

# BOLTED

A MAGAZINE ABOUT BOLTING TECHNOLOGIES

ISSUE 2 - 2019

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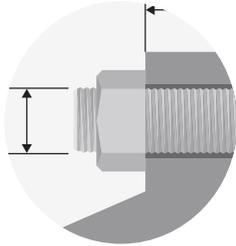
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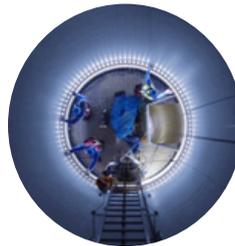
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Fredrik Mueller  
CEO Nord-Lock Group

## ***Let's get extreme!***

*Did you know that the temperature of a space rocket can fluctuate between  $-100^{\circ}\text{C}$  in the shade and  $150^{\circ}\text{C}$  when facing the sun? Or that combustion in a jet engine can reach temperatures as hot as  $900^{\circ}\text{C}$ ?*

In this issue of Bolted, we examine how extreme temperatures affect the metallic materials used to build common applications. We explain what you should keep in mind when facing very cold, very hot and extreme variations in temperatures in order to keep your applications performing at the highest level.

To investigate how operators handle working in such extreme conditions, we travelled to the South Pole to meet installer Trygve Jakobsen, who secured giant satellite antennas safely to the ground in freezing temperatures and gale-force winds — nature doesn't get more extreme than that!

Nord-Lock Group is used to securing bolts in all sorts of circumstances, from huge jet engines to tiny components you might even find in your home. However, no matter what challenge we are solving, our biggest focus is always on safety. A company that shares this value is Germany's largest supermarket corporation, EDEKA, who built "the world's safest trucking fleet." We paid them a visit to hear more about the project.

Speaking of safety, we also tracked down Allen Smith from DROPS on a remote oil rig in Scotland. He travels the world training industrial personnel on everything there is to know about preventing equipment from being dropped — a leading cause of accidents on industrial sites everywhere. Discover all this and much more from the world of bolting.

Let me also take this opportunity to thank you, our readers, customers and business partners, for your support. Nord-Lock Group is continuing to strengthen its market-leading position with new product launches such as our 'Superbolt Tool', and investments in Digital and SMART technology. These are just a few examples of how we help engineers worldwide to solve tough bolting and engineering challenges.

Happy reading!

# FROM POLE TO POLE AN EXTRAORDINARY INSTALLATION

*There is more to Antarctica than just ice-cold winter days. It's also the windiest place on earth. These conditions put an extreme amount of pressure on the applications used to survive in this part of the world — as well as on the bolted connections that keep these applications together.*

This is where installer Trygve Jakobsen needed to secure giant satellite antenna radomes safely to the ground. A radome (radar + dome) is the weatherproof enclosure that protects a radar antenna from the elements. In very few locations is this installation as crucial as in Antarctica. “When the winds reach hurricane force, the big radomes act almost like a plane wing — they generate a lifting force of up to 40 tonnes,” explains Trygve Jakobsen, a welder and installation expert at LNS Spitsbergen, based in Longyearbyen, the northernmost city in the world, located on the west coast of Spitsbergen island.

Jakobsen recently returned home after spending two months installing steel foundations for a new set of satellite antennas at the Troll Research Station in Antarctica — a base for climate researchers from the Norwegian Polar Institute, as well as the site for commercial satellite communication operated by Kongsberg Satellite Services.

Previously, the antenna foundations were welded together. Now, the steel structures are bolted instead. The process is much more efficient and just as strong — as long as the materials are top-notch. In the harsh climate, fasteners must be able to endure decades of temperatures as low as -60° and winds of up to 88 kilometers per hour.



“Our job is to build the foundation towers, which are up to 13 meters high, with the antennas and the protective radome perched on top,” says Jakobsen. “With such strong winds and the heavy loads and vibrations induced on the foundation, there is no room for error or weak links when we bolt it all together.”

Jakobsen and his team drilled poles deep into the ground. The prefabricated foundation base components were positioned on top of the poles and welded in place. From there, all the parts were bolted together. In this case, the installers relied on Nord-Lock washers to make the bolted joints as stable as possible.

“These washers are a bit different, as each part actually consist of two washers glued together,” Jakobsen says. “This solution provides an incredibly strong joint.”



## BEATING THE TOUGHEST CLIMATIC CONDITIONS TECHNICAL INSIGHTS

Hans Roger Borgersen, founder and CEO of Norwegian start-up HR Tech AS, helped to design the installation at the Troll station. His customer base is dominated by clients in the oil and gas industry, where strong winds, salt water and freezing temperatures are only a few of the challenges Borgersen enjoys meeting. He explains:

“My work focuses on delivering quality tools, welding equipment and fasteners used on installations in Svalbard, Canada and Antarctica, where the extreme climate demands very high quality from every single piece in the puzzle.”

In addition to the many parts they keep in stock, HR Tech also provide development and consulting work to ensure that critical installations are being planned and executed properly.

*“Installations in windy polar climates are exposed to heavy loads and vibration forces that place a lot of stress on every joint,” Borgersen says. “That is why we chose Nord-Lock original washers for the Troll Satellite Station.”*

Thanks to the reliability of Nord-Lock products, the lifetime of the new Troll station antenna systems increased compared to earlier installations. In conditions such as these, that’s a remarkable feat.”

### The client

Kongsberg Satellite Services

### End customers

Troll Satellite Station, Antarctica

### Application

Radar antenna foundations

### Challenge

Secure big radomes which protect satellite antennas from 80 kph (50mph, 22 m/s) winds.

### Nord-Lock Group solution

Nord-Lock original washers with zinc flake coating

### Benefits gained

Reliability, stability and extended installation lifetime



Trygve Jakobsen  
INSTALLATION EXPERT  
LNS SPITSBERGEN



Hans Roger Borgersen  
CEO HR TECH

Text Geir Anders Rybakken Ørslien    Photos Trygve Jakobsen and Reidar Norheim

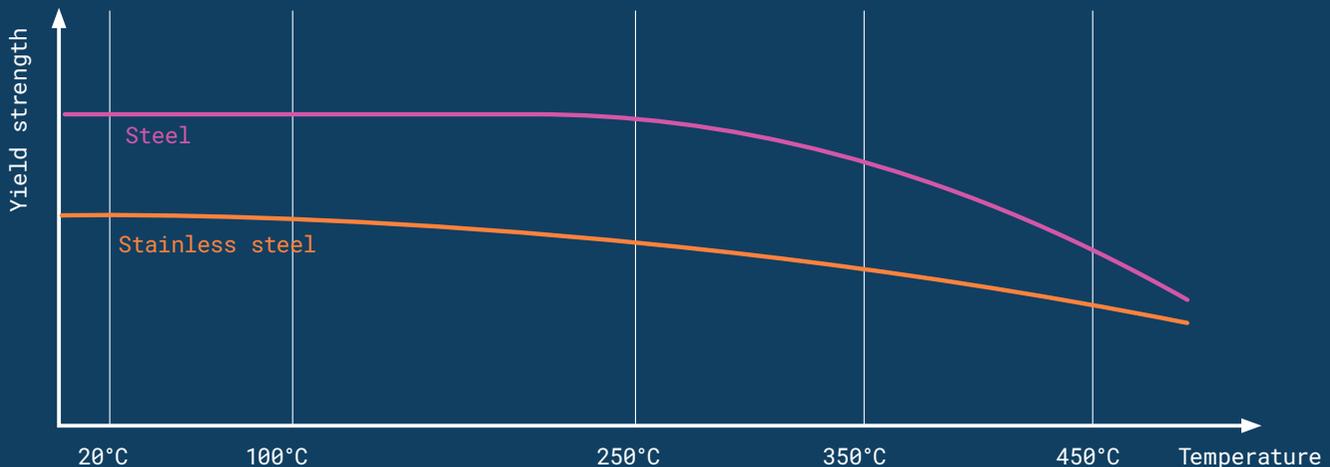
# What are the thermal effects on preloaded bolted joints?



