWALKER FATMATE, A 9-KG ALL-TERRAIN HIKING CART

THE SOLUTION
ALL COMPONENTS SCREWED ONTO THE MONOWALKER FATMATE ARE FITTED WITH NORD-LOCK WASHERS

In a self-built house in Switzerland, near the Italian border, using state-of-the-art technology to minimize energy consumption, live energy engineer Stefan Markert, his wife Mirjam Haag and their four children. They are an eco-conscious family with a story to tell.

This summer, the family enjoyed a magical three-month adventure trek along the "La Grande Traversata delle Alpi" (GTA) mountain trail. The 900-kilometer route from Switzerland to the Mediterranean, passes from one valley to another, on tracks that often date back to Roman times.

"We wanted to escape society's materialism and stress, but also show our children how fragile the Earth is," says Markert. "Sometimes, it was three days before we reached civilization. I was carrying a daily 40-kilogram load for our family including tent, rolling mats, sleeping bags, clothes, food and medical supplies."

To manage this load, Markert tried the Monowalker Fatmate, a customized, one-wheel, all-terrain hiking cart. It relies on Nord-Lock wedge-locking washers to secure all bolted joints and to guarantee that no bolt comes loose when in use – maybe in a remote location.

The washers make it easy to disassemble the Fatmate whenever you need to stop and rest. You unscrew the bolts and collapse the cart. You can reassemble it in seconds. Better still – the washers can be reused several times without any problems.

The brilliance of the Fatmate is its ability to displace weight. The wheel bears 50 percent of the load, with the other 50 percent carried by super-light aluminum handles. The handles are supported by carabiners which clip onto a waist harness.

Markert used an additional rack, fixed above the trailer wheel axle, with side panniers carrying 20 kilograms of gear, reducing weight on the handles and harness by another 20 percent.

"We had snow, ice, wind and blazing sun, with temperatures from zero to 42°, and sometimes gruelling terrain," he says, "but the Fatmate managed everything. It took a load off my mind – and my shoulders too."

Text Rob Hyde **Pictures** Monowalker Design

Sometimes you know that a very good solution can be further improved. But actually figuring out how to make a good product great can be difficult. Here's how the faster, safer and more robust Boltight TSR+ auto-tensioner came about.

"My targets were very clear," explains Samad Ludi, the engineer behind the creation of the new TSR+ hydraulic bolt tensioning tool. "I knew that if I was going to succeed, I had to improve three critical characteristics – Speed, Safety and Durability."

Over the years, Nord-Lock Group had looked at improving the existing design of Boltight TSR but up to this point had not found the right solution.

Load cell is the key

Samad focused his efforts on the main component in the TSR+, the hydraulic load cell. He planned to redesign it so that it would get the tensioning job done faster, while making it safer in case of any failure and also giving it a superior life cycle.

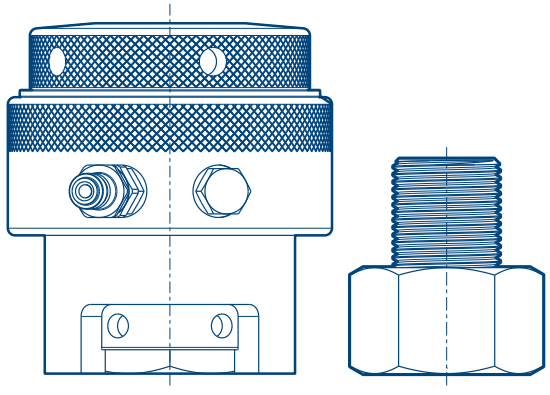
After getting the assignment, Samad worked for the first week just drawing out possible concepts for the new load cell on a sketch pad. He showed his designs one after the other to the review team for their input.

"Until," Samad says with a clear sense of pride, "based on the helpful feedback about my earlier sketches that I received from the team, and using all the design knowledge I have gained over the years, I came up with what

HYDRAULIC BOLT TENSIONER

FROM GOOD TO GREAT

Text Hugh O'Brian **Photos** Andy Coxsell



I considered to be a concept which solved all the issues. Fail safe, long life, and fast operation. I showed it to my engineering manager and gave a little brief about how it would work – and he just loved it!"

Interchangeability with existing components

Another requirement that Samad had to satisfy was interchangeability, meaning that customers could still use their existing Boltight TSR components and only needed to swap out the load cell to get all the benefits of the TSR+. By focusing only on the load cell, his solution meant that all the other parts could be used exactly as they had been in the past.

The new TSR+ load cell features the very latest technology in seals, springs and adaptors, with safety being a top priority, comments Samad. "Safety was such a key factor in this project, and we needed to make sure it would fail safe, with no risk to operators. The layout of the design was critical, and we did advanced analysis and testing to determine its safety factor and its life span. The load cell was designed so that if there is a major failure within the tool, the worst-case scenario, it would have a hydraulic blowout internally which is captured within the tool and avoids any potential harm to the operator."

Combines all experience in a single solution

The result is a state-of-the-art load cell design which combines the latest technology, including new seals, springs, and adaptors. “We have taken all the best experience and knowledge that we’ve gained with tensioners over the years, including tried and tested customized solutions, and put it into this unique design. All that data, experience and technology has been built into one single new product, the TSR+, to give users a wide range of valuable benefits.”

Among those benefits are:

— Speed which is 4 times faster than the previous TSR for return of the piston, that is the fastest on the market.

— Much better durability, with laboratory life cycle testing showing it easily out-performed the existing TSR at full pressure and full stroke.

— Greater operator safety due to the modern seal technology with a better pressure relief valve that will, in case of failure, blow inwards to avoid oil spray on operators.

— Full interchangeability with other components, as the load cell is easily swapped out.

Game changer for Boltight

This combination of advantages and benefits certainly gives Boltight and the Nord-Lock Group an even stronger position in the hydraulic bolt tensioner market. “When I presented the final design, my experienced colleagues said it could be a ‘game changer’ because it is such a specific type of tool – a spring-loaded auto-return tensioner,” says Samad. “We now have the fastest auto-return tensioner on the market. The initial response from the market has been very positive, generating a lot of interest, and we have orders going out for the tools as we speak.”

To learn more about Boltight TSR+ and what the hydraulic bolt tensioner does, visit
www.nord-lock.com/boltight/products/tsr-tensioners

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