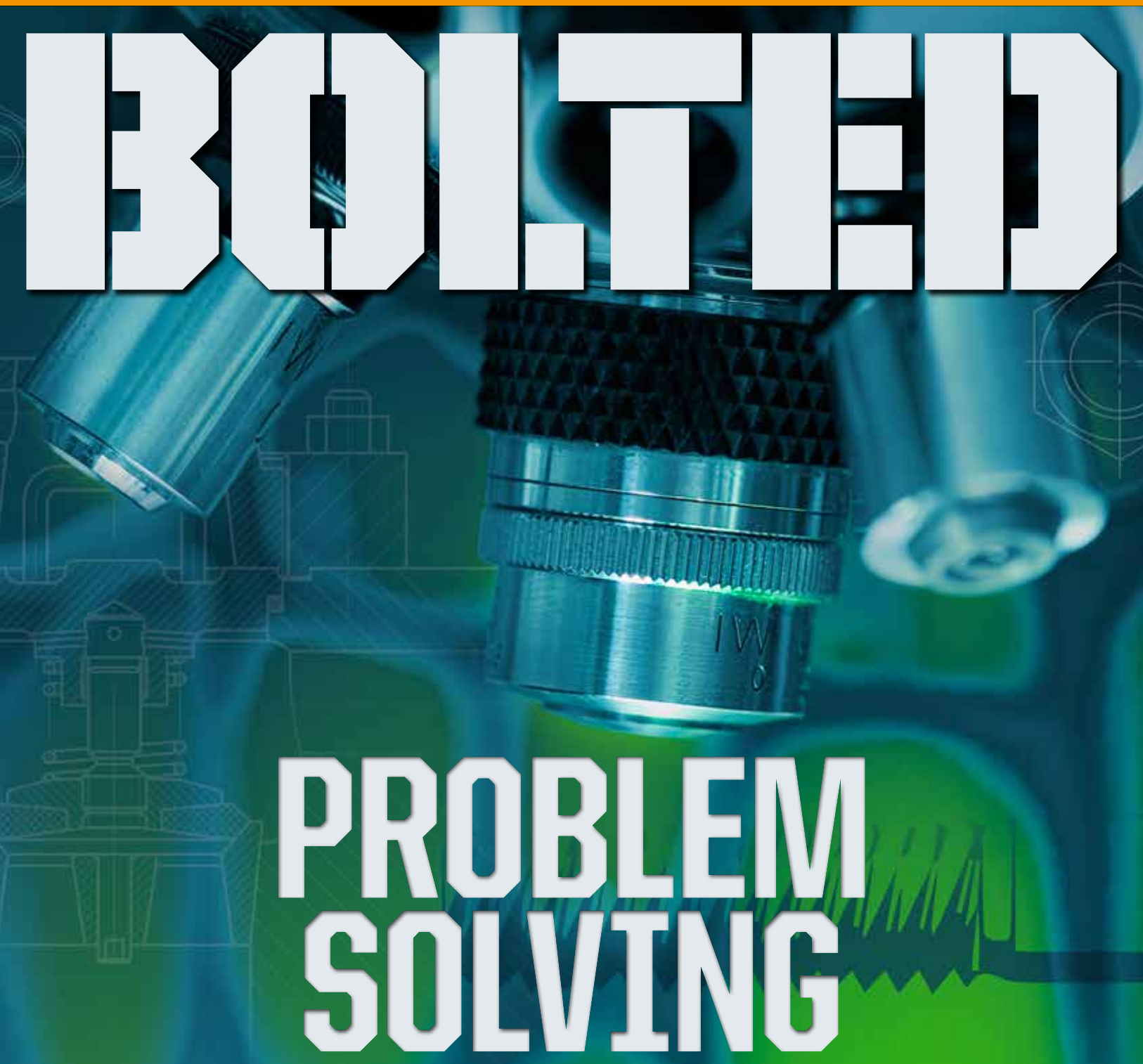
NORD-LOCK®
A MAGAZINE ABOUT OPTIMISING BOLT SECURING
WWW.BOLTED.COM # 2 2015

BOLTED



PROBLEM SOLVING

BOLTING FAILURE ANALYSIS GETS TO THE ROOT CAUSE

ALP POWER
IS THIS THE WORLD'S LARGEST BATTERY?

A MULTI-FRONT FIGHT
THE BATTLE TO OVERCOME HYDROGEN EMBRITTLEMENT

NEVER OUT OF JOINT
BOLTING VS. RIVETING: THE PROS AND CONS

GAME, SET AND CHANGE
THE TENNIS RACKET YOU CAN PERSONALISE

Let’s get #social

Follow us **@nordlockint**

Share your Nord-Lock themed photos on Instagram!

Follow Nord-Lock International and become our brand ambassador by tagging your photos that show applications secured by Nord-Lock with **#nordlock**.

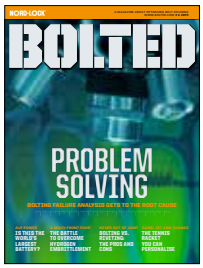
Post before end of 2015 and get a gift from us.

See you on Instagram!

NORD-LOCK®
Bolt securing systems

BOLTED # 2 2015

About optimising bolt securing – a customer magazine from Nord-Lock



Bolted magazine is published by Nord-Lock and strives to increase knowledge about bolt assemblies. The Nord-Lock Group is a world leader in bolt securing systems and offers a wide product portfolio, including wedge-locking technology and Superbolt tensioners. These unique solutions withstand vibration and dynamic loads. For further information visit **www.nord-lock.com**

Bolted is published twice a year in English, German, Japanese, French, Chinese, Swedish & Finnish. It is free to customers of the Nord-Lock Group worldwide. Published by Spoon in Gothenburg, Sweden, www.spoon.se

EDITOR-IN-CHIEF:
Carin Esberg Lagerstedt
carin.lagerstedt@nord-lock.com

CO-EDITORS:
Ewa Sewerynek
ewa.sewerynek@nord-lock.com

PRODUCTION:
Spoon, Gothenburg
www.spoonagency.com

EDITORIAL MANAGER:
Lisa Lundqvist
lisa.lundqvist@spoon.se

TRANSLATIONS:
Språkbolaget www.sprakbolaget.se

PREPRESS:
Spoon

COVER:
Illustration Justus Hultgren, picture Getty

Printed in Sweden by VTT Grafiska. Printed on UPM Finesse Gloss 100 gram and Maxigloss 200 gram.

NORD-LOCK®

Helping our customers solve their bolting problems

At Nord-Lock we have a thing for challenges. It can, for example, be a new product design that doesn't allow for traditional bolting, or an assembly that will be exposed to abnormal conditions. In this issue of Bolted we have dedicated four pages to explaining more about our approach to bolting failure analysis as a way of solving our customers' problems. The cause behind a failure is often a combination of factors, which is why bolting failure analysis requires deep insight in bolting behaviour. But it also takes a standardised approach. In the theme article on pages 8–11 you will learn more about bolting failures and how Nord-Lock experts work to find reliable solutions.

On the theme of bolting failures; maybe you remember that we talked to Salim Brahimi in the last issue of Bolted? Our chat with him about trends in bolting standards was so interesting that we now follow it up in this issue with a discussion on hydrogen embrittlement, a dreaded phenomenon for anyone with high-strength steel bolts. Brahimi received the Industrial Fastener Institute's 2015 IFI Soaring Eagle award for his "significant contributions to the technological advancement of the industry". In our article he tells how he is fighting hydrogen embrittlement on multiple fronts (page 17).