Damien Thomas  
EUROPEAN TECHNICAL MANAGER  
NORD-LOCK GROUP

Email your questions about bolting technologies to [experts@nord-lock.com](mailto:experts@nord-lock.com)

## Loss of mechanical resistance with increase in temperature



### Negative effects on bolted joints

Service temperatures above 250°C activate creep and relaxation phenomena in alloyed and construction steels. Hence, despite bolts being preloaded in their elastic state at the service temperature, a portion of the preload is relaxed in proportion to the reduction of yield strength of the steel fastener.

Due to temperature variations, parts and fasteners expand or contract with various amplitudes depending on rate of temperature change, the mass and size of parts, conductivity of metals, and the coefficient of expansion of each individual materials. These differences in relative expansions or retractions between materials and parts generate variations in preload in the joint. Often, the maximum amplitude of preload variation occurs during transient states.

Thermal cycling can also generate thermally-induced fatigue, since not all areas expand simultaneously with the same amplitude. The boundaries between “hotter” and “colder” areas undergo extra stress, which can lead to local fatigue of the material. However, when the temperature is stable and uniform in all parts, it is recommended to use materials with homogeneous coefficients of expansion to minimize the variation in clamp load, or take that preload modification into account for the joint design.

It's possible to overcome the above challenges by following state-of-the-art design codes, material selection, and joint-calculation guidelines by:

- Verifying adequate material selection regarding behavior of mechanical characteristics at service temperature to avoid dramatic metallurgic changes such as precipitates, aging or heat treatment (i.e. tempering or annealing).
- Checking that no excessive stress will occur due to load variation, caused by service loads and by differential relative thermal expansion (or contraction) during thermal cyclings.
- Anticipating how much preload will be lost via creep and relaxation phenomena.

### Nord-Lock Group experience and solutions

Nord-Lock Group products, from wedge-locking washers to multi-jackbolt tensioners, are often used in extreme environments.

When guiding customers through product selection, product design and joint design phases, we follow the state-of-the-art guidelines to provide safe and durable components for bolted joints. We review material selection to account for service temperatures and risks of corrosion and creep.

Next, we review the preload range, from tightening at ambient temperature to the residual (or extra) load in service. When necessary, coating, lubricant and dry films are applied. We also assist users in their design phase to avoid any risk of failure regarding the joint itself.



# THE FOOD RETAILER DRIVING TRUCK SAFETY

*Accidents involving trucks and vulnerable road users often end tragically, but is this something that could be avoided?*

*Yes, if you ask EDEKA Südbayern, a German food retailer that became a pioneer in traffic safety. —————>*

Few traffic safety topics are more vigorously discussed in Germany than the need for modern safety systems on trucks. According to the German Federal Statistical Office, 3,100 accidents involving trucks and cyclists occurred in 2017.

Seventy-six of these cases led to fatalities — which means more than one death per week. About a third of the accidents leading to personal injury were caused by trucks turning right, meaning the truck driver could not see the cyclist. In recent years, several children have fallen victim to these accidents.

Demands to ban trucks completely from cities are being raised and pressure is growing on the government to take action. An EU-wide regulation on extended truck safety systems is already under discussion but is not expected to become law before 2024.

### **Taking the initiative with truck safety**

One company that isn't waiting for new legislation is EDEKA Südbayern, one of the largest food retailers in Germany. Four years ago, the company developed a turning assistant with an integrated camera that eliminates the "blind spot" for the truck driver, who can now see cyclists and pedestrians more easily.

"After several fatal road accidents involving trucks in the region, I conducted research and found out that there were no corresponding safety solutions on the market," explains Anton Klott, the company's technical director. "Our trucks drive through all big cities in this region and turning is always a dangerous manoeuvre. I decided to develop the solution myself, and two months later, we had the first turning assistant on the road."

Today the system is distributed externally by a partner in the truck market. So far — as part of a project that doesn't generate any profit for EDEKA Südbayern — it has been installed in more than 2,000 vehicles belonging to other companies.

"We are a food retailer that loves safety," says Klott. "These accidents have dramatic consequences, also for the truck drivers. Statistics show that 80 percent of all drivers involved in a fatal accident suffer long term stress and are unable to continue working. Police and other first responders also need psychological support to cope with these incidents."

### **The safest truck fleet in Europe**

EDEKA Südbayern has a fleet of about 300 trucks and 475 truck drivers covering the entire southern part of Germany, driving in shifts, 24 hours a day.

Klott is a trained car mechanic and carriage builder, and has been with the company for 40 years — 19 years of which he has spent as technical director. He shares a great vision with the company's management: to provide the safest truck fleet in Europe. And their turning assistant is only one part of that.

*"Safety is more important than money," says Anton Klott.*

He uses the fire extinguisher in the truck's cockpit as an example. It is a safety feature that is not required by law but is standard equipment in all EDEKA Südbayern trucks. "Our drivers have been able to extinguish fires in accidents on the highway and have saved quite a few lives. Several colleagues have even been awarded the Bavarian Rescue Medal for their efforts."

The vehicles also have a reversing assistant that can initiate an automatic brake. Ultrasonic sensors at the rear make it impossible to drive over people or objects. Even before the technology was approved, EDEKA Südbayern installed side flashing lights. When the driver changes direction, the entire truck side blinks and warns cyclists who are travelling parallel to the truck.



## **THE BENEFITS OF NORD-LOCK WHEEL NUTS**

- 100% reliability and thus better road safety
- Fast and simple assembly and disassembly
- After tightening and retightening, the wheel nuts hold until they are loosened manually – without having to be checked
- Nord-Lock as a reliable partner (EDEKA Südbayern presents Nord-Lock's wheel securing solution at trade fairs)

## Loosening nuts are history now

“We used to have big problems with loosening wheel bolts,” says Klott. “Sometimes they were not properly derusted, sometimes the driver forgot to retighten them. Alternative solutions were always complicated. For example, the driver had to check regularly that certain indicators on the wheel nuts pointed in the right direction. That’s all history now. The wheel nut solution from Nord-Lock is a perfect system that increases safety.”

“Accidents due to loosening wheel nuts can be tragic and also very negative for a transport company’s public image,” says Stephan Gruber, sales engineer at Nord-Lock Group. “That’s why more and more companies use Nord-Lock to eliminate these kinds of accidents.”

EDEKA Südbayern proves that great visions don’t have to be expensive. “All our security attributes only account for about one percent of the total truck acquisition cost,” says Klott.

Truck safety is high on the public agenda in Germany, and EDEKA has a security partnership with the German Ministry of Transport. Anton Klott is proud that his company has been able to inspire others to increase their own safety.

“Today, all long trucks in Germany must have a turning assistant and side flashing lights, by law. Of course, that’s a great feeling for us.”

