

# BOLTED



**GRUNDFOS PUMPS**  
**CRACKING  
THE RIDDLE  
OF LOOSE NUTS**

**4** **NORD-LOCK  
SECURITY  
SOLUTIONS**

**SMART DESIGN**  
**THE ANCHOR BOLT  
THAT LASTS  
FOR 120 YEARS**

**OFFSHORE**  
**MEET THE MAN  
WHO MADE  
OIL RIGS SAFER**

## SIZE MATTERS

**CHOOSING THE RIGHT BOLT FOR THE JOB**

NORD-LOCK Product samples are available from MARYLAND METRICS

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SAMPLES!**  
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Lower your costs for maintenance, repair and overhaul?  
Eliminate production stops due to bolt failure?

Nord-Lock is designed to secure fasteners in extreme conditions. Go to [www.nord-lock.com/contact](http://www.nord-lock.com/contact) and order free samples for real life testing.

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**NORD-LOCK**<sup>®</sup>  
*Bolt securing system*

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Bolted magazine is published by Nord-Lock, and strives to increase knowledge about bolt assemblies. Nord-Lock offers a unique bolt securing system for demanding applications. The system makes bolted joints self-locking and does not rely on friction. Nord-Lock withstands vibration and dynamic loads. For more information on Nord-Lock, visit [www.nord-lock.com](http://www.nord-lock.com)

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**EDITOR-IN-CHIEF:**

Carin Esberg  
[carin.esberg@nord-lock.com](mailto:carin.esberg@nord-lock.com)

**EDITORIAL MANAGER:**

Sofia Eriksson  
[sofia.eriksson@tidningskompaniet.se](mailto:sofia.eriksson@tidningskompaniet.se)

**TRANSLATIONS:**

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Feel free to contact us with any comments: [bolted@tidningskompaniet.se](mailto:bolted@tidningskompaniet.se)

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**NORD-LOCK®**

## You can't lose when nothing is loose

**B**OLTS AND NUTS are the most used machine elements – installed in everything from computers and hospital beds to heavy machinery and nuclear plants. The obvious reason for this widely spread use, is of course that they offer the unbeatable combination of great holding power whilst still being easy to dismantle. Yet, in product development and design, fasteners often end up as one of the last problems that is examined. Courses on design and mechanical engineering also tend to focus very little on threaded fasteners. But spending a little extra time on bolts might just pay back. Multiple times.

**W**ITH ALMOST THIRTY YEARS of focus on bolt security, Nord-Lock has built up a knowledge bank through our quality testing and our technical service, which include customised tests for extreme applications. Nord-Lock has performed hundreds of tests for customers in a large variety of industries over the years. Every year, our global team of sales engineers meet clients locally to help optimise demanding and exposed bolted assemblies.

With this magazine we want to further share this knowledge with you, whether you are a customer

of ours or just someone who experiences problems with vibration-induced bolt loosening, fatigue failure or down time.

**T**HE MAGAZINE you hold in your hand takes a closer look at the optimisation of bolted joints in all kinds of industries – transportation, energy and offshore, with new ideas and interesting solutions to bolt security problems. For example the specially designed anchor bolt in the Swedish tunnel project that will stay tight for 120 years (page 16). Or the intricate yet simple one-nut solution in pump manufacturer Grundfos' CR-pumps (page 12). Or the bolts that make Vekoma's roller coaster safe in the middle of the thrill (page 5). These are all examples of companies that have spent just a little more time on bolts and nuts – with a breathtaking result of lowered costs, improved efficiency and product value. □



**CARIN ESBERG**  
MARKETING MANAGER



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The complexity of a bolt security system is sometimes under-estimated, and the bolts are often over-sized. Mistakes such as these can be avoided.

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## A FORMULA FOR SUCCESS

<b>CUSTOMER:</b> DINO PAOLI S.R.L	<b>PRODUCT:</b> WHEEL GUN	<b>FREE SPEED:</b> 8,600 RPM	<b>MAX TORQUE:</b> 2,800 NM	<b>NUT REMOVED:</b> <1 SEC.
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**A MOTOR RACE** can be won or lost in the pits. That handful of seconds when the tyres are changed and the fuel topped up are often the difference between spraying champagne from the podium and limping back to the pits in defeat.

A key piece of equipment in any pit stop is

the pneumatic impact wrench, or wheel gun, which is relied on to loosen the large nut holding on each wheel and then screw on a new wheel – all in the blink of an eye.

Dino Paoli S.r.l, based in Reggio Emilia in northern Italy, has been supplying Formula 1

teams with impact wrenches since 1975 and is today a supplier to teams in a long list of racing series around the world.

The Indy Racing League (IRL) in the US is perhaps the most demanding series for Paoli's impact wrenches; after each pit stop the tool is hurled out of the way and into a wall as the pit crew scrambles to get its car out again. Each Paoli tool is fitted with two pairs of Nord-Lock washers to ensure smooth and reliable operation in this high-vibration environment where speed, precision and safety are paramount. □



**FLYING IMPACT**  
A key piece of equipment in any pit stop, the Paoli tool is fitted with two pairs of Nord-Lock washers to ensure smooth and reliable operation in this high-vibration environment.



PHOTO: MICHAEL L. LEVITT

**SAFE CONNECTIONS**  
 Nord-Lock washers – about 200 pairs per train – are used on the steel-on-steel and steel-on-composite connections.



PHOTO: VEKOMA

## AN ABSOLUTE SCREAM

**CUSTOMER:**  
 VEKOMA RIDES MANUFACTURING

<b>RIDE:</b> SUSPENDED LOOPING COASTER		<b>MAX. SPEED:</b> 80 KM/H
<b>HEIGHT:</b> 33 M	<b>TRACK LENGTH:</b> 689 M	<b>INVERSIONS:</b> 5

**THE IDEA** behind a roller coaster is simple: use the laws of physics to thrill passengers by simulating danger with high speeds, big drops and inversions. But despite the hair-raising impression of being at risk, roller coasters are statistically the safest rides in theme parks.

Netherlands-based Vekoma Rides Manufacturing, one of the largest builders of roller coasters with rides at many of the world's leading theme parks, for example the big ones in the United States, chooses Nord-Lock washers as part of its comprehensive approach to safety. The washers – about 200 pairs per train – are used on the steel-on-steel and steel-on-composite connections which are subject to constant vibrations, often up to 12 hours per day, 365 days per year.

The washers' ability to prevent this vibration-induced loosening of bolts, plus the fact that the washers are approved by international certification organisations, lay behind Vekoma's decision to choose Nord-Lock.

The result is an adrenaline-filled experience that's guaranteed to make you scream – without ever exposing you to danger. □

# SECURED BY NORD-LOCK

## ALPINE OPERATIONS

Nord-Lock washers are used to achieve optimal locking of the bolted joints on the drive sprockets, to prevent loosening caused by the oscillating and dynamic loads.