We have many long-standing traditions within Nord-Lock. One of them is to really enjoy our work. In this issue you will meet Kurt Persson, who has been with Nord-Lock (previously Nobex) for 50 years this summer! He can give you the full story from the early days up until today, and shares some insights on page 15. Other personal favourites from this issue include our visit to the Swiss Alps (page 12) and the way Dunlop is innovating tennis racket design (page 4).

Enjoy!

CARIN LAGERSTEDT
MARKETING MANAGER

CONTENTS

08 What makes a bolt fail?
What seems to be an obvious reason for failure could be the tip of an iceberg. To find the best solution, it is crucial to get to the root cause.

12 Alps and amps
At the Veytaux hydroelectric plant in the Swiss Alps, bolts were replaced with Superbolts – a decision that helped Hydro Exploitation save both time and money.

15 The Grand Old Man
Kurt Persson has been with Nord-Lock for 50 years. Read what Kurt has to say about innovation and how the company has developed.

16 Heavy lifting
Terex Tower Cranes wanted to ensure a solution that fit its high-altitude assembly as well as being safe and easy for operators.

04 SECURED BY THE NORD-LOCK GROUP
07 THE EXPERTS
17 BOLTING NEWS

SECURED BY THE NORD-LOCK GROUP

WORDS: ULF WIMAN **PHOTO:** DUNLOP

Nicolás Almagro of Spain is one of Dunlop's tour players. The company has now come up with a concept that lets players at every skill level adapt their racket to fit their game.

ADVANTAGE IDAPT

CUSTOMER: DUNLOP SPORTS GROUP	**CONCEPT:** CUSTOMISABLE LOOK AND FEEL
LAUNCH: USA 2014, GLOBALLY 2015-2016	**PRODUCT:** IDAPT TENNIS RACKETS
APPLICATION: RACKET HEAD-HANDLE JOINT	

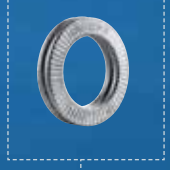
DESPITE CONTINUOUS CHANGES in material – from wood to metal to carbon fibre – tennis racket construction has remained pretty much intact. Dunlop's iDapt range changes the game.

Now tennis players can adapt the racket look and performance to fit their individual preferences. Choosing from different racket heads, shock sleeves and handles, a total of 432 combinations are possible.

The concept is in line with current trends, where consumers have come to expect that they should be able to personalise goods such as mobile phones. "The iDapt range has attracted a younger audience and more women to Dunlop's customer base," says Hunter Hines, Dunlop Director of Marketing and Product Development.

Tennis rackets are subject to huge amounts of stress. Ever-changing hitting angles, ball speed and forces lead to vibration, twisting, deformation and settling issues. Looking to upgrade the iDapt construction, Dunlop turned to Nord-Lock. "We did some research and the design of the X-series washers was exactly what we were looking for," Hines says. "They help make the connection more secure and resistant to both vibration and settlements better than any other washer we tried." ■

KEEPING IT TOGETHER



Nord-Lock X-series washers help make the connection between the racket head and the handle more secure and resistant to both vibration and settlements.

PHOTO: SCHADE

NEUTRALISING THE EFFECT OF VIBRATIONS

Nord-Lock wedge lock washers with an enlarged external diameter allow for secure connections to the scraper boom in spite of the vibrations.

POWERFUL CIRCLES

CUSTOMER:
SCHADE LAGERTECHNIK GMBH

ITEM:
CIRCULAR STORAGE UNIT FOR LIGNITE

LENGTH OF SCRAPER BOOM:
APPROX. 41 METRES

HEIGHT:	DIAMETER:
APPROX. 40 METRES	APPROX. 95 METRES

STACKING/UNSTACKING:
2,200 T LIGNITE/H

CIRCULAR STORAGE UNITS for bulk goods require very little space and have a high storage capacity. A slewing scraper with a double-strand chain and wear-resistant scraper blades ensures that the stockpiled bulk goods are discharged again.

A technical challenge is the horizontal guiding of the scoops by means of centre guide rollers screwed onto the scraper. Vibrations here can cause problems with fastening. The German company SCHADE Lagertechnik has resolved this issue on an enormous circular lignite storage unit in the USA, using Nord-Lock wedge lock washers.

Engineer Klaus Lechte, Technical Order Processing at SCHADE Lagertechnik, explains the vibrations on the scraper boom: "We use a chain system in which the links run over sprockets. The polygon effect created here generates a push–pull tension, which is responsible for some of the vibrations."

SCHADE Lagertechnik needed screw connectors that could not be loosened to secure the centre guide rollers. Nord-Lock supplied wedge locking washers with an enlarged outer diameter, which makes the connections absolutely secure. Nord-Lock securing system means that it is no longer necessary to weld the nuts into place or apply a high preload to the system, which could lead to plastic deformation. Nord-Lock offers the advantage of significantly lower tightening torques. ■

ECUADOR'S NEW POWER

CUSTOMER:	PROJECT:	PRODUCTION:
ČKD BLANSKO HOLDING	TOACHI-PILATON HYDROELECTRIC PROJECT	1,090 GWH PER YEAR

BUILT:	CAPACITY:	APPLICATION:
TO BE COMPLETED IN 2015	254.40 MW	FRANCIS TURBINES, MAIN INLET VALVES

ECUADOR ALREADY MEETS 45 PERCENT of its energy needs with hydroelectric power, but is aiming to increase this to 93 percent by 2016. The Toachi-Pilaton hydroelectric project, which includes the construction of the Sarapullo and Alluriquin power plants on the Toachi and Pilaton rivers, is one step closer towards meeting this goal.

ČKD Blansko Holding, the leading manufacturer of hydro-mechanical equipment in the territory of the former Czechoslovakia, specialises in the production of Francis and Kaplan turbines and closure valves for the power plants. The total power capacity of the company's turbines installed in more than 30 countries is over 19 GW. ČKD Blansko Holding's pipeline valves are connected to pipelines by means of bolted flanged connections. Due to the uneven distribution of load to the individual bolts, however, these connections must be very carefully dimensioned and inspected.

"We asked the manufacturer of Superbolt tensioners to provide material certificates and certificates for the applied anti-corrosion protection. We then carried out the FEM calculation in which we verified the uniformity of load distribution. The certificates and the results proved satisfactory," says Josef Plch, ČKD Blansko Holding's valve R&D Designer. "In recent time we have used Superbolt nuts and bolts – types MT, SB and SX – for six pieces of our butterfly valves at the Sarapullo and Alluriquin power plants in Equador. I really like the idea of Superbolt tensioners; the fact that somebody can come up with a new solution to something that already seemed perfect. The two main advantages of Superbolt tensioners are the simple tightening method and the uniform distribution of load on the individual threads."

ČKD Blansko Holding therefore uses Superbolt tensioners in power plant projects all over the world. ■

PHOTO: ČKD BLANSKO

THE EXPERTS

ZOUHAIR CHAIB
SENIOR TECHNICAL EXPERT

YINGHUI WU
PROJECT ENGINEER

Email your questions about bolt securing to **experts@nord-lock.com**

ASK THE EXPERTS

Do you have a question about bolt securing? Put the Nord-Lock experts to the test.