## NORD-LOCK WHEEL NUTS TECHNICAL INSIGHTS

*The loosening of wheel nuts is the main reason for wheel detachment – a problem that occurs more often than you might think. In the UK alone, there are up to 400 wheel detachments from heavy trucks every year\*. In the US, detached wheels result in about 20 accidents per week\*\*.*

Nord-Lock wheel nuts are suitable for both on- and off-road vehicles (M16-M24x1.5 & 7/8"-11 BSF). The products use the same principle as the Nord-Lock wedge-locking system, using preload instead of friction. Every wheel nut comes permanently attached to a pair of Nord-Lock washers. The washers have cam faces on one side and serrations on the other.

“When the wheel nut is tightened, the serrations on the outer faces of the washers grip into both the fastener and the mating surface of the wheel rims, thus creating a tight fit,” explains Stephan Gruber, Sales Engineer with Nord-Lock Group. “Each rotation of the nut leads to

an immediate increase in preload, making self-loosening impossible.”

For all vehicles, it’s important to be able to loosen the wheel nuts quickly and easily, for example in the case of tire changes. Again, the product offers great benefits, according to Stephan Gruber.

“The wheel nuts can be installed and removed using standard equipment and tools, making the process quick and easy. Nord-Lock wheel nuts are also reusable, depending on conditions of use, and can therefore be reinstalled.”

**Text** Linda Karlsson **Photos** Jörgen Lindström



### Customer

EDEKA Südbayern

### Location

Gaimersheim, Germany

### Project

To optimize the company’s approximately 300 trucks to become the safest truck fleet in Europe

### Solutions

Different safety features, such as turning assistant, reversing assistant, side flash lights, fire extinguisher and a reliable wheel nut solution

### Nord-Lock Group product

Nord-Lock Wheel nuts M22x1,5

\* United Kingdom Department of Transport. Report: Heavy Vehicle Wheel Detachment

\*\* National Transportation Safety Board, USA



**Stephan Gruber**  
SALES ENGINEER  
NORD-LOCK GROUP



**Anton Klott**  
TECHNICAL DIRECTOR  
EDEKA SÜDBAYERN

### Did you know?

In 2019 Nord-Lock introduced an extended wheel nut range to cover all on- and off-road vehicles. The wheel nuts are now available in 6 sizes (M16-M24, including 7/8" BSF).

# GETTING SMART WITH SUPERBOLT

*Superbolt achieves the desired preload on any critical bolted joint with ease and high accuracy. To further strengthen this ability, Nord-Lock Group has developed a smart preload monitoring technology, taking their proven Superbolt Multi-Jackbolt Tensioners (MJTs) to the next level: the Load-Sensing Tensioner (LST). This will allow customers to easily confirm that their application is tightened correctly.*

The Superbolt Multi-Jackbolt Tensioner (MJT) revolutionized how large-sized bolts are tightened. Rather than using special tools to reach the high preload requirements of a large bolt, the MJT breaks the preload into manageable torques using jackbolts threaded through the nut body. This allows operators to easily install and remove the MJT using simple hand tools.

“The Superbolt MJT is a unique product,” says Steve Busalacchi, Global Product Manager, Superbolt, Nord-Lock Group. “It has solved many issues within bolting but there are always improvements we can make to help the customer. One of those is having external indication of the exact preload.”

Nord-Lock Group adopted smart technology in order to incorporate this feature into the Superbolt MJT without encumbering the customer with complications. Indeed, different ways already exist to monitor preload, however, these rely on the customer having to retrofit their existing studs or bolts or even buy another system entirely — a process which is costly and time consuming.

## Measuring preload using nut dilation

Nord-Lock Group ran multiple tests at their European technical centers in Lyon, France, and St. Gallenkappel, Switzerland, to find the most

practical way to monitor preload. The thought occurred: Is it possible to correlate the inherent flexing action of the MJT to the preload generated into the bolt?

This is known as nut dilation — a process whereby a cylindrical shape expands when it is under pressure. Further tests showed that this relationship was linear, meaning that if the jackbolts are tensioned with double force, the expansion of the nut body will be double — making it easy to measure.

“The measurement is taken from strain gauge sensors placed in strategic locations of the MJT,” explains Pierre Kellner, Business Developer, Smart Products and Services at Nord-Lock Group. “You feed the sensors with a voltage and if the material expands, the resistance increases and if it shrinks, the resistance decreases. If you calibrate these measurements you can translate them into kilonewtons and thus measure the preload.”

## Accessible data anytime, anywhere

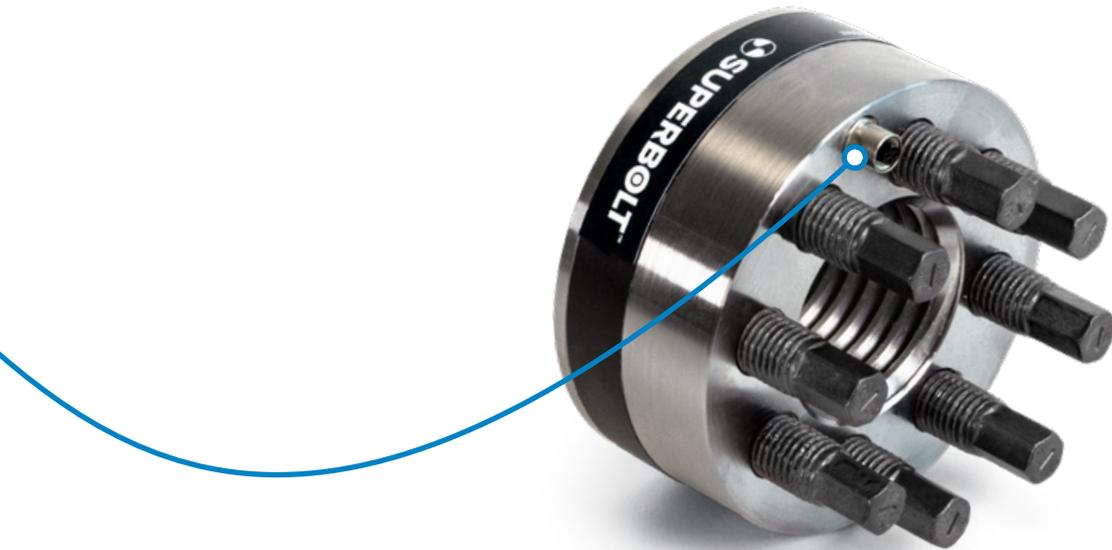
The strain gauge sensors on the MJT are connected to a wireless transmitter. This allows the operator to either read out the preload locally on a device, for example during installation, and/or monitor it remotely from the Nord-Lock Group portal.



**Steve Busalacchi**  
GLOBAL PRODUCT MANAGER  
SUPERBOLT TECHNOLOGY  
NORD-LOCK GROUP



**Pierre Kellner**  
BUSINESS DEVELOPER  
SMART PRODUCTS & SERVICES  
NORD-LOCK GROUP



This is a true Industrial Internet Of Things solution (IIOT). IOT-hub and Stream Analytics from the Microsoft Azure platform are used to collect and analyze the data. Notifications and alerts can be set easily for scenarios that need to be monitored.

“This evolution will be very useful for critical applications,” explains Busalacchi. “Let’s take critical joints that have gasketed flanges, that’s a highly volatile environment and this can cause gasket degradation and loss of preload. Preload monitoring lets you know whether to retighten the bolts or replace the gasket before it fails, saving you complications in the long run.”