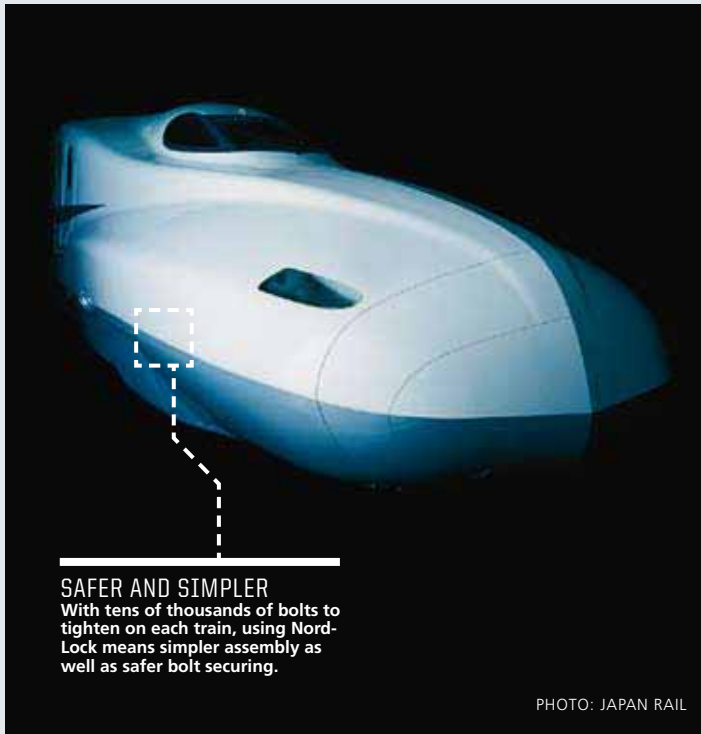
<b>PISTE PERFECT</b>		<b>CUSTOMER:</b> PRINOTH/LERIPA	<b>MODEL:</b> LEITWOLF	<b>ENGINE:</b> 12.8 LITRE DIESEL
<b>OUTPUT:</b> 435 BHP	<b>TORQUE:</b> 2,100 NM AT 1,000 RPM	<b>GROOMING CAPACITY:</b> 100,000 M <sup>2</sup> PER HOUR		

**WHATEVER SLOPE** a skier can ski down, this vehicle can drive up. Regardless of the angle, the pitch, the bumps and the dips, the extreme cold and driving snow, nothing stands in its way.

The Leitwolf, produced by piste machine pioneer Prinoth, based in the Gröden Valley in the South Tyrol, is a state-of-the-art snow-grooming vehicle, boasting Pininfarina styling, immense

horsepower and sportscar-like manoeuvrability. Nord-Lock has been supplying Prinoth's sub-supplier Leripa, Austria, with washers for its all-plastic drive sprockets since 2001. The washers are used to achieve optimal locking of the bolted joints on the sprockets, to prevent loosening caused by the oscillating and dynamic loads involved in the most challenging alpine operating conditions. □

PHOTO: PRINOTH



**SAFER AND SIMPLER**  
With tens of thousands of bolts to tighten on each train, using Nord-Lock means simpler assembly as well as safer bolt securing.

PHOTO: JAPAN RAIL

## BUILT FOR SPEED

<b>CUSTOMER:</b> HITACHI, KAWASAKI HI, NIPPON SHARYO		<b>TOP SPEED:</b> 300 KM/H	<b>WEIGHT:</b> 715 TONNES
<b>CAPACITY:</b> 1,323 PASSENGERS	<b>TOTAL LENGTH:</b> 400 M	<b>POWER OUTPUT:</b> 17.08 MW	

**THE WORLD'S FASTEST** in-service train just keeps getting faster. The latest version of Japan Railway's famous Shinkansen, known around the world as the Bullet Train, reaches speeds of 300 kilometres per hour (186 mph).

As the first Shinkansen with tilting capability to allow it to corner at even higher speeds than its predecessors, the N700 covers the 550 km between Tokyo and Osaka in just 2 hours and 25 minutes.

While riding Shinkansen N700 is a smooth and almost totally silent experience for those on board, attaining such speeds while carrying more than 1,300 passengers and with a total weight of over 700 tonnes inevitably entails considerable vibration.

To ensure that bolts do not vibrate loose, the manufacturers of the N700 turned to Nord-Lock washers after being impressed by their performance in a Junkers vibration test. Previous Shinkansen models used other bolt-securing solutions such as tab washers, locking wire and locking nuts. But with tens of thousands of bolts to tighten on each train, using Nord-Lock means simpler assembly as well as safer bolt securing. □



**OLENA KALMYKOVA**  
APPLICATIONS  
ENGINEER

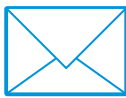


**CSABA MADRU**  
HEAD OF  
CUSTOMER TESTING



**FRIDA CULLIN**  
MATERIAL  
EXPERT

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



## ASK THE EXPERTS

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

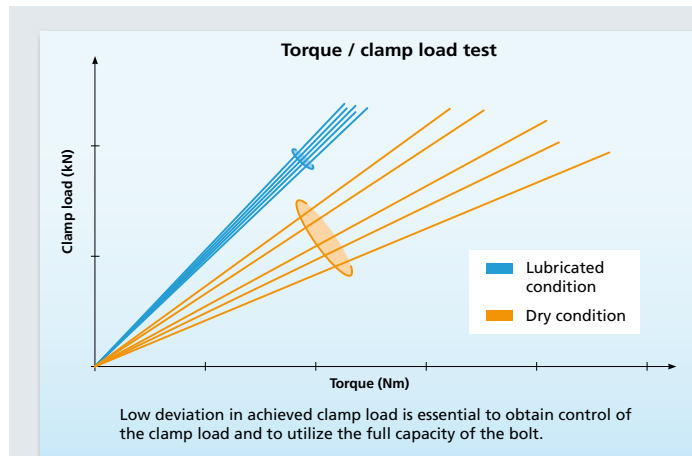
### Why do bolts rotate loose?



**Q:** Why do bolts and nuts rotate loose when a bolted joint is subjected to vibration and/or dynamic loads?

**A:** Loosening of threaded fasteners due to vibration and/or dynamic loads is an important phenomenon since it is one of the most common causes for failure of bolted joints.

A tightened bolt is elastically elongated but strives to assume its original length, much like a spring. This can only be accomplished by rotation of the bolt/nut in the loosening direction so that the bolt preload is lost. However the bolt/nut is prevented from rotating by friction between the contact surfaces in the threads and under the bolt head/nut.



## Why use wedge-locking instead of friction based?

**Q:** What is the difference between friction-based locking and wedge locking and when is lubrication needed?

**A:** The principle of friction locking is based on increased friction in the thread or under the bolt

head/nut. The main disadvantage of this method is increased torsion stress in the joint. High torsion may cause the fastener to yield at a lower preload than expected. Since friction conditions are uneven you may not reach the necessary preload. Insufficient preload

is the most common cause of the bolt's failure, often due to fatigue. Lubricants are often used to minimise friction and to obtain uniform clamp load. However lubrication will significantly reduce or even discharge locking ability of any friction-based method. Friction-based locking results in little or no control over achieved clamp load.

