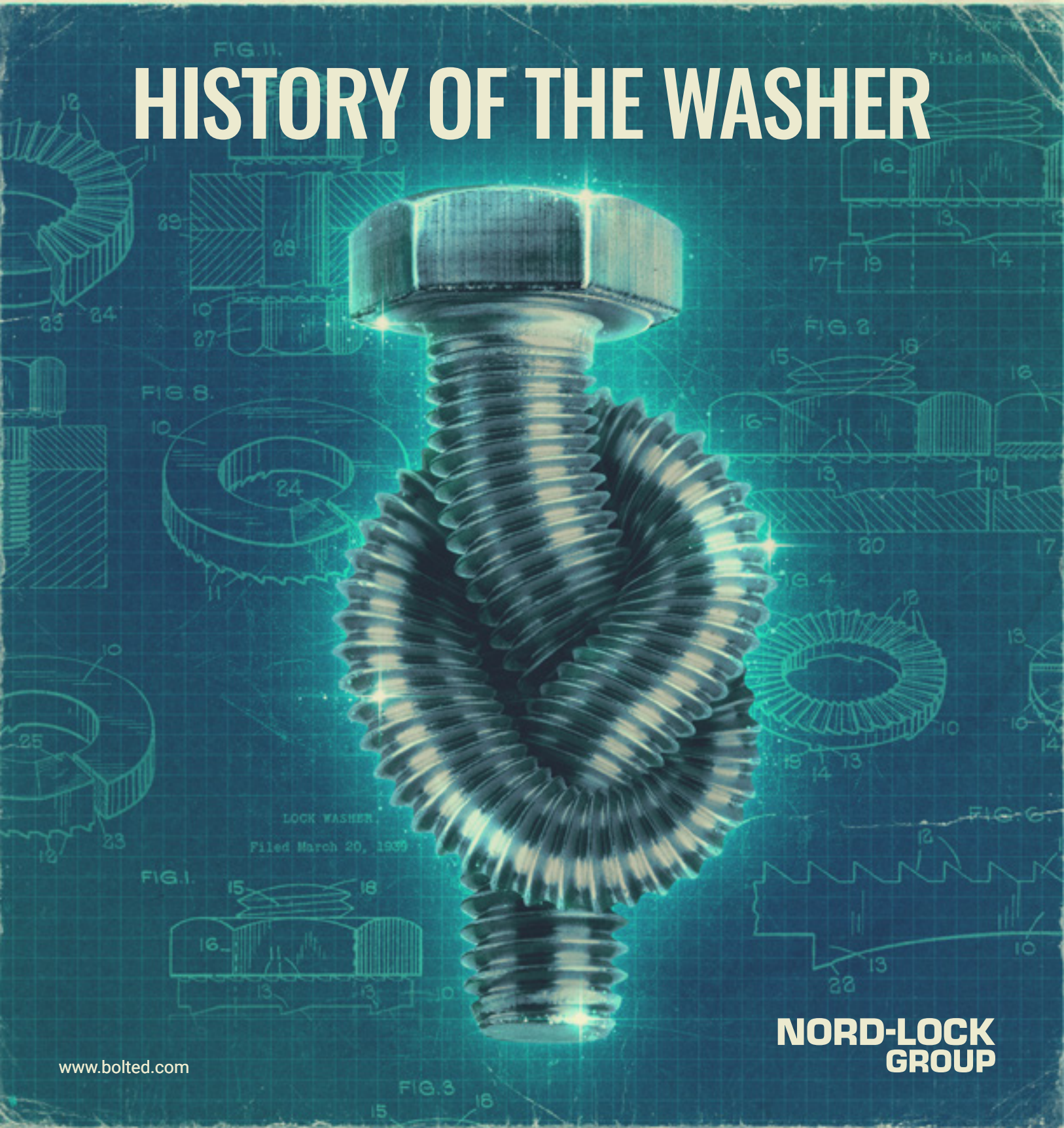
BOLTED

A MAGAZINE ABOUT BOLTING TECHNOLOGIES

ISSUE 2 - 2022

HISTORY OF THE WASHER



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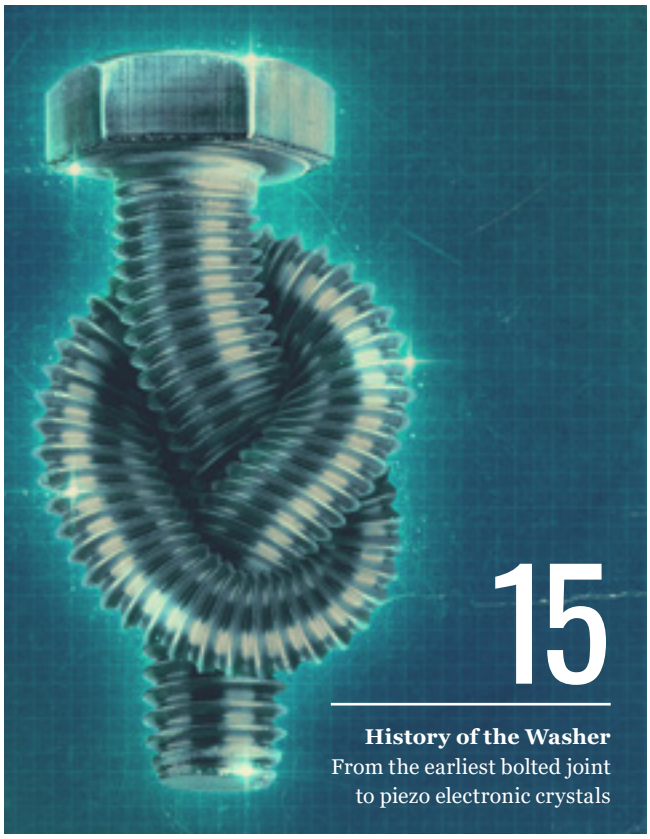

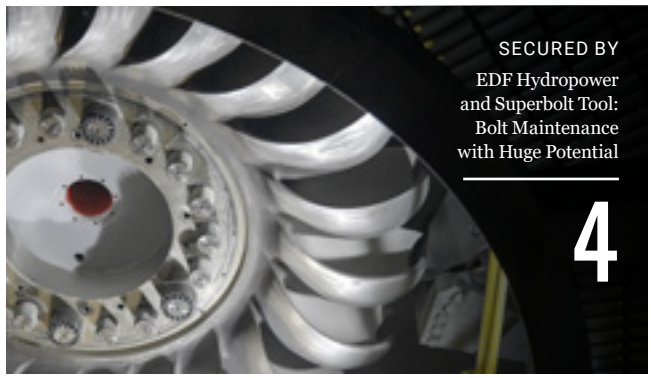

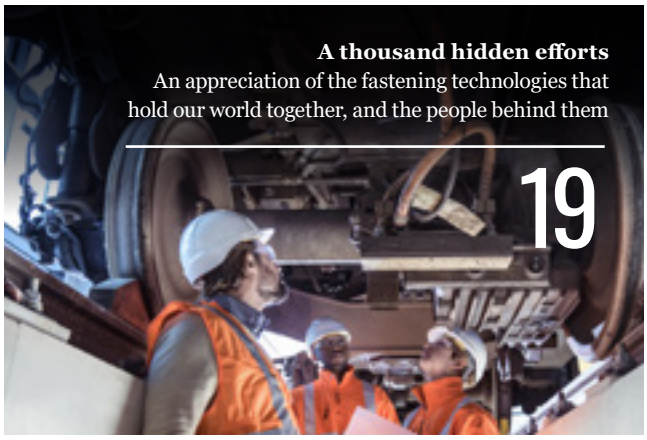

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Feel free to contact us with any comments at **info@nord-lock.com**

Fredrik Meuller
CEO Nord-Lock Group

Our engineering helps society to travel safely, work efficiently, create tomorrow's energy and so much more.

In 1982, Nord-Lock Group began developing the original wedge-locking washers that prevent bolts and nuts from loosening. Today, our four technology brands innovate new, advanced bolting solutions to secure applications and critical infrastructure in every major industry worldwide.