### **Ensuring peace of mind with each installation**

The reliability of the LST provides customers with the knowledge that their Superbolt MJT has achieved the correct preload. This provides peace of mind and rightly so. Although Superbolt provides customers with highly accurate torque values that correlate with the desired preload of their MJT, operator mistakes do occur.

In this way, being able to monitor preload during installation provides the service team with the knowledge that they have done their job correctly and the application owner with the assurance that their piece of equipment will function as expected.

The Superbolt LST is an exciting step into the world of smart products for Nord-Lock Group, allowing the company to upgrade already successful products to provide even more practical and innovative solutions for their customers. With more projects under development, the future of bolting is sure to be smarter than ever.

**Text** Ariane Osman



### **What are smart products?**

Smart products incorporate a digital element in order to collect data and transfer it to an online database such as the cloud. This data can include location tracking, condition monitoring or fault diagnosis. Smart products are part of the Internet of Things (IOT); the online connectivity of everyday products that can be tracked and controlled remotely.

# IMPACT OF EXTREME TEMPERATURES ON METALLIC MATERIALS

A meteorite that crashed into the Earth around 35 million years ago produced what is believed to be the hottest-ever naturally-occurring temperature on our planet. Scientists estimate that a temperature of 2370°C, which is about half as hot as the Sun's surface, was reached via this extraterrestrial impact.

On the opposite end of the scale, the lowest natural temperature ever directly recorded at ground level on Earth is -89.2°C at the Soviet Vostok Station in Antarctica on 21 July 1983.

*Text Hugh O'Brian*

# NUCLEAR FUSION

(EXPERIMENTAL REACTORS LIKE ITER, TORE-SUPRA, JT-60SA)  
PLASMA: 100 MILLION°C BUT CONFINED BY MAGNETIC FIELD IN VACUUM VESSEL, WHICH MUST BE COOLED BY CRYOSTAT AT -196°C OR EVEN AS LOW AS -269°C

# AVIATION

COMBUSTION IN JET ENGINES  
700°C TO 900°C

# POWER GENERATION

GAS AND STEAM TURBINES: 350°C TO 500°C  
NUCLEAR POWER PLANTS: 160°C TO 550°C

# MACHINERY

ENGINES AND EXHAUSTS UP TO 300°C  
OVENS, MAINLY UP TO 1200°C, ABOVE THIS CERAMIC MATERIALS ARE REQUIRED  
HEAT TREATMENT LINES 400°C TO 900°C  
STEEL FOUNDRIES AND HOT FORGING OPERATIONS LIKE HOT ROLLING, UP TO 600°C

# AEROSPACE

HUGE THERMAL SWING OF PERHAPS -100°C IN THE SHADE TO +150°C WHEN FACING THE SUN  
EXPOSURE IN SPACECRAFT, SATELLITES, ROCKETS, AS WELL AS BOOSTERS/FUEL TANKS FILLED WITH LIQUEFIED HYDROGEN (H<sub>2</sub>), HELIUM (He) OR NITROGEN (N<sub>2</sub>)

# OIL & GAS, CHEMICAL

CHEMICAL REACTORS UP TO 450°C  
LIQUEFIED GAS AND CRYOGENICS, -196°C FOR HYDROGEN (H<sub>2</sub>), HELIUM (He), NITROGEN (N<sub>2</sub>) AND METHANE (CH<sub>4</sub>)  
INCINERATORS: UP TO 800°C TO 1000°C

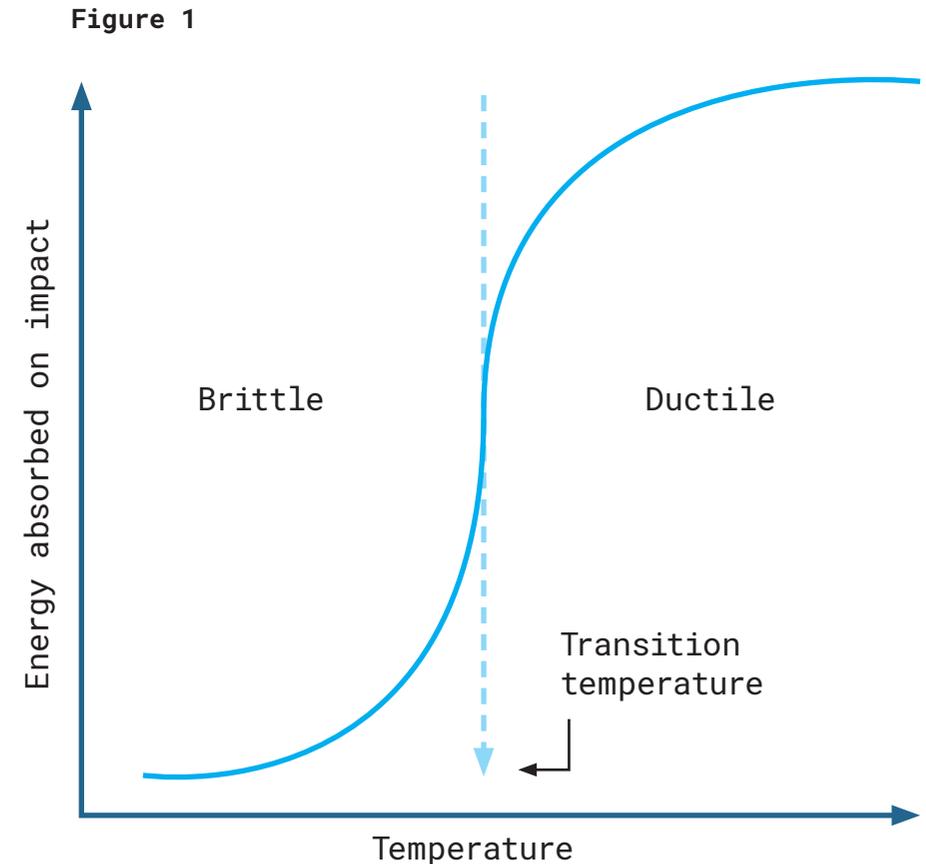
Table 1: Examples of applications at extreme temperatures for metallic materials

## HEADING DOWN TOWARD 'ABSOLUTE ZERO'

While the temperatures mentioned on the previous page were naturally occurring, the temperatures that metals in industrial applications are subjected to sometimes approach those ranges, leading to significant challenges. Just think about a jet engine: Temperatures can reach 900°C, while industrial ovens can go to 1200°C. On the opposite cold end of the scale, cryogenics may involve exposure to temperatures of -196°C or even as low as -269°C. For anyone who recalls their high school physics, this is just slightly above “absolute zero” which at -273°C is the lowest possible temperature — where nothing could be colder, and no heat energy remains in a substance.

Therefore, when designing equipment for any application involving either very low or high temperatures, or wide swings in temperatures, it’s especially important to consider the effects these temperatures will have on the metals being used. There are dozens of bolting and fastening applications that may involve extreme temperatures, with some examples shown in Table 1 on the previous page.

The science of metallurgy studies the ways in which various metals behave over wide temperature ranges, and also how specific metals or combinations of metals can help mitigate possible negative effects. Thus, steel and other metal alloys can be tailored to meet the requirements of an application that is subjected to temperature extremes.