Improving fatigue resistance

A: The fatigue capacity of a bolted joint is very small, as compared to its static capacity. To improve fatigue resistance, designers can increase the thread capacity and decrease the alternating stresses at the threads.

To increase the thread capacity, it is recommended to use a rolled thread instead of a cutting process. To increase the bolted joint capacity, utilize multiple smaller fasteners instead of a single larger fastener.

The capacity is also increased by using an improved connector, such as a Superbolt MJT (Multi-Jackbolt Fastener) or Flexnut, which improves the load distribution in the threads and adds elasticity to the bolted joint.

The best way to improve fatigue resistance is to reduce the alternating stresses at the threads. There are three main ways of doing this: Assembly design, assembly tightening, and assembly security.

The assembly design process provides an opportunity for improvement of the load distribution on bolted joints and to reduce the level of external stresses supported by each joint. To facilitate that, keep these principals in mind:

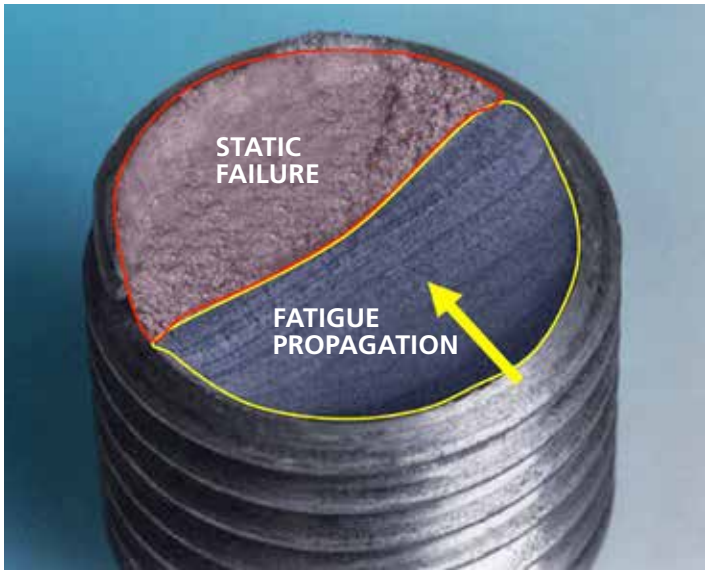
1. Use the highest possible preload
2. Minimize the bolt to load eccentricity
3. Use the largest possible contact surfaces
4. Use the largest possible clamping lengths
5. In most cases, use a preload higher than the working load

Other assembly design options include the use of necked-down studs or bolts, and the use of elastic washers, which counter the effects of relaxation, creeping, and thermal differential elongation.

With regard to assembly tightening, achieving the necessary preload is the main factor in reducing alternating stresses. It is recommended to use calibrated tools with high accuracy. It is also recommended to use a proper lubricant to achieve preload accuracy, and to reduce the risk of seizing. A suitable tightening sequence should be used to mitigate the risk of un-evenly loaded bolts and to ensure overall bolted joint integrity.

Regarding assembly security, it is recommended to secure the bolted joint against loss of preload. Further, secure the assembly against environmental effects, such as corrosion that could initiate a fatigue crack. This may be done through the selection of suitable materials and/or coatings for parts and fasteners.

ZC



To improve fatigue resistance, designers can increase the thread capacity and decrease the alternate stress at threads. The image shows the result of fatigue and a failed bolted join.

Tightening Superbolt

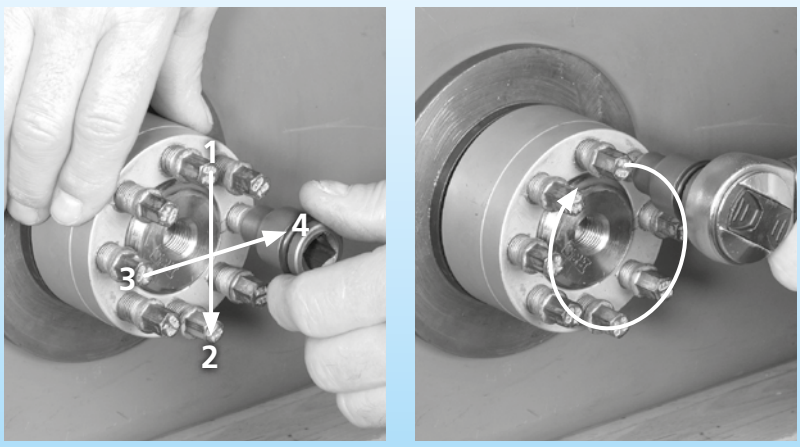
Q: Why should I tighten a Superbolt initially in a crosswise pattern?

A: The crosswise pattern is necessary because the main thread of the multi-jackbolt tensioners needs to be centered with the main thread of the stud during the whole tightening procedure.

This is to prevent an uneven load distribution in the nut body. After you have tightened the jackbolts crosswise with 100% recommended torque, change to a circular tightening pattern to tighten all jackbolts to their full capacity.

Note: Loosening always uses a circular pattern.