The wedge locking method is based on tension instead of friction. The most common example of the wedge locking system is a pair of washers which have cams with a rise greater than the thread pitch of the bolt. The washer pair is installed cam face to cam face. When the bolt/nut is tightened teeth grip and lock the mating surfaces, allowing movement only across the cam faces. Any rotation of the bolt/nut is blocked by the wedge effect of the cams. The wedge locking ability is not affected by lubrication; furthermore by using it you can utilise each bolt to its full capacity. **OK**

If a joint is subjected to vibrations and/or dynamic loads that cause relative movement between the contact surfaces the friction is

reduced because dynamic friction is lower than static. Therefore the bolt/nut is then no longer captivated by friction and rotates loose.

The most common causes of movement between contact surfaces are vibration and external dynamic forces. **CM**

### Which washer material should I choose?

**Q:** I have read that Nord-Lock washers come in five different materials. How do I know which one to use in my application?

**A:** It is correct that Nord-Lock washers are available in five dif-

ferent materials. Two of the materials are offered as standard and work in a wide range of applications. The most common material is a through-hardened steel washer coated with a zinc flake coating. We also offer our washers in stainless

steel in A4 quality. The stainless steel washers are surface hardened to safely secure all grades of stainless steel fasteners. For customers with applications in extreme environments, fasteners in special materials may be needed. We offer three

special alloys upon request. Which material to choose depends on the environment, see below table. If you need further assistance with choosing the right material for your application, you are always welcome to contact our material expert. **FC**

Material	Application area	Industry examples
Steel, EN 1.71825, Zinc flake coating	All purpose	Machine screws
A4, AISI 316L, EN 1.4404	Corrosive environment	Most stainless steel applications
SMO 254, AISI S31254, EN 1.4547	Salt water, Chlorides	Food/Subsea/ Pump applications
Inconel 718, ASTM N07718, EN 2.4667	High temperature	Gas/Steam turbines, Heat exhausts, Turbo compressors
Hastelloy/Inconel C-276, ASTM N10276, EN 2.4819	Severe corrosive environments	Chemical industries, Pulp & paper, Acidic natural gas

### ASK THE EXPERTS

Do you have a question for Bolted's expert panel? If you want to learn more about bolt securing, email your question to [experts@nord-lock.com](mailto:experts@nord-lock.com)



PHOTO: MARTIN MAGNITON



# HOW TO PICK THE RIGHT SIZE

**BOLTED JOINTS** In engineering, manufacturing and construction, the bolted joint is an assembly that sometimes is very much taken for granted. When a joint uses a simple nut and bolt system as a retainer or fastener, there is sometimes a tendency to underestimate the complexity of the system. A common mistake is to oversize the bolt, which can result in costly failure and censure.

**WORDS:**  
HUW KIDWELL

**PHOTOS:**  
TIDNINGSKOMPANIET



**IN THE MORNING OF** November 7, 1940, a wind blew through the Tacoma Narrows between Tacoma and the Kitsap Peninsula, Washington, USA. Not an extraordinarily strong wind, but it still set the newly opened dual suspension bridge across the narrow in motion. A local camera shop owner, Barney Elliott, took out his camera and recorded the incident, thereby creating a

unique historical document.

It had been noted that the bridge swayed and buckled on windy days. On this particular day, the twisting turned into a so-called torsional vibration mode, eventually making the bridge collapse. Fortunately, no one was killed. →

The Tacoma Narrows Bridge collapsed in the 1940s due to high winds. The bolts in the north mid-span cable were subjected to forces beyond their design capacity.

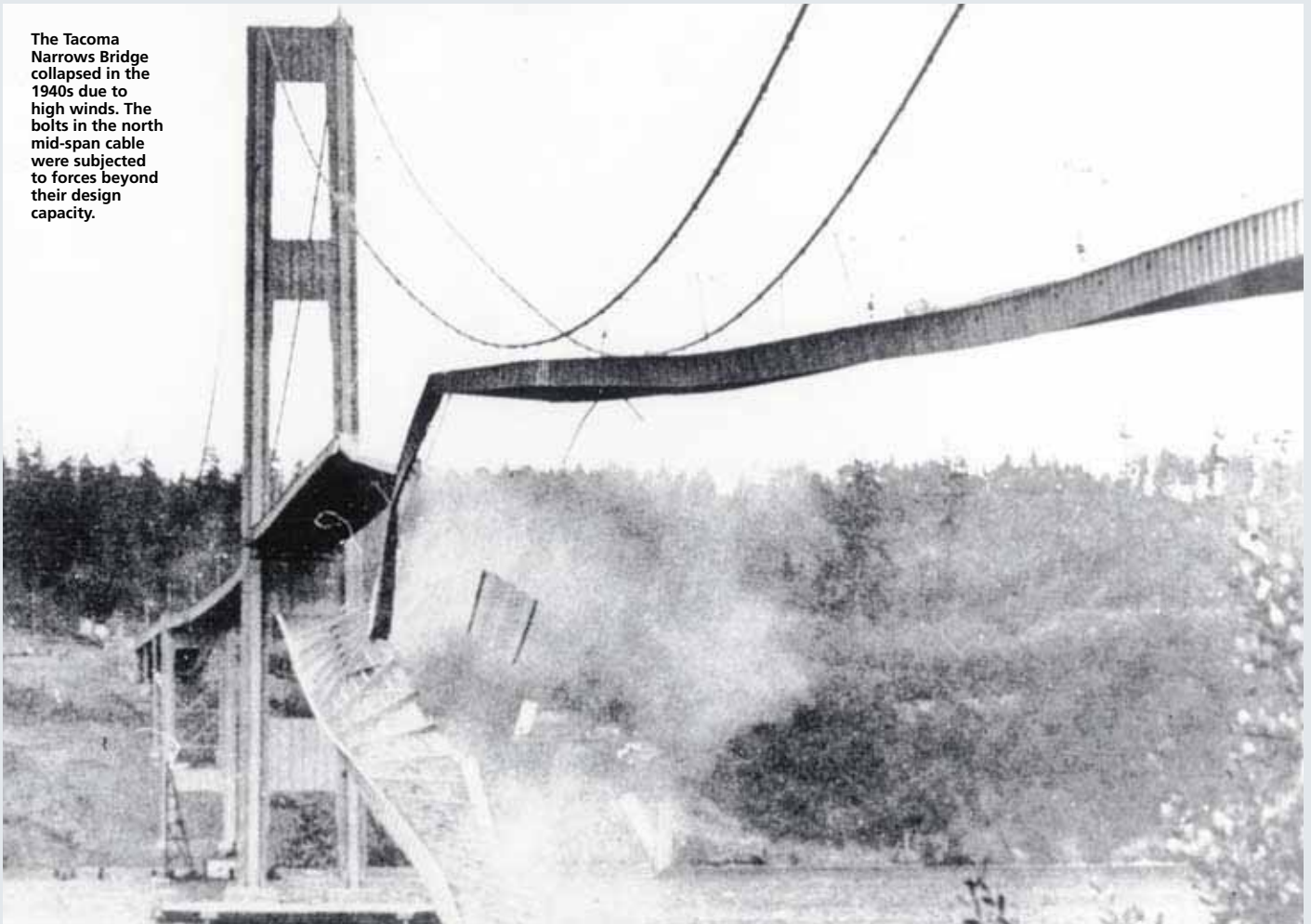


PHOTO: SCANPIX

**“The bolt size used can affect how much tension can be applied – generally the larger the bolt diameter or stronger the bolt material the greater the tension that can be applied.”**