## THE CHALLENGES THAT LOW TEMPERATURES POSE

The primary adverse effects that low temperatures cause are the loss of ductility (the ability to undergo plastic deformation before rupture) and increasing embrittlement of the material as the temperature falls below what is called the ductile-to-brittle transition temperature or DBTT (see Figure 1).

“A ductile material will first deform before finally fracturing,” explains Alexandre Fleurentin, an expert in the area of metallurgy and heat and surface treatments, and founder of the company Métallo Corner in France, “while a brittle material will more likely break immediately when a load exceeds its yield strength.”

As temperature decreases many materials shift from ductile to brittle behavior at the DBTT. Obviously, shattering is more likely

to have negative consequences, compared with deforming, and at very low temperature steels generally tend to be more sensitive to impacts, with a risk of breaking in case of a sudden shock or bending. This characteristic is close to resilience and is evaluated under the impact test.

On the other hand, lower temperature frequently results in an increase of mechanical tensile strength of a metal and less elongation at break. To keep the mechanical strength high and achieve a less brittle material, austenitic stainless steels with a high content of nickel and nitrogen are often preferred.



Alexandre  
Fleurentin  
MATERIAL EXPERT  
MÉTALLO CORNER

## HIGH TEMPERATURES ARE EVEN MORE COMPLEX

At extremely high temperatures, there are some reversible phenomena which occur, while others are permanent. Reversible ones, which regress if the temperature returns to what is considered normal, include a temporary loss of mechanical tensile strength and changes in ductility.

Regarding the permanent phenomena, aging and heat-treatment processes occurring at elevated temperatures can cause over-tempering, which results in reduced fatigue resistance. Therefore, the temperature of service should also remain under the annealing or tempering temperature of the steel.

In stainless steel, high temperatures can lead to the loss or decrease of the protective passivating layer, so at these temperatures the designer must be careful about ambient factors such as humidity

and certain elements in the atmosphere. “Even fluids, which have indirect impact on metal performance, can be influenced,” says Fleurentin. “For example, at high temperatures some lubricants like molybdenum disulfide ( $\text{MoS}_2$ ) change properties and completely lose their lubrication ability ( $\text{MoS}_2$  becomes  $\text{MoS}_3$  = molybdenum trisulfide), leading to possible problems.”

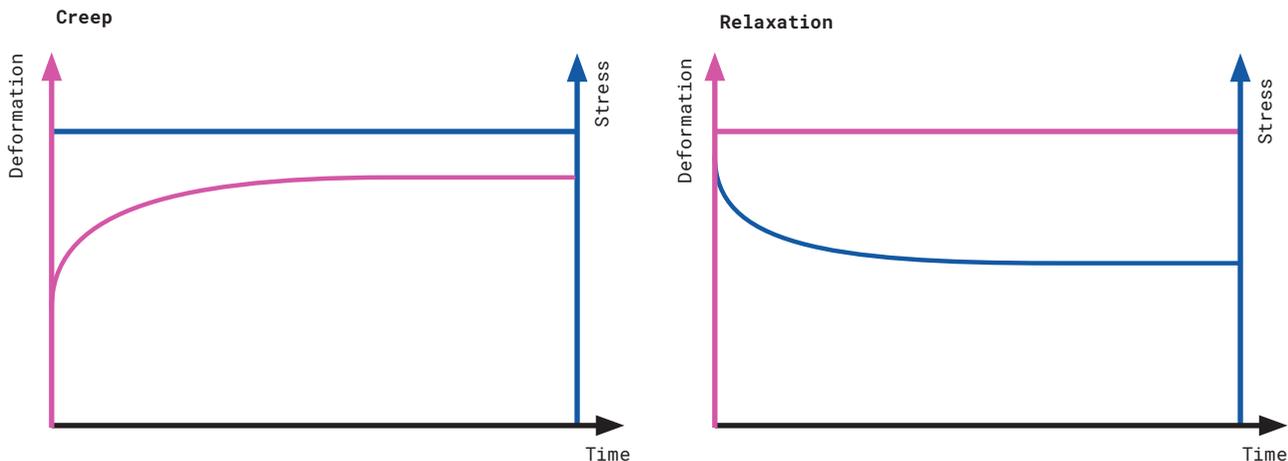
## CREEP AND RELAXATION ARE ALSO HEAT ACTIVATED

The important, and often detrimental, phenomena of creep and relaxation can also be activated at high temperatures. Creep is when a material deforms slowly and permanently due to constant mechanical stress, even though it is below the material’s yield strength. Relaxation is when the material, even though it is initially loaded below its yield strength, releases stress when exposed to a fixed strain by transform-

ing a portion of this elastic deformation into plastic deformation (see Figure 2).

Creep or relaxation in metals both occur more readily if subjected to elevated temperatures, even before the loads or deformations exceed the yield strength of the material. The extent of creep or relaxation depends on the amount of stress, the temperature and time of exposure. These phenomena can be activated from about  $200^\circ\text{C}$  for steels and as low as just over  $100^\circ\text{C}$  for some light alloys and stainless steels. To meet really challenging applications, designers may choose to use creep-resistant alloys that are nickel-based or cobalt-based. Keep in mind that creep and relaxation permanently modify the parts in terms of deformation or stress relief.

Figure 2



## COEFFICIENT OF THERMAL EXPANSION VARIES OVER WIDE TEMPERATURE RANGES

Another result of extreme temperatures is that a material will expand or contract in proportion to the temperature, due to physics. So when the temperature rises in a steel structure the atoms start to vibrate more and more. This thermal agitation, in turn, leads to an increase in inter-atomic distances and thus causes an expansion in the material.

The actual expansion that occurs with increasing temperature is described by what is called the coefficient of linear thermal expansion (CTE), which is normally defined at  $20^\circ\text{C}$  for various materials. It is generally constant over a particular temperature

range, say from 0 to  $100^\circ\text{C}$ . However, states Mr. Fleurentin, “the CTE for a given material is not always constant over a wide range of extreme temperatures so it is usually updated every  $100^\circ\text{C}$ .”

“In addition to the fact that the CTE itself can vary with temperature, the designer must also take into account ageing and changes in material properties over the service time. These are both tremendously important for any type of equipment, or bolting and fastening solution, that will be facing extreme temperatures.”

IN THE SPOTLIGHT

# ALLEN SMITH

*Allen Smith travels the world to deliver comprehensive familiarization and coaching on behalf of DROPS, a global working group that offers dropped objects prevention strategies across the industrial sector. This includes Train the Trainer sessions, classroom-based awareness sessions and practical training. He found time in his busy schedule en route from New York, USA, to Muscat, Oman, to talk to Bolted about the latest safety trends in the oil and gas industry and beyond.*

Text David Nikel  
Photo Justin Scobie



### What level of safety awareness do you see on your travels?

There has long been significant awareness of the potential and consequences of dropped objects within the drilling and well services sector. It's a fundamental consideration of working and using equipment at height, and everyone is aware of the issue regardless of their role. The concerted effort over the last 20 years through DROPS has established a consensus on prevention and mitigation best practices. This has created a recognized resource that others may freely exploit and benefit from.

### How are industries collaborating on safety?

Through DROPS, a broad cross-section of the energy industry has collaborated to explore and develop tools and techniques designed to reduce or eliminate dropped objects.

These cover a variety of applications, from awareness and risk assessment, task planning and control, equipment design and manufacture, inspection and inventory management, transportation and logistics, and much more. All DROPS guidance materials reflect a commitment to share and learn.