YW

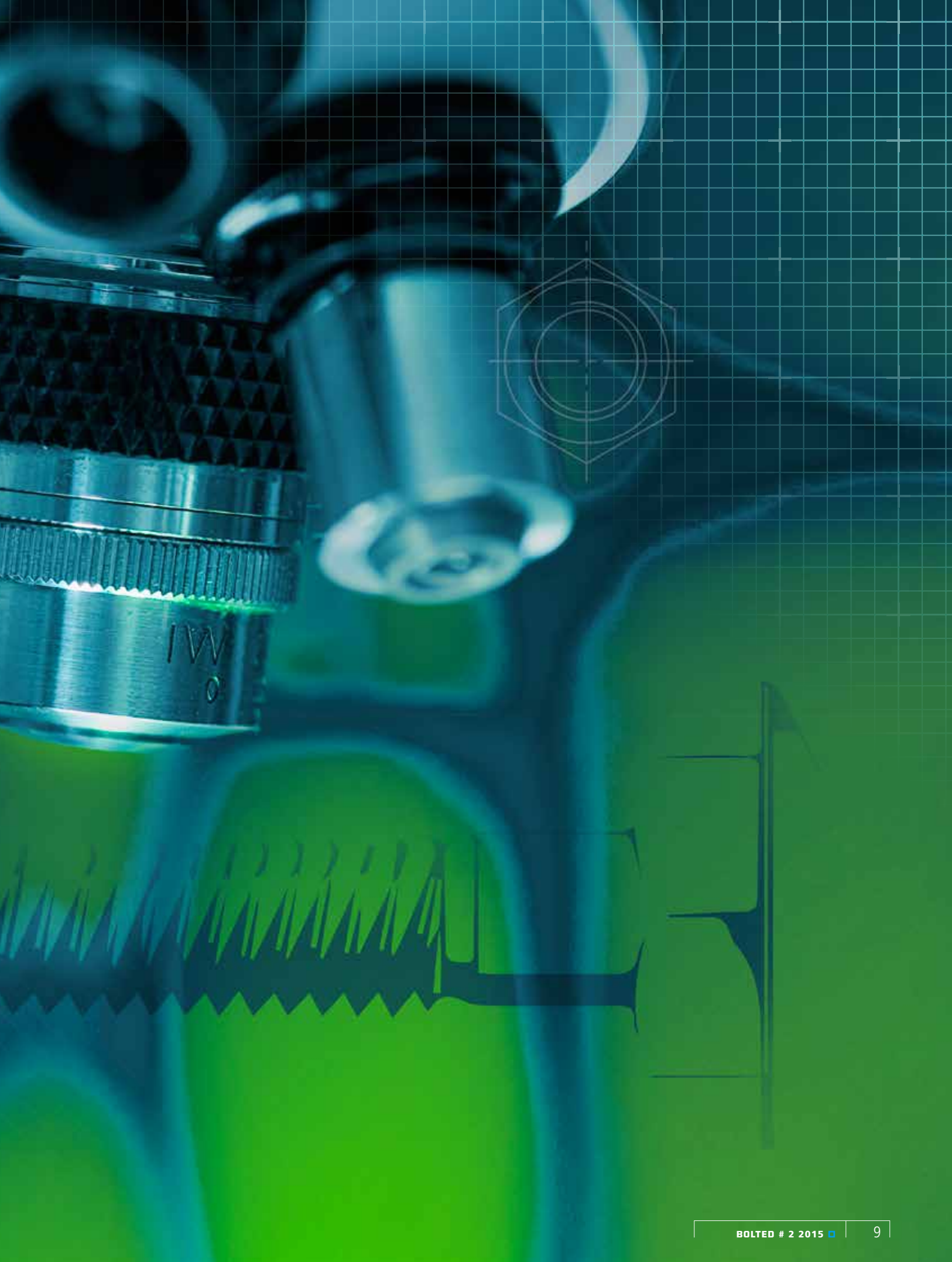


After you have tightened the jackbolts crosswise, change to a circular tightening pattern to tighten all jackbolts to their full capacity.

BOLTING FAILURE ANALYSIS

Nuts and bolts are used everywhere. A bolting failure at home is usually only a minor nuisance. However, a similar failure at a nuclear power plant could be catastrophic, which is why bolt failure analysis of damaged bolted joints is so vital. →

WORDS: MARTIN NEANDER
PHOTO: GETTY
ILLUSTRATIONS: NORD-LOCK, JUSTUS HULTGREN



There are many reasons why bolting failures happen. In fact, they are often caused by a combination of factors.

According to Laurent Dastas, a Bolting Analysis Expert at Alstom Transport, there are four main root causes that explain bolt failure:

1. The tightening operation was forgotten.
2. The tightening tool was not accurate enough regarding tightening tolerances.
3. An error in the fastener's steel class.
4. A failure in the tightening sequence.

In technical terms, there are two main types of bolting failure: static failures and fatigue – also called dynamic – failures. "The use of electronic keys, for the simultaneous recording of couples and angle-values during the tightening operation, allows securing on every assembly according to these four parameters," says Laurent Dastas.

Static failures are generally easy to identify. For instance, they occur during overloading, after overtightening of the assembly, through an accident of external loads, or due to a 'non-conforming product'.

Fatigue failure is often more complex, because the fatigue develops during the service cycle. There can be cracks in the material, such as in the fasteners, the threads of the bolt, or any component of the assembly. These cracks will increase and propagate on the normal section (stress section) of the screw before the total failure of the assembly.

"Actually, crack-related damage is the most dangerous failure in a bolted assembly," says Zouhair Chaib, Senior Technical Expert at Nord-Lock.

In fatigue failures, the assembly can be correctly tightened at first. However, after external loading, the bolted joint starts to lose the force of the preloads due, for instance, to relaxation or self-loosening.

"When the loss of preload starts, it is not so easy to stop," Chaib says. "When losing preload, both the alternated stress and the sliding between parts increase. When the sliding is repeated, more and more preload is lost."

The alternated stress also continues to grow, eventually resulting in a fatigue crack. Under the external and cyclic loads, the fatigue crack will propagate. After some propagation of the screw, and when there is enough capacity against the fatigue load, total failure occurs. A fatigue crack can be initiated by corrosion or an impurity in the screw material, by cutting quality of threads or by an accidental load (impact).

When multiple screws are involved, the failure of one screw can overload other screws nearby. Overloading will then create a chain reaction of failures that happens very quickly, and it does not have to occur many times before the screws start to propagate.

"In terms of fatigue failures, one never knows when the fatigue, the cracks, and the total failure of the assembly will appear," Chaib says. "Generally, the fatigue failure appears suddenly, and comes as a most unwelcome surprise."

One way of finding out why a failure occurred is by using the Ischikawa (fishbone) diagram. This method is often used by Nord-Lock Technical Center when helping its customers.

"Once there is a failure, before replacing the existing assembly and changing parts, the customer needs to secure the environment," Chaib says. "Pictures of all parts need to be taken and all parts must be marked with a number. It is also important not to touch the failure surfaces, contact surfaces or threads. We also need a description of the accident and the failure conditions to quickly identify the problem."

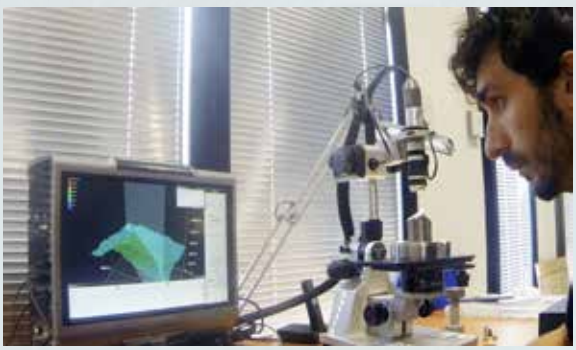
The customer also needs to protect all the parts against corrosion during transportation to the Technical Center for analysis – this is to avoid any erroneous assumption that crack failures were due to corrosion, when they were not.

"By doing all this, the customer helps us to analyse the situation quickly and accurately, which enables us to give a prompt answer and solution," Chaib says. "After doing this, changing the assembly is no longer critical. The customer can change any endangered parts to continue production, for example."

Customers often have constraints and need to restart production as soon as possible. For this reason, it is very important to check and verify

"Actually, crack-related damage is the most dangerous failure in a bolted assembly."

ZOUHAIR CHAIB, SENIOR TECHNICAL EXPERT



Brice Calvarese at Nord-Lock Technical Center in Lyon using a 3D microscope to compare and control failing factors.

THE TENSIONER CASE:

Superbolt tensioners are used for their preload accuracy and because they allow the introduction of a high level of preload with a small torque.

One customer tested a multi-jackbolt from another manufacturer in a structure. After some time, a failure of the structure occurred and the customer asked Nord-Lock to investigate.

"We used the 3D microscope to analyse the failure," Chaib says. "We understood that the main cause of the failure was fatigue, and that preload had accelerated it."

The observed matting at the end of the jackbolts suggested that the preload was correctly introduced, but when the 'course of jackbolts' distance between the end of the jackbolt and the nut body was examined, there was a large difference in all the multi-jackbolts. One jackbolt had zero course. This was due to a self-loosening of the jackbolt.

"We also checked the capacity of the copy tensioner against the self-loosening, concluding that this factor was not considered by the copy tensioner," Chaib says. "When we compared the copy with our tensioner, they both had the same thread diameter, the same material, and the same outside diameter, but some particularities of the multi-jackbolts were not respected."

The tensioner had a good static capacity, but there was still the issue of self-loosening that caused the fatigue failure. ■

The main cause of the failure for the customer in this case was fatigue, and that the preload had accelerated it.