DR JEFF VOGWELL, BATH UNIVERSITY, UK

→ A paper published in the *Journal of Sound and Vibration* in 2008 highlighted that the collapse was caused by aeroelastic fluttering, enhanced by the slippage of the north mid-span cable band (loss of friction grip) which was clamped together by several bolts that were subjected to forces beyond their design capacity. The collapse of the Tacoma Narrows Bridge has become a cautionary tale and a lesson for construction engineering students even today.

A bolt needs to be tightened or tensioned to its design pre-load creating a clamp force on the joint to obtain the best service from it. Any deviation from this will cast doubt on the integrity of the joint. In a bolted joint the fully-tightened bolt will only bear a small portion of the external load placed on the joint. The two ends of the scale are

a hard joint with a low stiffness bolt and a high stiffness joint material; and a soft joint with a high stiffness bolt and a low stiffness material. In the first case, the bolt only sustains a small proportion of increased force from an external source, but in the other case, the bolt will sustain the majority of the increased external force.

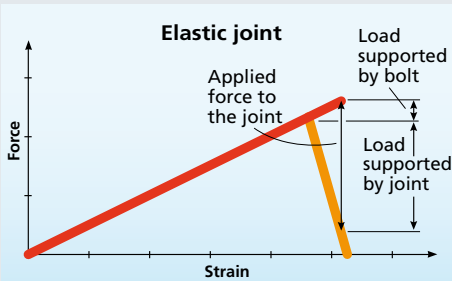
**BILL ECCLES IS A** consultant in bolted joints and the founder of the British website Bolt Science, a leading provider of independent technical expertise in bolted joint technology. In his opinion it is important to understand and quantify the forces on a bolted joint and also their relationship to determine what size bolt is suitable.

“The usual function of a bolt is to apply a clamp force to the joint so that when external

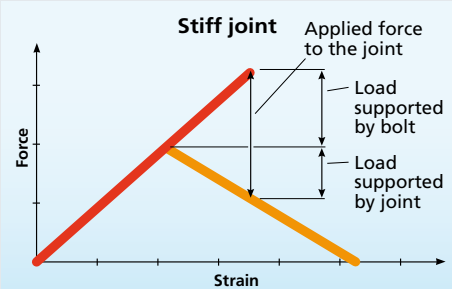
forces are applied, no joint separation or transverse movement will occur. The bolt is placed under tension on tightening and will stretch slightly to provide the best tensile force on the joint.”

Using the largest bolt possible is not the best solution, according to Bill Eccles.

“If too big a bolt is used not only are there cost implications, but as the bolt gets bigger for a given joint thickness the stretch in the bolt will decrease. This is complicated by the fact that in any bolted joint relaxation or embedding loss in the clamp force will occur, meaning that even if a bolt is tightened fully the joint material will ‘give’ a little under compression over a period of time and if a large bolt is used there will be much less stretch in the bolt leading to possible loosening and gap formation.”



An example of a hard joint with a low stiffness bolt and a high stiffness joint material. The bolt only sustains a small proportion of increased force from an external source, which is a good scenario.



Here, the bolt will sustain the majority of the increased external force and may therefore fail. Then the bolt stiffness/size needs to be reduced, either by using a smaller bolt or by reducing the shank diameter of the bolt.



In this example of a bridge member there is a complex relationship between the bolted joints which means that modelling of the forces on them prior to fabrication would be essential.



It's very important to choose the right bolt for the joint.

## How to determine the right size

**THE FUNCTION OF A BOLTED JOINT** is to clamp two or more parts together. However, the specific purpose of a bolt is to create a clamp force in the joint and not to sustain shear, bending or excessive dynamic loads.

The aim is to choose a bolt which can sustain a clamp force sufficient to prevent separation or movement between the clamped parts after external forces has been applied and settlement in the joint has occurred. It is always an advantage to choose a bolt with a small diameter and long clamp length in order to minimize the loss of clamp force due to settlement and to create an elastic joint that can absorb vibrations and applied loads. If the bolt is oversized it is not stretched as much as a smaller diameter bolt in order to reach a given pre-load. Even a small settlement will result in a significant loss of clamp force. Furthermore,

since a thick bolt is not as elastic as a thin, the bolt will absorb more of the applied load rather than the clamped parts and may fatigue.

Over-sizing a bolt does not always mean that a higher clamp force, and thereby a stronger joint, is obtained. Instead it often results in a joint with low clamp load, high risk for fatigue failure, increased cost and difficult tightening.

This is how you choose the right bolt for the joint:

- First identify the load case
- Determine the necessary clamping force in the joint
- Choose the smallest bolt diameter that can support the clamp load
- Choose an effective bolt securing method
- Decide on the most appropriate tightening method.

So what happens with a smaller bolt?

“In the case of a smaller bolt, the relaxation loss will lead to some loss in tension but it won't be as significant since the bolt has more stretch.”

**DR JEFF VOGWELL** is a senior lecturer at Bath University, UK, in the Department of Mechanical Engineering. In his view the size of bolt needed is generally dictated by the bolt material strength. “The bolt size used can affect how much tension can be applied – generally the larger the bolt diameter or stronger the bolt material the greater the tension that can be applied.”

A good bolted joint, Vogwell says, is one which places the bolt in tension and hence the clamped

members in compression. Friction between the clamped members helps resist any sliding (shearing) of the joint thus protecting the bolt in shear. Any force trying to separate the plates apart must first ‘uncompress’ the members – this also protects the bolt from metal fatigue should the external loading fluctuate.

“A good example is the tightening of bolts securing a cylinder head to the engine block of a car – a high tightening torque is very desirable for withstanding the loading caused by the gas pressure in the engine cylinder each cycle.”

Nobuyoshi Niina is a Mechanical Metier Manager working for Schlumberger at the Stonehouse Technology Centre in Gloucestershire, UK – a drilling centre of excellence supporting Schlumberger Oilfield Services.

The centre designs and tests drilling equipment and bolted joints are a large part of this work.

“Bolted joints in drilling tools are crucial because they have to operate under conditions of extreme temperature, pressure, shock and vibration. In operation the breakdown of a drilling tool would cost a great deal in loss of man hours and recovery would be almost impossible.” Several ways are used to produce the strongest bolted joint.