From a bolting perspective, DROPS has encouraged a broader appreciation and understanding of the principles of fastenings that has benefited equipment design and informed worksite inspections.

### How important is qualification and certification in the industry?

Qualification and certification are very important in an industry where integrity is critical to ensuring safety and efficiency. It assures the selection of approved and appropriate products which benefit the whole life cycle. Certification affords clarity and certainty on materials, the testing process, and the accuracy of safety data.

### What's next for DROPS?

There is an opportunity to develop common industry standards that demand greater consideration to dropped object prevention, particularly in how fastenings are selected and managed.

To enable this, DROPS will continue to promote a collaborative environment where product manufacturers, equipment specialists and technical authorities can explore various technologies and techniques in open, transparent working groups.



#### Name

Allen Smith

#### Title

Principal DROPS trainer, Silverdot Limited

#### Age

53

#### Professional Background

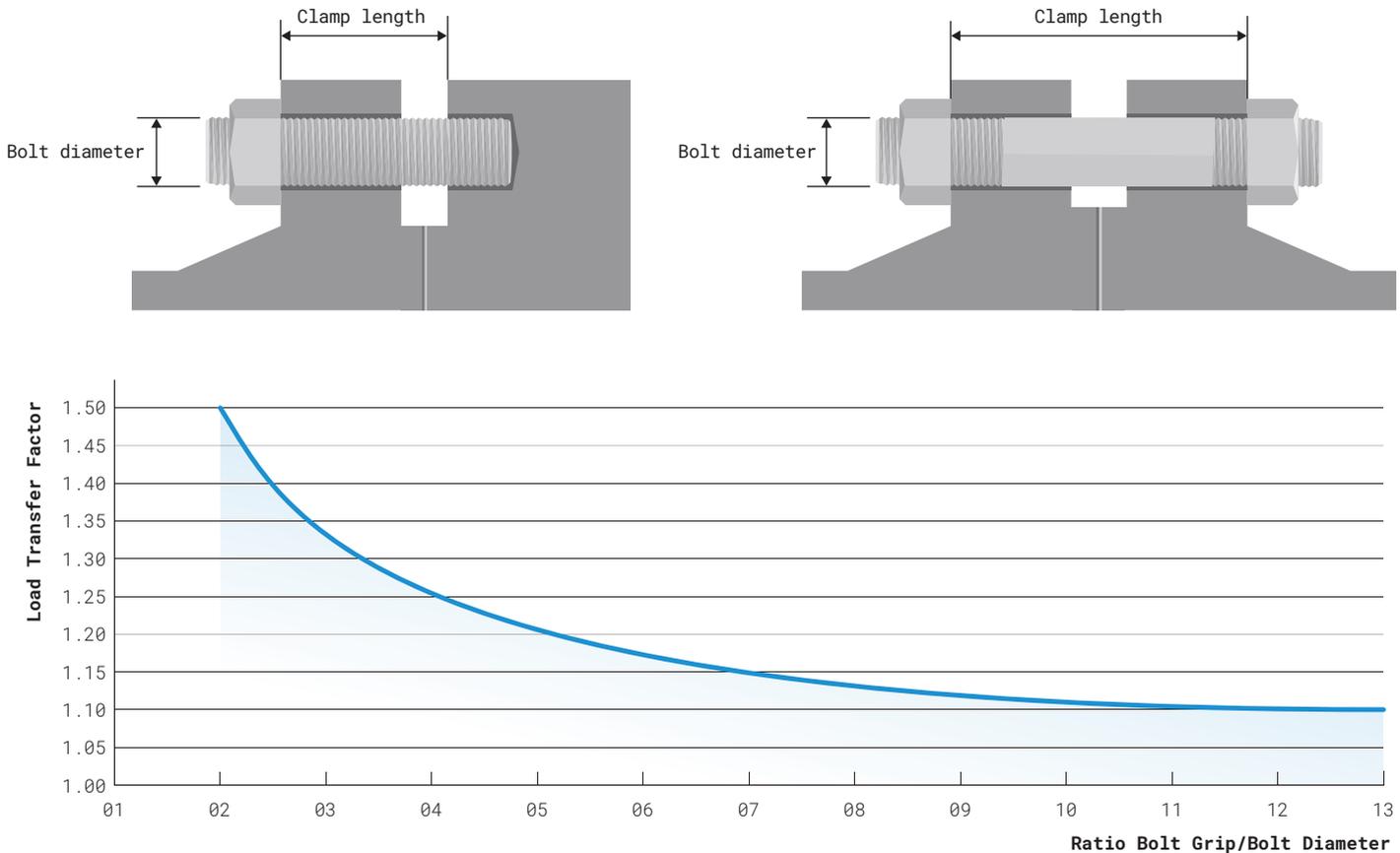
Director of Silverdot Ltd, based in Banchory, Scotland. Silverdot administers and facilitates DROPS globally on behalf of the DROPS Steering Committee.



Lee Campbell  
 ENGINEERING LEAD  
 BOLTIGHT TECHNOLOGY  
 NORD-LOCK GROUP

# What is the load transfer factor?

Email your questions about bolting technologies to [experts@nord-lock.com](mailto:experts@nord-lock.com)



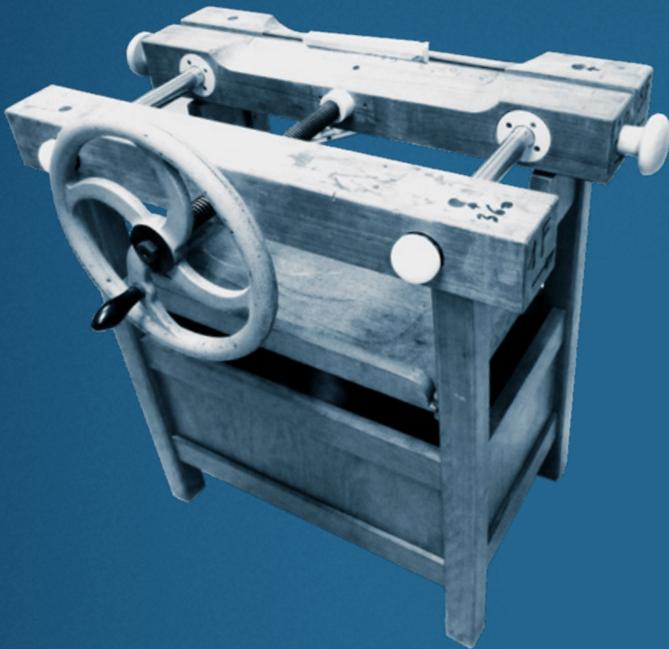
When utilizing hydraulic bolt tensioners to induce a controlled preload into a bolted joint, several key factors including load transfer factor need to be examined. This is key in ensuring that the selected tooling is capable of providing a load greater than the required preload of the joint to overcome any potential losses.

Load can be lost within a joint due to a number of factors, including localized yielding, joint deformation and an imbalance in geometry. It can however be observed that the difference in stiffness between the joint structure and the bolt can have an effect on the overall load lost in the joint. Load loss in a joint can be theoretically calculated using varying formula primarily based on known data of the bolt diameter and clamp length. The resultant value of this calculations is commonly known as the load transfer factor (LTF). The LTF gives a theoretical ratio which can be multiplied against the required preload to generate an applied load which overcomes the theoretical losses.