At the Technical Center, all damaged components are checked.

the assembly during transit. In the meantime, the customer and the expert analysts can work together to find the best and most accurate solution to replace the existing assembly.

At Nord-Lock Technical Center, all components are checked and photos taken of all damaged parts. In some cases, a 3D microscope is used to compare and control some factors. External partner laboratories can also be asked to perform additional analyses. Finally, the results are analysed and the overall picture is defined.

"In our laboratory, we can carry out vibration, torque and preload tests," Chaib says. "We can also test the manner of the screw for instance – to be completely sure that the proposed solution will work correctly and safely."

"At the Technical Center, we analyse several situations, identify the cause and propose a technical solution to the problem," he continues. "We always take into account many other aspects, such as economical, practical and operational factors."

THE CLAMP LENGTH CASE:

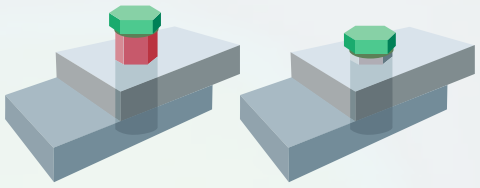
The customer used a standard bolted-joint solution, while having a damaged assembly. The customer replaced the assembly with new bolts, nuts, flat washers and spacers, took pictures and sent in the damaged parts. The customer also sent CAD, to provide information about the situation and the external load.

The customer had used spacers to increase the clamp length, and believed that this would resolve the problem. After re-starting the machine, the same failure occurred.

"After analysing the customer's assembly, we understood that there was a fatigue failure," Chaib says. "The assembly was highly preloaded. High preload is not dangerous, and is a good solution generally. We had to look for another reason for the failure and investigate further."

We concluded that, in this situation, there was a high shear loading – a transversal loading. The customer needed to use the same clamp length as before, but increase the preload level by increasing the torque and the grade of the screw to be able to use a securing solution. For transversal load, the best solution was to increase the preload and maintain it using securing solutions.

"We suggested the customer use a Nord-Lock washer to protect his assembly against self-loosening," Chaib says. "With our solution, he required a few modifications to his assembly: two Nord-Lock washers with a high grade bolt (10.9) and a suitable torque."



The image on the left shows the first design, and on the right the improved customer-modified design after the examination.

THE THREAD FAILURE CASE:

The customer had lost half of its assembly, but there was no visible damage to the threads.

"We asked the customer for additional information about the estimated load, and about the condition of the assembly," Chaib says. "The customer said it was subjected to shock load, but no fatigue load. "

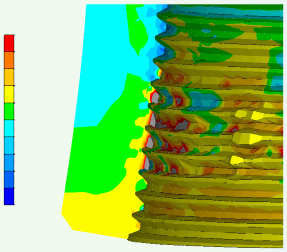
"When we looked into the structure's external profile, there was minor plastic deformation at the end of the threads. We also observed axial traces along the threads, and a non-constant outside diameter."

The analysts identified a potential failure scenario: the outside diameter and the material properties were not resistant enough to support the hoop stress introduced by the thread angle and axial load. Under a full load, part one expanded (radial elongation) and, due to the fine pitch, part two slipped and separated from part one.

"To validate this scenario, we performed a FEM (Finite Element Method) calculation and compared the measured diameter to the FEM diameter (after axial loading) and the thread form given by FEM and reality," Chaib says.

FEM results were so similar to reality that his scenario was accepted and a practical solution was proposed:

- Increase the outside diameter of the threaded part.
- Use coarse pitch.
- Use a stiff material (high Young's modulus).
- Optimised form of part one.



During the inspection axial traces were observed along the threads, as well as a non-constant outside diameter.

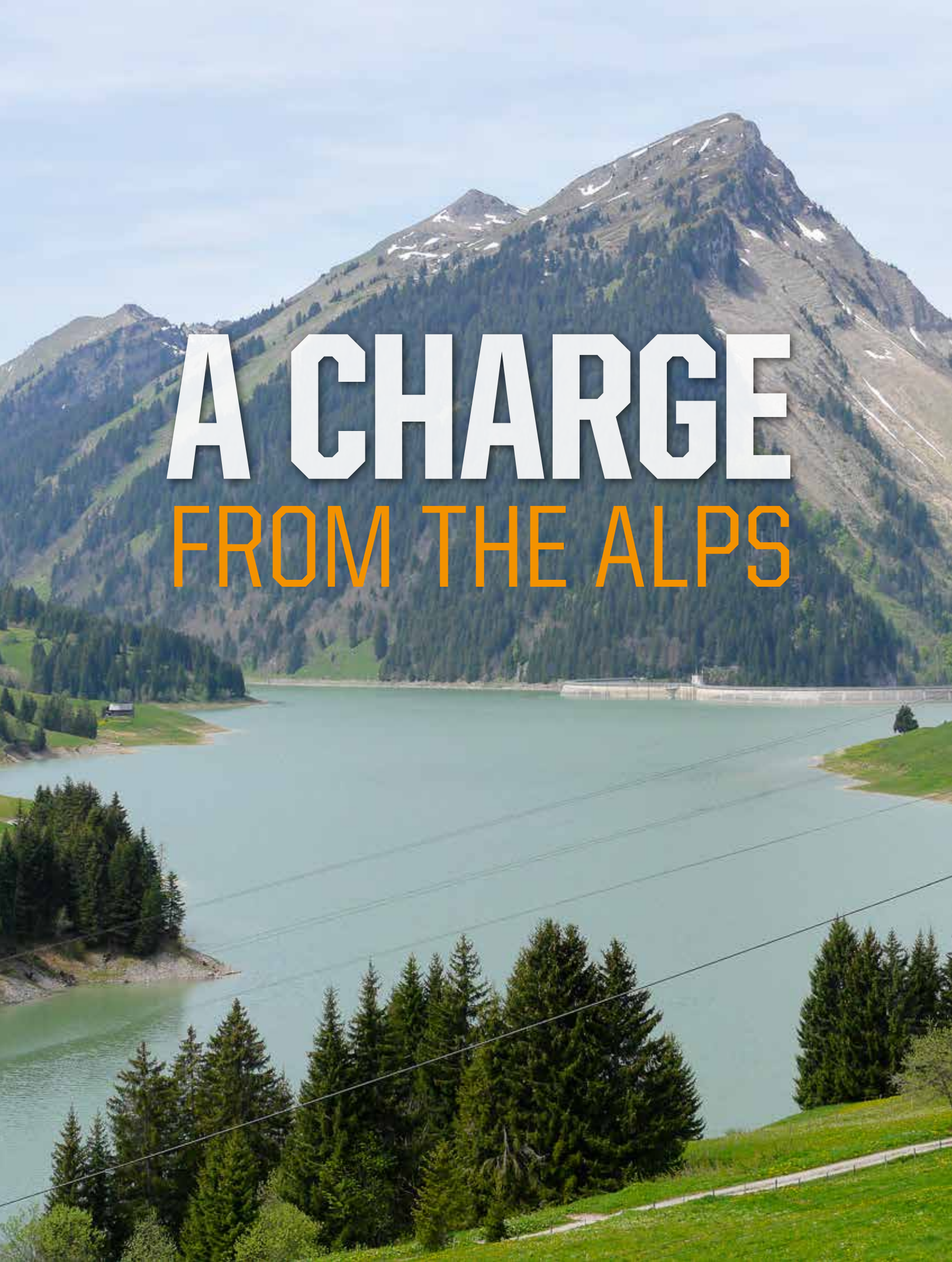
The most common reasons for bolt failures:

1. Human error.
2. Material defects, e.g. an impurity in the material that initiates fatigue cracks.
3. Tools that are not correctly calibrated.
4. Design.
5. When the external load is underestimated or wrong assumptions are made.
6. Calculation, e.g. the torque or stress in the bolt is miscalculated.