“The required clamping force for the application is calculated and modelled from a complex algorithm by computer, and anti-rotation devices such as the Nord-Lock locking washer system are used to avoid ‘bucking off’, caused by a bolt coming loose,” says Nobuyoshi Niina. □

# GRUNDFOS





# PUMPS IT UP

**PUMPS** Grundfos, one of the world's largest pump manufacturers, had a problem. A combination of vibrations, high temperatures and corrosive liquids meant that the nylon locking nuts at the heart of its machines were coming loose. The result for the Danish company, with its global reputation for quality and reliability, was sometimes pump failure. But in a chance encounter they stumbled upon what they describe as a brilliant fix for their predicament.

**WORDS:**  
DAVID WILES

**PHOTOS:**  
GETTY IMAGES, MARTIN MAGTORN AND GRUNDFOS

**G** **RUNDFOS IS ONE** of Denmark's largest companies with 18,000 employees around the world, of whom about 5,000 work at its sprawling headquarters, set among gently rolling hills in the northwest of the country. The company is the world's largest manufacturer of circulator pumps, and also produces submersible pumps for pumping groundwater and so-called CR pumps for use in industry.

It was the latter that were suffering from the failure of the nylon locking nuts. "This loosening of the nuts was a huge problem," says Segment Director General Industry Morten Gylling. "It is the smallest component in the pump but it is also one of the most important." →



Segment Director General Industry Morten Gylling (left), Grundfos pump assembly (centre) and Chief Engineer Per Frost Vedsted (right)

**“We pay a premium price to solve this problem, but it allows us to sleep at night.”**

PER FROST VEDSTED, CHIEF ENGINEER, GRUNDFOS

→ While the nylon locking nuts worked well up to a certain temperature, once over about 80 degrees the nylon simply will not lock anymore. “And then if you have a lot of vibration the locking nut will also lose the pretension of the rotating assembly over time. We had quite a lot of failures on pumps due to this loosening,” says Grundfos’ Chief Engineer Per Frost Vedsted. “We needed a new design that would get rid of these problems.”

**SO GRUNDFOS’ ENGINEERS** set about solving the problem and came up with a number of potential solutions, but none proved to be ideal. And then in a chance encounter at an industrial seminar they came across Nord-Lock.

“There was this Junker test demonstration which caught my colleague’s interest,” says Vedsted. “We invited this company to come to Denmark so we could see it with our own eyes, and I think it took about half an hour before we were convinced that this could solve our problems.”

Grundfos’ long sought-after solution was Nord-Lock’s bolt securing system.

“It is fair to say that their concept was brilliant – but it didn’t match our applications,” says Gylling. Grundfos needed washers that were both harder and had a smaller inner diameter, and so engineers from both companies worked together for more than half a year to come up with today’s solution using the high-performance alloy Hastelloy (SMO254).

**FROM ORDERING** 50,000 Nord-Lock washers that first year, Grundfos is now using 500,000 a year. And with the solution set to be used in a new pump range, that figure could be over 1 million within the next two years.

“This is a great example of two companies coming together to achieve something remarkable,” says Gylling. “Nord-Lock has a brilliant concept, while Grundfos has the knowledge of the market and the corrosion material expertise. By joining forces in an open and honest relationship we achieved something that was a breakthrough technology. Nord-Lock couldn’t have done it, Grundfos couldn’t have done it. But by joining the forces we have a winning solution.” □

**FACTS:**

**GRUNDFOS CR MULTISTAGE PUMPS**

**APPLICATIONS:**

**PRESSURE BOOSTING, BOILER FEEDING,**

**WASH AND CLEAN, TEMPERATURE CONTROL**

**INDUSTRIES:**

**MINING, MARINE, MACHINE TOOL, OFF-SHORE**

**FIRE-FIGHTING, PHARMA, PETROCHEMICAL**

**CONSTRUCTION MATERIALS:**

**CAST IRON, STAINLESS STEEL, TITANIUM**

**TEMPERATURE RANGE:**

**UP TO 120°C (STANDARD), UP TO 180°C (VARIANT)**

**FLOW RANGE:**

**1-180 M<sup>3</sup>/H**

**BOLT SECURING:**

**NORD-LOCK**



**Business arguments**

**THIS IS HOW** Grundfos benefits from Nord-Lock washers:

- **LOWER LIFECYCLE COST** – even if the initial investment is higher
- **BETTER CONTROL** of the pretension on the rotating assembly
- **LOWER FRICTION** – lubricants can be used
- **NO WEAR**, such as that caused by heat, vibration and corrosives
- **A TAILOR-MADE SOLUTION** was made possible through company collaboration.



Tetra Pak is one of the companies using Grundfos CR pumps in its production.

# Making life safer offshore

**WORDS:** ISABELLE KLIGER | **PHOTO:** GRETHE NYGAARD

**OFFSHORE DROPPED OBJECTS** are the single most common cause of serious accidents on offshore installations. But Norwegian engineer Johan Kolstø wanted to change that. He is the man responsible for the Statoil Hydro Health Safety & Environment (HSE) project that set the industry standard for dropped object management on oil rigs, saving lives, time and money.

**Please describe the HSE project for which you were responsible.**

“Our objective was to minimise the frequency of dropped objects on offshore installations. There were no set guidelines at the time, so we examined measures for securing loose items and developed a dropped object inspection system. Between 2004 and 2006 we halved the frequency of falling objects at Statoil Hydro and our best practice manual went on to form the basis for the industry standard in dropped object management, recommended by the Norwegian Oil Industry Association.”