## Applied Load = Preload x LTF

The LTF is important in both tool design and tool selection. The maximum output force of the tooling must at a minimum match the applied load, however, it often exceeds this value. Careful consideration to the stresses in the joint and bolt is required to ensure loading conditions do not exceed accepted design criteria. In addition, performing the LTF calculation can highlight the need for changes in the loading conditions, joint design and tensioner design solution.

It is important to remember that load transfer factor is a theoretical value and cannot be used to determine the precise load lost within a bolted joint. However, for design and load application, LTF provides loading conditions, which allow for the physical losses within the joint. For accurate load measurement, systems such as bolt elongation measurement via dial indicators or ultrasonic measurements via the Boltight Echometer product range can be utilized.



**CUSTOMER**  
THE MEDIA LIBRARY IN TOUL, FRANCE

**CHALLENGE**  
THE PRESS WAS EXTREMELY HEAVY AND DIFFICULT TO OPERATE

**APPLICATION**  
OLD-STYLE BOOKBINDING PRESS

**SOLUTION**  
SUPERBOLT TENSIONERS

**CAPACITY**  
REPAIRING 20 CHILDREN'S BOOKS EVERY WEEK

*Wear on books is a problem for any library. This was also true for the media library in Toul, France, but a retired engineer came to the rescue, using Superbolt tensioners to revive an old bookbinding press.*

# A PRESSING ISSUE

Text Anna McQueen Photos Patrick Pignot

It's fair to say that "Once an engineer, always an engineer." When Philippe Gauvin retired from the position as a consultant engineer for French electric utility company EDF Hydro in 2012, he didn't leave his problem-solving skills behind.

"My job involved analysing technical problems that led to failures and damage to our hydropower generation facilities all over France," he says. "I then had to study the technical data to find technological long-term solutions to correct these disparities."

Superbolt tensioners were often used in these solutions, and when the media library in his hometown of Toul, south-eastern France, needed help, he came up with an idea.

For a small-town library with a tight budget, the wear on popular books is a real challenge.

Gauvin recalled that at the school where his wife used to work, there were some very talented technicians who repaired all kinds of things. For example, they made a bookbinding press for mending books. "I went back to the lycée, we had a dig around and found the press tucked away in the back of a cupboard!" he says.

The press was fixed, but it is a cumbersome and heavy object, not easy to operate. "I knew the size of regular bolts would make them too difficult to operate on a regular basis," says Gauvin who, remembering the positive experience he'd had with Superbolt tensioners, called his old contact Sébastien Bruyas at Nord-Lock Group and ordered four Superbolt tensioners.

"Using Superbolts in the press has allowed the media library to handle all the mainte-

nance of the press without having to use a 30-millimetre wrench, which would require considerable strength."

The press has been restored to perfect working order and the media library is repairing 20 books each week. The process is very simple: The book is firmly sandwiched in place in the press, allowing the pages to be trimmed square, the binding sewn, and the cover glued back into place.

"It was a lovely chance to bring something very useful that had been forgotten back to life," says Gauvin. "For just over 100 euros, we are making sure that the children's books can continue to give pleasure to younger readers, long after other libraries would have had to replace them. It's the perfect example of a circular economy."

# A WIND-WIN SITUATION

## THE CHALLENGE

Although it's not obvious from a distance, wind turbine towers are designed to flex and bend, which helps them dissipate the significant forces being exerted upon them. This flexing and bending, however, had been causing a major North American power company dangerous and expensive-to-repair failures in the bolts that hold up the Yaw and Saddle decks inside the tower (see Figure 2, page 21).

It was a major problem. The company alone has around 6,000 towers of this design and, in total at all companies, there are up to 35,000 of this type in North America. The wind tower OEM suggested various fixes, mostly putting stronger bolts in the L-angle deck brackets. To do this fix was complex and costly, involving maintenance crews working over shutdowns of 24 hours or more. But still the failures continued.

After struggling with this for several years, a creative engineer at the power company concluded that the bolts weren't the problem; the bracket was. Recognizing that a successful solution would most likely involve an articulating joint, he scanned the market for the right parts. Since no off-the-shelf piece of hardware was readily available, the engineer approached his local Fastenal store to look for possible equipment that could replace the OEM bracket.



**Figure 1**  
Actual installation on the Yaw deck of an operating wind turbine. The Nord-Lock original washers on each of the bolts help mitigate any problems due to stress and vibration.

## THE SOLUTION

Deeper discussions between the engineer and Fastenal's technical experts took place. Eventually, a simple solution based on an articulating joint which is secured with Nord-Lock wedge-locking washers (see Figure 1 below) was assembled and installed on two of the company's wind towers as a test.

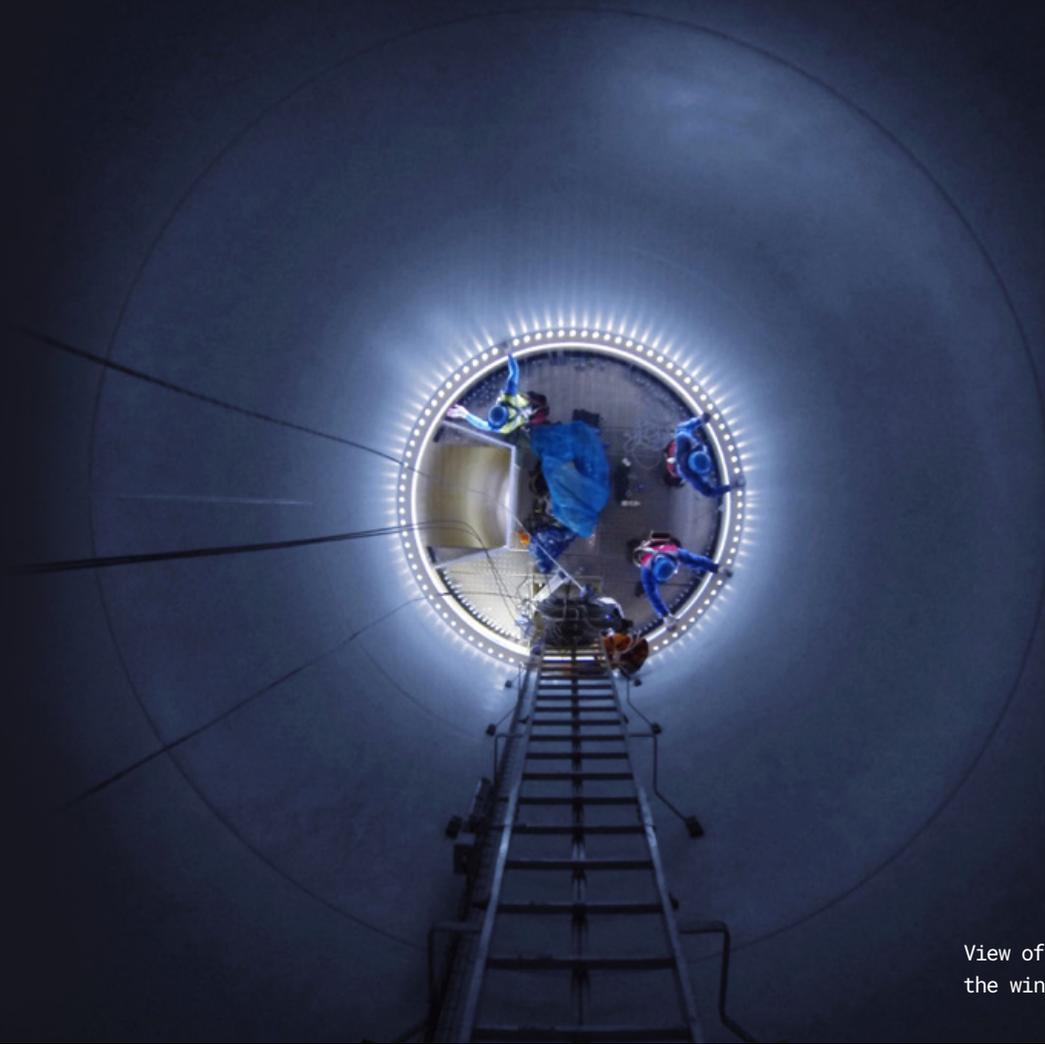
The Nord-Lock washers are important because they prevent the bolts in the articulating joints from coming loose, holding the decks securely in place during operation, something that previous methods had failed to do. The chosen design allows the decks to move slightly in multiple directions when the tower deforms in the wind.