With the first 40 years of innovation behind us, I'm delighted to be celebrating this milestone by highlighting Nord-Lock Group's story of entrepreneurial beginnings and tremendous profitable growth.

Inside this issue we put the spotlight on Superbolt mechanical tensioning, trace the history of the Nord-Lock washer and share an appreciation of the often-overlooked fastening technologies that hold our world together.

To put it simply, 2022 is a year for us to be proud of going from the development of wedge-locking washers, out of a small red barn in northern Sweden, to becoming the global number one in secure bolting.

It's also the year that our new and upgraded operational platform fully kicks in, with three new or upgraded factories providing even greater quality, availability, and sustainability than ever before. So, despite a still challenging macroeconomic environment, Nord-Lock Group's agility, performance track record and stable long-term ownership by Investment AB Latour sees us at the beginning of an exciting new S-curve — with a highly positive outlook for capturing additional organic growth.

What excites us the most is that we have barely scratched the surface when it comes to the potential uses for our expertise and solutions — including how even the most 'traditional' industries can be supported with smart, sensor-enabled bolting technologies.

In the magazine you'll find how our Red Dot award-winning Superbolt Tool is used in one of Europe's largest hydropower plants, how Nord-Lock washers are used in a novel drone application to optimize agriculture in China, DIY drag-racing and more.

As always, enjoy reading!

BOLT MAINTENANCE WITH HUGE POTENTIAL

With more than 250 jackbolts to tighten on a critical turbine, the maintenance team at one of EDF's most productive hydroelectric power plants look for tools to lighten the load of annual maintenance.

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

A major force in European renewable energy production

According to Our World In Data, hydroelectric power was the largest global source of renewable energy in 2020. In France, hydropower plants produced 62.5 TWh in 2021, or 12% of metropolitan France's production according to Réseau de Transport d'Électricité's 2021 electricity balance sheet. EDF are the leading hydroelectric energy producer in the European Union.

One of their biggest facilities is EDF de la Coche, a hydroelectric plant located in the northern Alps at the entrance to the Tarentaise valley in Savoie, France. La Coche, as it's known, is one of the six main pumped-storage hydropower plants in France, responsible for producing one third of the nation's hydroelectric power.

At the development's highest point sits the La Coche basin, a dam which is fed by 28km of watercourses and stores the potential energy that is used by La Coche to generate electricity. It is a so-called 'high fall' development, with a 900m difference in altitude between the basin and its subterranean power station. This height, known as the hydraulic head, creates a flow rate of 40 cubic metres per second as water funnels through the penstock into five turbine units.

Four of these turbines are reversible, so the residual water in the lower reservoir (the Aigueblanche dam) can be pumped back up to the basin to reconstitute the potential energy, like creating a large battery, during periods of low demand.

"When we need electricity during peak consumption, we can use the water to produce electricity for the French residents. At La Coche, we're producing the equivalent of 270,000 people's annual consumption," says Benoît Pezous, Head of the La Coche Randens plant group at EDF.

Maintaining a 15-ton Pelton wheel turbine

Unit number five, unlike the other four Francis turbines, is a non-reversible G5 Pelton wheel. This latest addition to the La Coche development is a one-way turbine that is particularly efficient when the site receives excessive water inflows, such as those brought through the alpine water network as winter snow melts.

With a 3.6 metre diameter and 15-ton weight, the Pelton wheel is at the heart of production and EDF's most powerful hydro unit in France. But despite having an abrasion-specific coating, sediment-laden water is projected through five injectors at around 500 km/h to rotate the wheel, so the unit needs replacing almost annually.

David Enault is the First Line Manager of the Mechanical Intervention Team at EDF, and his team are tasked with responsive maintenance and optimizing the availability of units across the EDF group.

"During wheel replacement operations on the G5 Pelton wheel at La Coche, we work on eighteen M125 multi-jack-bolt tensioners that must be loosened from a ceiling height of 1.8m," says Enault.

Optimizing hydropower turbine maintenance

Due to the volume of bolted connections and restricted operating space they can use to tighten/untighten the multiple overhead jackbolts, Enault's team look for tools that can optimize the maintenance time and ergonomics of this work.