Bolting failure analysis in brief:
The owner of the failed bolt assembly should do the following:
1. Secure the environment of the failed assembly.
2. Take pictures of all parts.
3. Number all components.
4. Protect the parts against corrosion.
5. Describe the accident and failure conditions carefully.

Nord-Lock Technical Center's method:
1. Identify the problem.
2. Check all components and take photos of all damaged parts.
3. Use a 3D microscope to compare and control factors.
4. Use the Ishikawa diagram to figure out the possible failure factors.
5. Carry out relevant tests, e.g. vibration, torque and preload tests.
6. Ask partner laboratories to perform an additional analysis.
7. Analyse the results, define the main realistic scenario and present it to the customer.
8. Define practical solutions (economical, safe and easy to install).

Contact information for the Nord-Lock Technical Center in Lyon, France:
E-mail:
performance-services@nord-lock.com
Office: + 33 4 37 25 90 30
Fax: + 33 4 37 25 85 77



A CHARGE FROM THE ALPS

One thousand metres up, is Le Barrage de l'Hongrin, a man-made and dammed-up reservoir, which drops 32 cubic metres of water per second onto the Veytaux hydro-electric station.

Fabrice Blanchut, Head of Maintenance at Hydro Exploitation.

Backdropped by the Alps, a Swiss power plant has solved the problem of storing electricity. Using and reusing water that is dropped through a nine kilometre tunnel inside the mountain, the plant functions as a giant battery.

WORDS & PHOTO:
ALEXANDER FARNSWORTH

AFTER ALMOST 50 years of reliable service to the Swiss national grid, the 240 MW hydroelectric plant in Veytaux is now doubling its capacity to reach about 1,000 million kWh per year, up from today's 507 million kWh per year. This is the equivalent of 80 wind turbines – enough electricity to power half a billion refrigerators.

Located on the shores of eastern Lake Geneva, the power station, Forces Motrices Hongrin-Léman, SA, Centrale de Veytaux, is itself a non-descript cinderblock industrial building. But outside the office windows, the local paddle steamer or the occasional sailboat trace ripples across the picturesque lake. Small farmhouses dot the landscape, and cows and mountain goats are out to pasture.

HOWEVER, inside the mountain and out of sight is a masterpiece of Swiss engineering.

It takes a bird's eye view to appreciate the big picture. First there is Lake Geneva, or Lac Léman as it is known to the Swiss, a 580 square kilometre Rhône-fed body of fresh water stretching 70 kilometres between Switzerland and France and surrounded by the Alps and the Juras mountain ranges.

One thousand metres up, to the east, is Le Barrage de l'Hongrin, a man-made and dammed-up reservoir, which is fed by the Hongrin River, other high country tributaries and snowmelt. Snow persists all year round on north-facing peaks. The reservoir drops 32 cubic metres of water per second onto the Veytaux hydroelectric station down below through a vertical and horizontal nine kilometre excavated tunnel big enough for an SUV. The plan is to increase flow to 60 cubic metres per second.

INSIDE THE POWER PLANT are four generators, two so-called Pelton wheels, several subterranean house-sized pumps, and assorted cables, pipelines and control rooms; everything neatly aligned and colour-coded – blue for pumps, red for alternators, green for turbines. It is so quiet you could hear a bolt drop.

"We basically function as one big battery in the mountains," says Fabrice Blanchut, Head of Maintenance at Hydro Exploitation, the company that runs the Veytaux plant on behalf of a Swiss consortium consisting of Romande →

The power station plays a crucial role in supplying electricity to the French-speaking part of Switzerland. A special feature of the dam is its design: a double curvature arch dam connected by an abutment. "We basically function as one big battery in the mountains," says Head of Maintenance Fabrice Blanchut (right). Hans-Peter Wild, Account Manager Switzerland (left).

→ Energie, Alpiq Suisse, Groupe E, and the municipality of Lausanne. "Water is gravity-fed into our generators to produce electricity when the demand and price are highest. When electricity prices go down during the day, we pump water back up to l´Hongrin from Lake Geneva. This charges the batteries, so to speak."

In technical terms, this pumped storage cycle transfers an amount of electricity from night to day, from hours of cheap unused electricity to hours of high consumption.

HANS-PETER WILD, Nord-Lock Account Manager, says, "It's like cheap flights or hotel reservations. Prices go up with demand."

The Swiss market, just like the global market for electricity, is a so-called spot market, where prices fluctuate in second increments when there is currently an overcapacity. New, alternative sources, such as wind and solar energy have been added to the electricity grid, pushing prices down.

A hydroelectric power station like the one in Veytaux has a long-term perspective, hence the on-going 331 million Swiss Franc (USD 356 million) work to double its capacity by 2016.

ACCORDING TO BLANCHUT, plans were drawn up for the expansion over ten years ago under very different market circumstances. "In all honesty," he now says, "these expansion plans would not have been made today."

The doubling of the Veytaux plant's output to 480 MW (60 MW in reserve) utilises the existing nine kilometre-long chute from the reservoir for both pumping Lake Geneva-water up, and letting it run down again.

The main difference is the installation of a massive bifurcation valve, like the plumbing in a household sink, at the bottom of the mountain in Veytaux to redirect the source or direction of the mountain or lake water into a brand new underground pump and generator hall. ■

FACTS:

REPLACED WITH SUPERBOLT TENSIONERS

As part of massive overhaul of the 50 year old Veytaux hydroelectric plant in 2001, pre-existing coupling bolts were replaced with Superbolt Expansion bolts on the Pelton wheels. In 2010, the first Expansion bolts in stainless steel have been installed.

FACTS:

LE BARRAGE DE L'HONGRIN

CAPACITY:
The man-made and dammed reservoir contains 53 million cubic metres of water.

ALTITUDE:
1,255 metres.

HEIGHT:
123 metres.

PRODUCTION FROM GRAVITATIONAL FEED:
180 million kWh annually.

PRODUCTION FROM PUMPED WATER:
Currently, 327 million kWh produced annually from water pumped into the reservoir from Lake Geneva.

Business arguments for Superbolt

According to Maintenance Engineers George Rey and Francois Lerch, "With Nord-Lock we know what we are getting." They list the advantages:

- **EASY TOOLING** and installation.
- **LESS COMPLEX** and easier handling.
- **TIME SAVING** turnaround during onsite cleaning.
- **NO** corrosion.
- **GOOD AND FAST** support and collaboration.

"If you copy, you'll never be Number One." Kurt Persson practices what he preaches and during his time as CEO he secured, among other things, the deal with Latour, the company that acquired Nord-Lock in 1994.

FACTS:
KURT PERSSON

NAME: Kurt Persson.
AGE: 66.
TITLE: Senior Advisor.
BACKGROUND: started cleaning machines at the age of 4 at Nobex, Nord-Lock's predecessor. Joined the family business aged 16 and has since worked as, for example, production technician, workshop manager and production manager. Nord-Lock CEO 1985–2010. Now works part time as Senior Advisor.