## THE RESULT

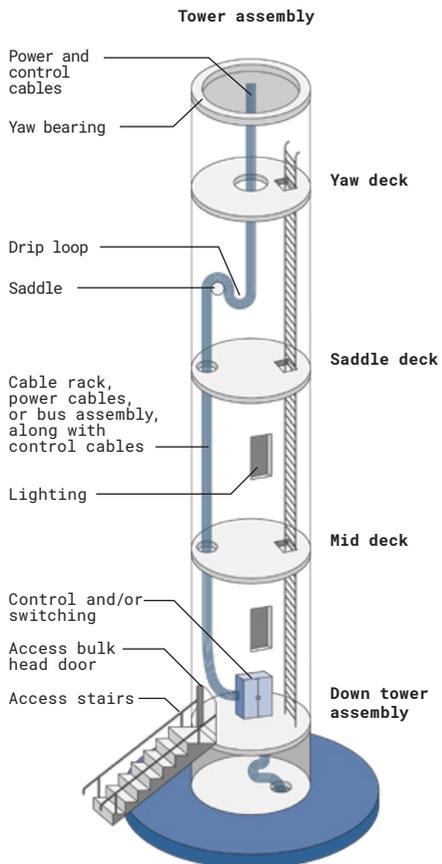
After studying the condition of the twenty new test brackets installed for more than a year in the Yaw and Saddle decks in operating wind turbines, no signs of wear have been apparent. Based on these positive results, the power company and Fastenal, supported by Nord-Lock Group, created a simple Deck Bracket Replacement Kit.

The kit, which will soon be available for shipment to Wind Turbine Sites for replacement work, consists of five articulating joints and the associated bolts, as well as the Nord-Lock washers. Besides offering a permanent solution to the problem, the articulating joint is also much faster to install, taking around 3-4 hours. This solution is positive and beneficial for several reasons, including revenue generation, safety of personnel, maintenance costs and financial payback over the long run.

**Text** Hugh O'Brian    **Photos** Hide Araki and Getty Images



View of a deck inside of the wind turbine tower



**Figure 2**  
The Yaw and Saddle decks are highest up, and therefore most impacted by movement.

**Client**

Major North American power generation and distribution company

**End customer**

The wind power industry

**Location**

Up to 35,000 wind turbines across the USA and Canada, and others worldwide

**Application**

Key bolted brackets on the Yaw and Saddle decks in operating wind turbines

**Solution**

Articulating joint which manages the stresses and is secured with Nord-Lock wedge-locking washers

# KEEPING MUNICIPAL PROJECTS ON TRACK

*A simple solution using the Expander System fixed a costly and time-consuming problem.*

One of the biggest municipalities in Iowa, USA, had a recurring problem with Liebherr 900 excavator it used for digging trenches and manholes. The problem was that the four traditional straight pivot pins which hold the bucket area together were frequently coming loose in the lug ears, which of course caused trouble in operating the bucket.

The municipality was thus forced to replace pivot pins in the bucket section at least 18 times during the eight years that they had owned the excavator. Statistically, this meant they were replacing an average of more than two of the four pivot pins every year.

The machine had to be taken to a workshop in order to undergo line boring, a costly and time consuming process that created a lot of downtime. This was incredibly problematic as the municipality did not have many excavators in its fleet, meaning that whole projects had to be put on hold while the excavator was repaired.

With the cost of the excavator growing year by year, the municipality needed to find a solution. They decided to try Expander System and initially installed one pin in the bucket area. Rather than having to take the excavator to a workshop, the Expander System pivot pin was installed in a couple of hours directly on site, providing the municipality with instant time and cost savings.

After a problem-free year with the Expander System pivot pin, the municipality decided to install one more. This was quickly followed by a third and fourth pin, which now secure the entire bucket area of the excavator.

“We would recommend Expander to anyone using heavy equipment who is having issues with pivot pins,” says a foreman working at the municipality. “We have also told maintenance personnel from other municipality cities about Expander System and plan to use this solution on some of the other machines in our fleet.”

**Text** Ariane Osman    **Photos** Matt Sommers and Alf van Beem



Liebherr 900



Before



After

**CUSTOMER**  
MUNICIPALITY WITH A  
POPULATION OF 130,000

**CHALLENGE**  
INCREASE MACHINE UPTIME AND  
REDUCE COST FOR THE MUNICIPALITY

**SOLUTION**  
EXPANDER SYSTEM

**PINS REPLACED SINCE SYSTEM INSTALLED**  
ZERO

**LOCATION**  
IOWA, UNITED STATES



# ENSURING SAFETY IN STUDENT RACING

Student formula racing is gaining popularity in Korea. The Korean Formula Student Competition (KSAE) allows engineering students to design and race their own cars – putting their engineering skills to the test in a real life environment.

BAQU4 is the formula student team from Hanyang University, one of the most prestigious institutions in the country that is well known for its engineering program. The team first participated in the Formula Student Competition in 2012 and won the grand prize in the formula section. Since then, they have been performing at a consistently high level and improving the quality of the race car they build every year.

The skill and passion of the student engineers caught the attention of Nord-Lock Group, which now sponsors the team and supports their engineering efforts. “This sponsorship has served as an opportunity for

us to grow as engineers,” explains a team member. “Nord-Lock Group is a company that has encouraged us to reconsider the word ‘safety’, one of the most basic principles, which school does not really teach us.”

Getting the opportunity to use Nord-Lock washers taught the students the value of high-quality fasteners and the difference they can make to the performance of an application. “Until now, we had been using nylon nuts and safety wires to prevent loosening but the effect did not last long,” explains one of the students. “We noticed a clear difference when we used Nord-Lock washers.”

*Nord-Lock Group regularly support various local initiatives related to the future of engineering. Let us know about your project through [info@nord-lock.com](mailto:info@nord-lock.com), or by contacting your local office.*

Text Ariane Osman Photo Baqu4 team



# SAFETY IS OUR THRILL

Whether you are traveling by train, crossing a bridge or riding an elevator, the last thing you are thinking about are the bolted connections holding everything together.

For example, on a roller coaster there are thousands of critical bolted joints. And while you're enjoying the thrill, we take care of the safety.



We made a video so you can experience the fun of the roller coaster in all its glory. Enjoy the ride while learning about the safety measures behind it.