**Why are dropped objects a safety risk?**

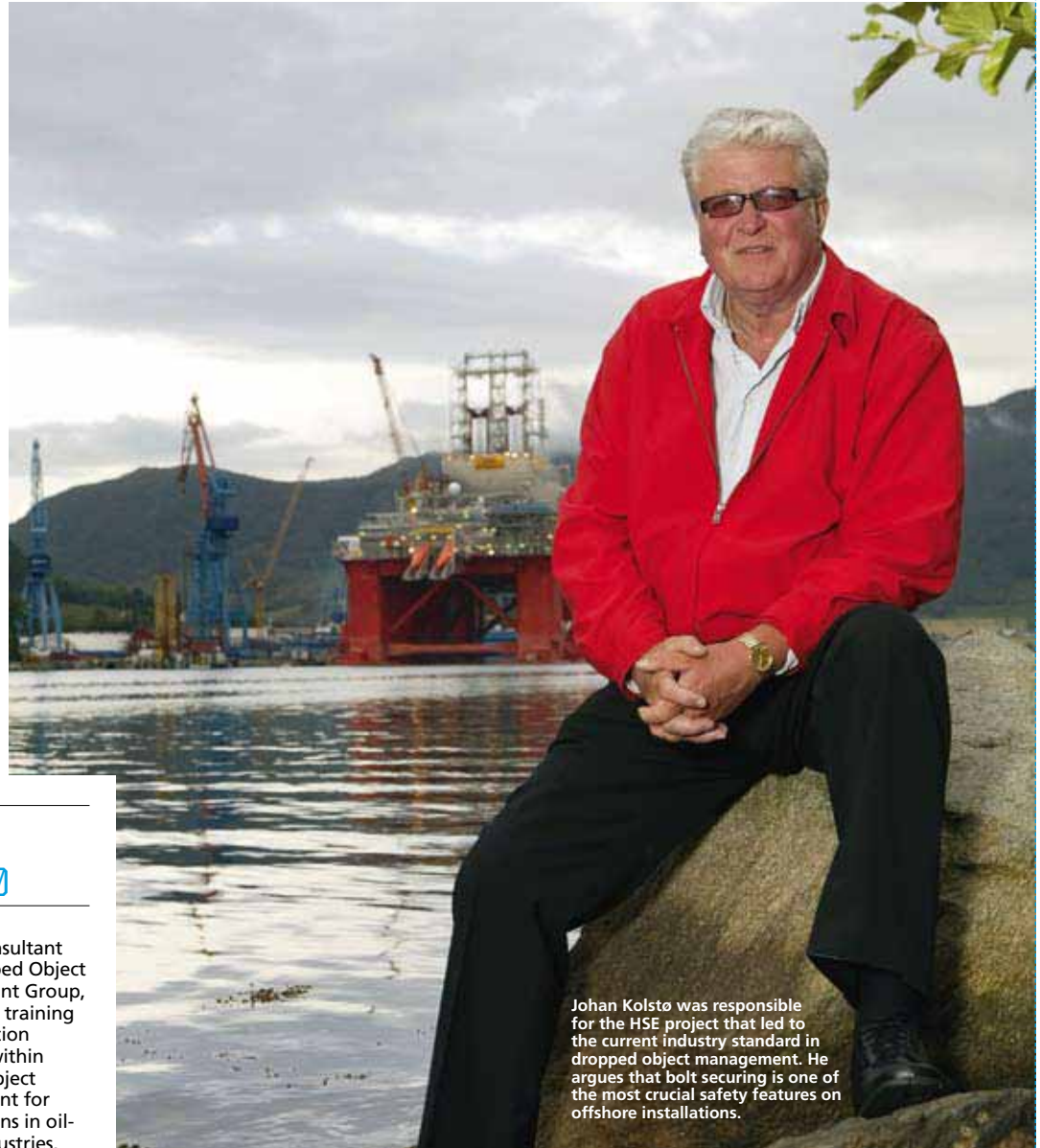
“More than 60 per cent of the most serious incidents on offshore installations are caused by falling objects. You have to consider the fall-energy factor, like what actually happens when 1 kg drops 30 metres...”

**Can you give an example?**

“One incident I recall was when a small piece of tubing, weighing about 30 kg, had been left unsecured on an upper deck. Work was under way one deck down, but there was a small hole in the upper deck. The tubing was rolling back and forth on the upper deck – it fell through the hole, hit a pipe and changed direction. It struck a man on the neck and he was killed instantly.”

**How could this incident have been avoided?**

“It is crucial to secure all loose items! In our best practice manual,



**FACTS:**  
**JOHAN KOLSTØ**

**AGE:** 62  
**ROLE:** A consultant with Dropped Object Management Group, developing training and inspection processes within dropped object management for organisations in oil-related industries.

Johan Kolstø was responsible for the HSE project that led to the current industry standard in dropped object management. He argues that bolt securing is one of the most crucial safety features on offshore installations.

we expressly recommend Nord-Lock’s bolt securing system for connections that are exposed to vibration, such as gratings, loudspeakers, cable trays, ladders and guide rails, but it has an almost unlimited range of applications. The technical system is excellent – it’s extremely reliable and easy to inspect. In fact, I have never heard of a Nord-Lock system that came loose.”

**What is special about Nord-Lock’s products?**

“They are unique because of the washers. The technical design means the tension is always maintained and it simply can’t come loose, regard-

## “Some might say safety is expensive - try an accident!”

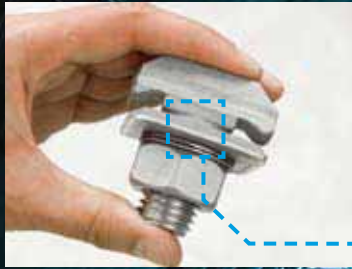
JOHAN KOLSTØ, SAFETY CONSULTANT

less of the movement or vibration to which it is exposed.”

**What is your advice to people working with offshore safety?**

“Some might say safety is expensive – but try an accident! Usually accidents do not happen but, if items are not properly secured and inspected, something will eventually go wrong. The repercussions can be terrible, in terms of both accidents

and breakages, which cost money and delay the work. The challenge for me and my colleagues is constantly to educate people – it’s all about a systematic approach to identifying and controlling risk. If people work according to our best practice recommendations and make sure loose items are properly secured, there will be no need for accidents of this kind to take place.” □



### TIME RESISTANT DESIGN

The head of the bolt is slotted into the rail cast into the tunnel roof. Nord-Lock washers secure the bolt system against forces created by trains entering and exiting the station. This should hold for 120 years.

Light at the end of the tunnel: Malmö Citytunnel will be completed six months ahead of schedule. About 243,000 cubic metres of concrete were used for its two parallel tunnels.

# Tunnel vision

WORDS:  
DAVID WILES

PHOTO:  
MARTIN MAGNTORN

**THE CHALLENGE** Twenty metres beneath the streets of Malmö, Sweden, the new underground section of the city's central station is gradually taking shape. Currently cavernous and empty, with music from workmen's radios echoing off the walls and the smell of concrete dust in the air, it will in December next year be a major transport hub connecting Sweden's third city with Denmark's largest, Copenhagen.

Malmö Citytunnel Group, the consortium behind the project, has demanded that the concrete in the tunnel lasts 120 years – as must everything mounted in it, such as the gantry carrying electric cables, water pipes and ventilation pipes that run the length of the 350m-long platform. Contractor NCC, responsible for the underground station and platform, was tasked with finding a solution that would keep the gantry firmly bolted to the tunnel's roof and able to resist the pressure waves created by trains entering and leaving the station.

**THE SOLUTION** The answer was a series of steel rails cast into the concrete of the tunnel roof. Into these rails are secured thousands of anchor bolts manufactured by Halfen-Deha in top-quality A5 steel, each of which is secured with a Nord-Lock washer pair.

"We insert each anchor bolt into the rail, twist it 90 degrees, and then tighten it," says Jörgen Andersson, site engineer with NCC. "This is supposed to hold for a very long time, so the demands on the bolts and the washers are very high. We are counting on them to do a good job."