"They didn't think we could succeed"

WORDS: JANNA THALÉN
PHOTO: SANDRA LEE PETTERSSON

IF NOT FOR THE BIG BARN next to his grandparent's home in Halabacken in Jämtland, in Sweden's northwest, this story would probably have been completely different. The rather humble business that started here 55 years ago, in the middle of the woods with a backdrop of snow-clad mountains some 40 kilometres from the nearest town, has evolved into an international industrial company.

Kurt Persson has been with Nord-Lock (and its predecessor Nobex) for 50 years, and can these days be addressed as both Senior Advisor and senior citizen. He describes himself as a person who always looks forward and who never gives in.

"I finished school after nine years of compulsory schooling and since then it has been 'learning by doing'."

Nobex' business sprang out of his father Bengt's interest in technology. For a long period, the production focused on an innovative oil burner, which was later succeeded by mitre saws. These were produced until 2001. When Nobex acquired a company that produced locking washers in 1982, the seed was sown for Nord-Lock.

"For the first seven years of washer production we were in the red. We didn't have a clue about what we were getting into. We have taken some pretty hard knocks, but have never doubted the longevity of the product."

How did you solve the issues?

"The technology has always been good, but initially the product was not up to standard, and we more or less got thrown out of some large-scale Swedish companies when we tried to enter that world. We turned it around through continuous improvements of the wedge-locking system, design developments, and by making sure that we had technically skilled people in the sales organisation. Now we act as a partner to large international companies in a variety of sectors and fine-tune customer-specific solutions."

What does the production look like?

"During the 33 years that we have produced our washers, production technology has changed immensely. We have roughly 350 variants of the wedge-locking system, but quite often get specific inquiries. A nuclear plant wanted a unique solution and we had to develop a special tool to produce the ten washers that they requested. It was not a cheap solution, especially as they only used two of the washers, but they were satisfied."

Are there any decisive moments in the company's history?

"One milestone was when we built the first real industrial building in Mattmar in 1980. The municipality supported us, but the county administrative board said no. They didn't think we could succeed in this sparsely populated area. In the end we received the funding and were able to start construction, provided we put in 'real doors, so that it at least can be used as a bus depot'."

How do you feel about Nord-Lock's future?

"It is incredibly satisfying to retire knowing that Nord-Lock is growing strongly and has a dynamic management team and wonderful employees." ■

Towering challenge for a giant crane

WORDS: CLAUDIA FLISI
PHOTO: TEREX CTL 650F

THE CHALLENGE Challenges are nothing new to Terex Tower Cranes, an Italian-based manufacturer of cranes for construction and industrial use founded (as Comedil S.r.l) in 1962. It has been a part of Terex Cranes since 1998, and sells its flat top, luffing jib, hammerhead, and self-erecting tower cranes all over the world.

Recently, with an eye to the growing demand for tall, powerful cranes at large construction sites in the global market, Terex Cranes developed a new luffing jib tower crane with a maximum jib length of 75 metres, capable of handling a 66 tonne load. It is the largest tower crane ever built by Terex.

What eventually became the CTL 1600-66 presented a unique challenge: designing the coupling between the tower and the jib. Eight M100 bolts were needed for assembly, and a standard solution would have called for the use of a hydraulic torque wrench of 90 kilos to tighten them. This in turn would have required two workers to perform the assembly and a separate mini-crane to handle the weighty wrench, all in very limited space at high altitude.

THE SOLUTION While the standard solution was feasible, it meant modification of the crane's design. Engineers working on the project were loath to make such changes because they were satisfied with the original plan. Their challenge was to ensure that the high-altitude assembly of the tower would be easy and safe for operators without altering their design.

Nord-Lock is one of Terex's suppliers, and suggested an alternative solution – Superbolt multi-jackbolt tensioners. The Superbolt CY-M 100X6/W ensured the technical performance sought by the design team without the need for modification. Only a small amount of space is necessary because tightening requires only one worker, who can tighten the bolts to the correct clamp load using a simple torque wrench, instead of the 90-kilo hydraulic version.

THE RESULT The overall speed of operation is about 40 minutes, the same as the standard solution. Although each bolt can be tightened faster, there are eight per unit. However, speed was not a deciding factor. More important for this kind of application – very large cranes with long extensions – are the advantages of manageability, reduced space, safety, and the need for one worker rather than two.

The CTL 1600-66 made its market debut in 2014, so it is still too soon to evaluate customer reaction. But Terex is optimistic about the long-term prospects for its giant crane. ■

Fastener peace of mind

Hydrogen embrittlement occurs in various forms, but always involves applied tensile stress and the ingress of hydrogen into the metal.

THE DREADED HYDROGEN EMBRITTLEMENT may cause high-strength steel bolts to break with no prior warning. Hopefully, the problem can be solved through a combination of research, improved standards and education.

In the world of fasteners, few things are as anxiety provoking as hydrogen embrittlement (HE) and the potential of failing critical fasteners. While not a common problem, HE failure is unpredictable and the consequences might be a nightmare – think aeroplane in mid-flight or nuclear plant.

AGGRAVATING THE PROBLEM, explains Salim Brahimi, a Canadian authority on HE, "Many 'experts' offer unfounded opinions, which are either wrong or misleading and based on fear rather than fact."

He says that the controversy surrounding HE is a reflection of the lack of true understanding of the phenomena as well as inconsistent and confusing standards.

Hydrogen embrittlement occurs in various forms, but always involves applied tensile stress and the ingress of hydrogen into the metal. High-strength and low-alloy steels, nickel and titanium alloys are all susceptible to different mechanisms of HE.

IN THE CASE of high-strength steel fasteners, hydrogen atoms diffuse through the metal lattice and accumulate in areas of stress concentration. At sufficiently high combined localised concentrations of hydrogen and stress, the metal loses ductility and becomes brittle, resulting in cracking and, eventually, failure.

Hydrogen can enter metal in many ways, such as during steel production, parts processing, electroplating, or as a by-product of corrosion. Brahimi stresses that HE is a mechanism of failure; the root cause is invariably related to either poor manufacturing or poor design.

Salim Brahimi has spent the last 25 years fighting hydrogen embrittlement. He received the Industrial Fastener Institute's 2015 IFI Soaring Eagle award for his "significant contributions to the technological advancement of the industry".

PHOTO: ALLEN MCEACHERN

"The root cause is invariably related to either poor manufacturing or poor design."

SALIM BRAHIMI

The last 25 years, Brahimi has been trying to find effective solutions, working with various consensus standards organisations, running his own company, IBECA Technologies, and conducting academic research at McGill University in Montreal, Canada, where he is also currently completing his doctorate on fastener HE.

The most effective tool for prevention of HE failures, Brahimi says, is to produce fasteners in a well-controlled process, instead of relying on costly "feel-good" baking of parts that don't really benefit from it. "I promote the notion of industry spending its resources on targeted prevention by means of good manufacturing practice, and for parts that need it, such as PC 12.9 fasteners, sufficiently long baking supported by test data."

THE RISK OF HYDROGEN EMBRITTLEMENT failures can be further reduced with the help of standards and practices that are solidly based on facts founded in research, Brahimi says. Education also plays a key role.