**THE RESULT** While there is much to be done before the first train pulls in – the Citytunnel is currently six months ahead of schedule – the gantry project is finished. There are 5,000 anchor bolts, painted with white fire-resistant paint, holding the gantry solidly in place in preparation for the buffeting created by the arrival of dozens of trains a day passing through Malmö Central Station along the €1 bn Citytunnel line.

At €5 a piece for more than a century of service, the lifecycle cost is minimal.

"We are pleased with the result. No problems at all," says Andersson. "With the Citytunnel it would be very difficult to do repairs or maintenance if something went wrong because it is out of the question to close the tunnel to get access. But they won't have to worry about this gantry for another 120 years." □

## New on the market – the GTP600 lubricant

Nord-Lock is now broadening their product range in the area of bolt security. Their lubricant, GTP600, is a smart way of reducing friction and improving corrosion protection as well as facilitating reuse of fasteners.



**ACCORDING TO** Frida Cullin, applications engineer at Nord-Lock, the new graphite lubricant has numerous advantages. Low and uniform friction that will reduce deviation when tightening numerous bolts is one of them. Thanks to the graphite formula this low friction will also be maintained after long-term use in harsh and corrosive environments. This will facilitate the dismantling and increase the lifetime performance of the bolt. With GTP600, the desired clamp load is reached at a lower tightening torque, helping to utilise as much of the bolt's capacity as possible without the risk of stretching it.

"The risk of not using a lubricant is that a bolted joint will either not be tightened enough and loosen after a period of time or that it will be tightened too much, with a risk of torsion that could even result in breakage."

### Who will benefit from Nord-Lock's new lubricant?

"Anyone working with bolted joints where it is essential to have a predictable clamp load. Without a lubricant, it is difficult to get the necessary precision and control of the clamp force. But I would recommend everyone to use a suitable lubricant."

"Surprisingly few people lubricate and many of them don't think that it makes much difference, but it does."

Many people are using friction-based solutions to prevent their bolts from rotating loose and then it is not possible to lubricate as it will reduce the friction. Our security washers work mechanically making it possible to lubricate and use all the benefits that come with it," she says.

GTP600 helps optimise all types of bolted joints and also increases cost-efficiency. This lubricant is environmentally friendly and meets the requirements of EINECS (EU) and TSCA (US).

"By introducing our own lubricant we hope to spread information about how beneficial it is to lubricate, as well as offering a complete and competitive bolt securing system that gives the customer control of the pre-load and optimised security," says Frida Cullin. □

### FACTS: GTP600 LUBRICANT

- GTP600 is a high-quality graphite lubricant that is superior to all traditional lubricants. Using GTP600 when tightening bolted joints guarantees low and uniform friction, which makes it possible to fully utilise the bolt's capacity.
- GTP600 withstand temperatures up to 600°C.
- GTP600 is available in 250 ml (8.5 oz). Contact your local supplier for additional information.

## Nord-Lock stands the test and is looking for new challenges

**TELLING PEOPLE** your product is good is one thing. Proving it is another. To show that Nord-Lock meets quality requirements, environmental management criteria and delivers optimum performance, the products and production methods are regularly tested by independent test bodies.

So far, Nord-Lock has been tested by a number of independent institutes. And they have all approved and certified Nord-Lock's products. Here are some of the certificates and approvals Nord-Lock has obtained to date:

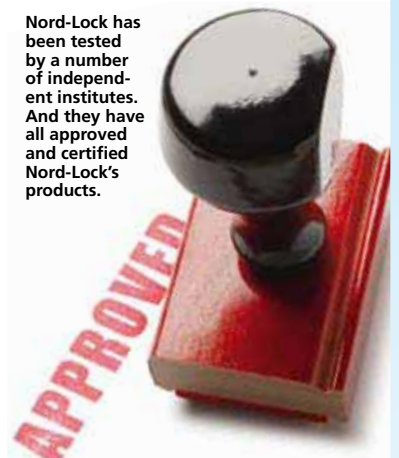
- **DNV type approval D-3029** – quality assurance by the independent organisation DNV (Det Norske Veritas).
- **EbA approval** for the German railroad industry.
- **ISO 14001** – independent quality and environmental management certificate issued by Swedac (the Swedish Board for Accreditation and Conformity Assessment).
- **ISO 9001** – quality and environmental management system approval issued by the Swedish Standards Institute.
- **TÜV certificate** – quality assur-

ance by the German body Technischer Überwachungsverein.

- **Deutsche Bahn approval** – German railway authority approval.
- **EU directives** on the environment, product durability and restrictions on the use of toxic or environmentally harmful chemicals (ELV & RoHS).

For 25 years Nord-Lock has been dedicated to producing the most effective bolt securing system on the market, and regularly proves this ability. Nord-Lock is not afraid of new challenges. It has passed every test so far, and will not back away from new ones. □

Nord-Lock has been tested by a number of independent institutes. And they have all approved and certified Nord-Lock's products.



## Nord-Lock certified by DNV

**NORD-LOCK IS THE FIRST** bolt securing system in the world to have been type-approved by the independent foundation Det Norske Veritas (DNV). The certification process has taken more than two years and has comprised a number of independent tests including vibration, acceleration and an overview of Nord-Lock's production and its quality assurance system.

In its decision, DNV recommends Nord-Lock for preloaded bolted assemblies subjected to dynamic, fatigue, impact and vibration induced loading.

Det Norske Veritas is a global supplier of services for managing risks. □

## General Approval from the German Federal Railway Authority

**NORD-LOCK** has worked together with the German railway industry and its suppliers for many years. Since the safety of rolling stock and tracks, switches and bridges in the railway superstructure is generally of the highest priority, the German Federal Railway Authority requires approval for component parts in the majority of cases.

Since Nord-Lock has the general approval for the use of its washers in predominantly non-static stressed applications specific to railways, for individual cases and multiple uses, the required approvals have been waived or significantly simplified within the Federal Railway ambit.

Today Nord-Lock manufactures washers for a multitude of railway applications, e.g. high speed switches, noise abatement wall anchorages, rail applications, guard rails, expansion joints, temporary bridges, and hardware installations for railway bridge equipment, to name a few.

Deutsche Bahn AG has also confirmed that Nord-Lock washers meet the technical requirements for bolt securing systems in accordance with railway standard BN 208 010.

These approvals allow companies working with the German Federal Railways to use Nord-Lock solutions without the requirement for individual approvals. Download approval through [www.nord-lock.com/downloads](http://www.nord-lock.com/downloads). □

In every edition of Bolted, we present one of the areas in which Nord-Lock is working actively on quality assurance and competitiveness. In this issue we focus on the quality in the choice of material.

# Quality in every step



"There is no magic way of getting a good product if the material is not of the highest quality," says Daniel Eriksson, Production Manager at the Nord-Lock production plant in Mattmar, in the north of Sweden. FOTO: TINA STAFRÉN

Tougher competition makes ever-increasing demands for higher quality. That's why Nord-Lock is working steadily to meet the competition and to be at the forefront of cutting-edge development. The first step is choosing brand steel.