When asked what end-users should think of when sourcing fasteners, he says: "Look beyond the unit cost of a fastener. Good sourcing means asking informed questions about quality-related issues and the capability of the manufacturer to produce quality parts consistently." ■

China

Opportunities on the coal market

THE DOMESTIC COAL MARKET continues its downward trend since China implemented integration of coal resources in 2008. With coal mining output decreasing, coal mining enterprises are buying less mining equipment, forcing machine manufacturers to restructure and look for new opportunities in the industry. Xi'an Coal Mining Machinery Co. Ltd is an outstanding player in the pursuit of innovation and development.

Smart, customised, automatic, safe and reliable – these are the qualities that Xi'an Coal Mining Machinery aims to have embodied in its products. A coal shearer is a machine that operates in a harsh environment and frequently faces problems in terms of a poor clamping force of main joint parts and joint loosening easily under the impact load, which affects productivity and threatens the safety of the operators. At present, the company is preparing for the launch of its self-developed Shear MG1660, which allows automated production with unmanned operation. The MG1660 uses Nord-Lock washers and Superbolt tensioners on its joint parts to help improve the machine's seal, anti-collision and vibration performance.

Moreover, Xi'an Coal Mining Machinery has established a Roadheader Machine Unit, reaching out to new markets. The company has approved Nord-Lock washers and Superbolt tensioners as specialised components for its shearers and roadheaders. ■

CRYSTAL YAN

Xi'an Coal Mining Machinery Co. was founded in 1951 and is based in Xian, China.

PHOTO: WANG JING

FACTS:

XI'AN COAL MINING MACHINERY CO. LTD

ESTABLISHED: 1951.
EMPLOYEES: 1,500.
CAPACITY: 130 shearers and 40 roadheaders.
APPLICATIONS: Shearer MG1660.
MINING HEIGHT: 4 metres.
POWER: 1,660 kw.

MYTH BUSTERS

THE MYTH: Chemical thread locking (adhesives) works as a lubricant during tightening.

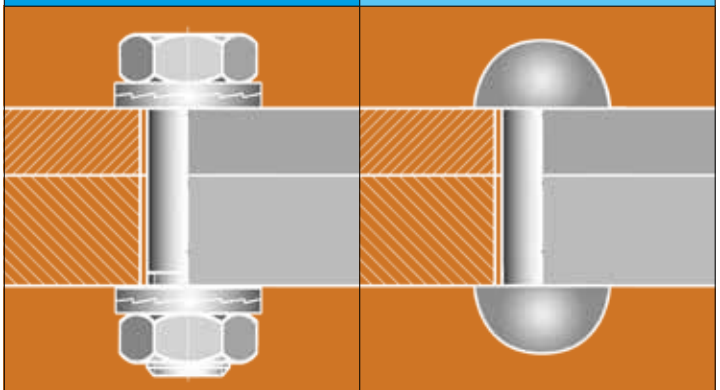
THE TRUTH: Chemical thread locking is an traditional solution used to protect bolted assemblies against self-loosening. The majority of users of this solution consider chemical thread locking as a lubricant. This approach is not usually realistic. Since the lubricant effect of this adhesive depends on the cleanliness of threaded surfaces (surface energy + roughness), materials, chemical properties of adhesive (polymerisation speed), temperature, tightening speed and its sequences (in the case of multi-joint assemblies). For the many applications, chemical thread locking reduces friction but this does not have the same effect as a real lubricant. For this reason, friction values are not mentioned on chemical thread locking packages. ■

THE COMPARISON Bolts versus rivets

By using Nord-Lock washers, a bolted fastener can overcome many of the disadvantages of rivets, while still offering the advantages of bolts.

Rivets offer a number of advantages over threaded bolts. They won't loosen when subjected to vibration, and can secure joints with short clamp length. On the other hand, compared to threaded bolts, they are cumbersome and time consuming to install and remove, and offer limited clamp load.

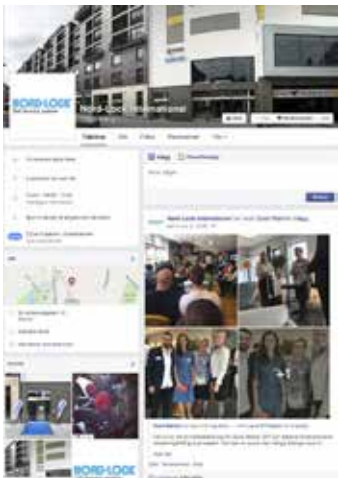
However, securing a threaded bolt with a Nord-Lock washer ensures resistance to vibration, and also makes it possible to secure joints with short clamp length.

	BOLT WITH NORD-LOCK WASHER	RIVETS
		
CLAMP LOAD	A high clamp load can be created simply by turning the nut and bolt.	Since rivets have no threads, they can create a very limited clamp load.
ACCESS	Through hole installation requires access to both sides of the bolted joint. However, this can be solved by a tapped hole design.	Can be installed from one side. Useful in applications with limited access to the opposite side.
TOOLING	Standard handheld tools are sufficient.	Specialised tooling required for installation.
VIBRATION RESISTANCE	While standard threaded bolts will loosen when subjected to heavy vibration, it can be prevented by securing with Nord-Lock washers.	Will not rotate loose because of vibration.
REUSABILITY	Can be removed quickly and easily using standard tools, and parts can be reused.	Need to be cut out. No reusablity during disassembly.
INSTALLATION	Fast and simple. For example in the construction industry used with easy to install HV/HR kits.	Time-consuming. Traditionally riveting was commonly used in the steel construction industry. Nowadays this method is being replaced by HV/HR kits as they do not require special tool kits.

Like us on Facebook

DON'T MISS the new Nord-Lock International Facebook page. It is a great way to interact with the company as well as with its customers, suppliers and partners. Keep updated on what is happening at Nord-Lock.

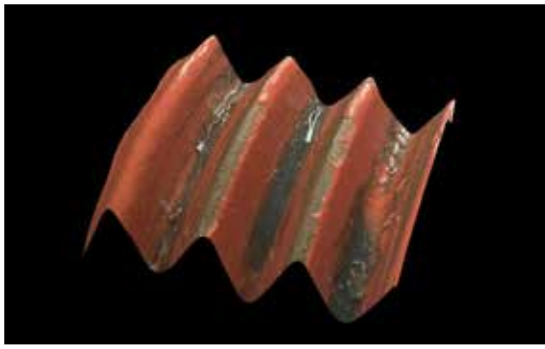
Go to: https://www.facebook.com/nordlockint. ■



Would you like to read about your company in Bolted?

NORD-LOCK IS ALWAYS on the lookout for good stories for its customer magazine, Bolted. If you currently use Nord-Lock products in a unique product or interesting application, we would love to hear from you. Contact us at: bolted@nord-lock.com. ■

Put an end to your bolting challenges



With more than 30 years experience from solving customers' problems, the Nord-Lock Group guarantees you a high-quality solution, tailored to your individual needs.

Nord-Lock Performance Services is a complete range of added-value services that covers specific customer needs in a wide range of industries.

Whatever your need, our skilled engineers will work together with you, reviewing and discussing your applications to optimise your bolted connections.

Nord-Lock Performance Services include:

- **Bolted joint design**
- **Bolt failure analysis**
- **Bolted joint calculation**
- **Measurement and control**
- **Testing and characterisation**
- **Software development**
- **Installation and tightening control**

For more information, email us today!

info@nord-lock.com

NORD-LOCK®
Bolt securing systems