**PERHAPS THE MOST IMPORTANT** cornerstone in assuring the quality of Nord-Lock's wedge locking washers is the choice of material. Just as the foundation is the most important part of a building, a product can never be better than the material used to produce it. Daniel Eriksson, Production Manager at Nord-Lock's plant in Mattmar, Sweden explains this concept.

"We only purchase brand steel from well-respected suppli-

ers where we know what we will get every time: above all, steel with stable characteristics that is always produced using the same process. For the sake of the product, it is not only the composition but also the way in which it is produced that leads to these characteristics."

A brand steel also has a number of advantages over generic steel.

"It is difficult to consistently get the same characteristics in

generic steel and to get material-related support from the supplier. When we purchase steel from European sources, it is much easier to carry on a dialogue with the supplier and to get help in the form of know-how and support."

According to Daniel Eriksson, there are a number of factors to take into account when choosing a supplier. He looks at what other customers are using, has an ongoing dialogue with different suppliers, and he checks price levels, delivery times and flexibility. But nothing is as important as the material.

"You can get around most of the other factors, but there is no magic way of getting a good product if the material is not of the highest quality," he says.

The decision to use brand steel was made as far back as Nord-Lock's infancy in the early 1980s. The company quickly realised that in order to guarantee the best products, it was necessary to use the best materials available.

**THE STEEL** is purchased exclusively in Europe since Asian suppliers may not always be able to guarantee that the material meets EN standards.

Another important factor in choosing a supplier, and a compelling argument for brand steel, is that it does not contain the radioactive substance Cobalt 60.

"All suppliers of brand steel continuously monitor the materials used in production to ensure that nothing is contaminated. All material, without exception, is also inspected so that there is no contamination in the finished product either. This is also guaranteed through the purchase of brand steel," says Daniel Eriksson. □

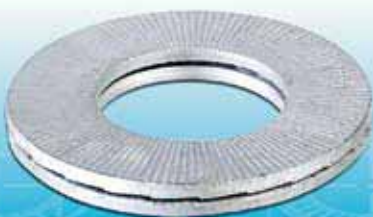
# Comparing solutions for bolt securing

Adhesives or Nord-Lock washers? Finding the ultimate bolt securing system is no easy task. Here is a guide to making the right choice.



LOCKING CAPABILITY	Reliable.	Varies.
RANGE	M3-M130.	Unlimited (not size dependant).
TEMPERATURE	Same temperature characteristics as regular bolts/nuts.	Sensitive to high temperatures.
ASSEMBLY	No preparation required.	Requires degreasing.
CURING TIME	No curing time.	Up to 12 hours (increased downtime of equipment).
CONTROL OVER CLAMP LOAD	Linear relationship between torque/load thus possible to predict the clamp load. Does not increase the risk of torsion.	Adds friction in the thread, making it difficult to predict the clamp load. Also increases the risk of torsion.
DISASSEMBLY	No special requirements.	Requires heating.
REUSABILITY	Reusable. Does not affect reusability of bolts/nuts.	Not possible to reuse. Bolts/nuts needs to be cleaned before reuse, which is time consuming.
ENVIRONMENT	Recyclable. Meets ELV and RoHS directives.	Not recyclable, contains contaminous chemicals. May cause allergic reactions.
LUBRICATION	Possible to lubricate.	Not possible.
VISUAL INSPECTION	Visual inspection possible.	Visual inspection not possible.
LIFE CYCLE COST (LCC)	Low. Relative high price per unit. Long life cycle. Improves stability and minimizes maintenance cost.	High. Relative low price per unit. Short life cycle. Increases maintenance costs and assembly time.

This zinc flaked NL6sp washer pair can easily be made into a 3D CAD model.



## Download CAD-files for Nord-Lock products

**IF YOU NEED** a CAD-file for any Nord-Lock product, you can easily download 2D and 3D CAD models in several formats via the Nord-Lock site. Pdf-files can be generated for each product, with thorough product information, date and article number. You'll find the CAD-library at [www.nord-lock.com/cad](http://www.nord-lock.com/cad). □

## CALENDAR

### Exhibitions

**EACH YEAR**, Nord-Lock participates in over 60 large exhibitions and events for various industries. In the Nord-Lock stands you will find experts on bolt securing, and you can also see Juncker demonstrations, a comparative worst-case scenario test for bolted joints. Here are some of this autumn's highlights:



#### □ SPE Offshore Europe, Aberdeen, Scotland

**WHAT:** the largest upstream oil and gas event outside North America, with conferences, debates and demonstrations of the latest well technology.

**WHEN:** Sep 8–11, 2009

**WHERE:** Stand no. 866



#### □ Agritechnica, Hanover, Germany

**WHAT:** the worldwide meeting point for the agricultural machinery sector.

**WHEN:** Nov 10–14, 2009

**WHERE:** Stand no. 07-B24



#### □ Power Gen Show, Las Vegas, US

**WHAT:** knowledge and ideas on the latest power industry trends and challenges.

**WHEN:** Dec 8–10, 2009

**WHERE:** Stand no. C5-538

You'll find the complete list of exhibitions at [www.nord-lock.com/events](http://www.nord-lock.com/events).



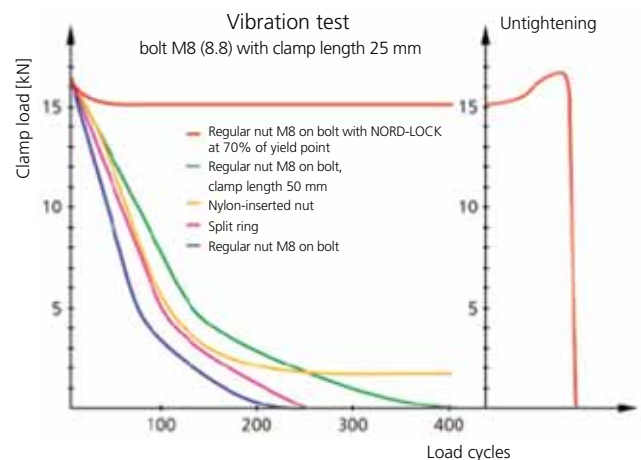
# 7 SECONDS IS ALL IT TAKES

Nord-Lock's international team of sales engineers meet clients locally with a Junker demonstration tool, which illustrates the difference between Nord-Lock and other locking methods.

7 seconds is all it takes to learn how unique Nord-Lock's bolt securing system is.

We help you optimise your bolted joints in order to minimise overall costs and maximise safety.

[www.nord-lock.com](http://www.nord-lock.com)  
**MADE IN SWEDEN**



**NORD-LOCK**<sup>®</sup>  
Bolt securing system

NORD-LOCK Products are available from  
MARYLAND METRICS  
P.O. Box 261 Owings Mills, MD 21117 USA  
ph: (410)358-3130 (800)638-1830  
fx: (410)358-3142 (800)872-9329  
email: [sales@mdmetric.com](mailto:sales@mdmetric.com) web: <http://mdmetric.com>