EDF's La Coche hydroelectric plant

Picture edf-C.Huret

Jean-Christophe Bette, Business Preparation Manager and Enault's colleague, first discovered the Superbolt Tool when leafing through a previous issue of this very magazine. He says that "our contact at Nord-Lock Group explained to us that this device could indeed be adapted to our use."

Subsequent tests of the Superbolt Tool on a ball valve at La Coche convinced the team that it had the ergonomic qualities and speed of implementation that they were looking for, hence they chose to proceed with developing an application-specific tooling for the G5 Pelton wheel.

Superbolt Tool makes tightening up to three times faster

The Superbolt Tool is a project-based, modular manufacture that includes a drive unit and cassette that is, for example, specific to the nut sizes on the EDF Pelton wheel. In use, it amplifies a small torque input into a large and uniform torque output, so that all jackbolts can be tightened simultaneously to an accurate and even preload.

"Unlike the single tightening of the Superbolt jackbolts, where we had about 1,000 strokes on all the nuts, here we have a simultaneous tightening which guarantees a homogeneous preload and generates a considerable time saving," says Bette.

The Pelton wheel at La Coche is secured by eighteen large tensioners, so previously there were more than 250 individual jackbolts to tension by hand.

Albin Paluello, Senior Maintenance Technician at EDF, reflects happily on the annual maintenance procedure since the addition of the Superbolt tool:

"It's a very good experience. If we compare before and after using the Superbolt Tool, we really see that the times are greatly reduced, the tooling makes it easy."

"By tightening everything at the same time, we can easily reduce the maintenance hours by two thirds," adds Bette. "We achieved what we set out to do, develop a tooling that allows our employees to work more ergonomically under the Pelton wheel, and to gain in operation time," concludes Enault.

Albin Paluello
SENIOR MAINTENANCE TECHNICIAN, EDF

Jean-Christophe Bette
BUSINESS PREPARATION MANAGER, EDF

Watch how Delvator, the general agent for Hitachi's construction machinery in Sweden, uses Expander System

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Thomas Johnsson, Delvator After Market Manager

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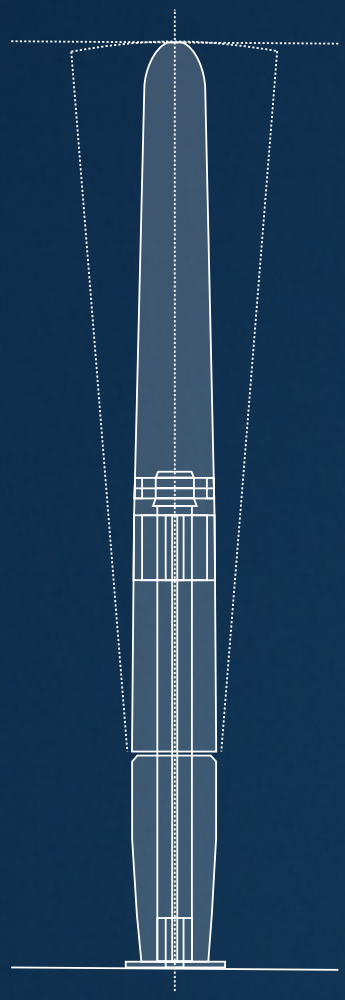


Humans have made practical use of the wind for aeons. But we are still coming up with new ways, such as the Spanish company Vortex Bladeless' innovative technology that harnesses wind power for smaller-scale applications.

REINVENTING WIND POWER

Text Ulf Wiman **Pictures** Vortex Bladeless

Discussions about wind energy usually deal with large-scale horizontal-axis three-bladed towered wind turbines (HAWTs). However, innovative, smaller-scale solutions are emerging that, despite their size, can prove invaluable in providing just the right solution for specific applications.

The Spanish company Vortex Bladeless S.L. boldly claims that its technology is helping reinvent wind power. And doubtlessly, they are onto something. Vortex Bladeless has won several innovation awards and is now backed by the Norwegian state energy company Equinor, plus partly funded by the European Commission's Horizon 2020 programme for research and innovation.

Perfect for urban applications

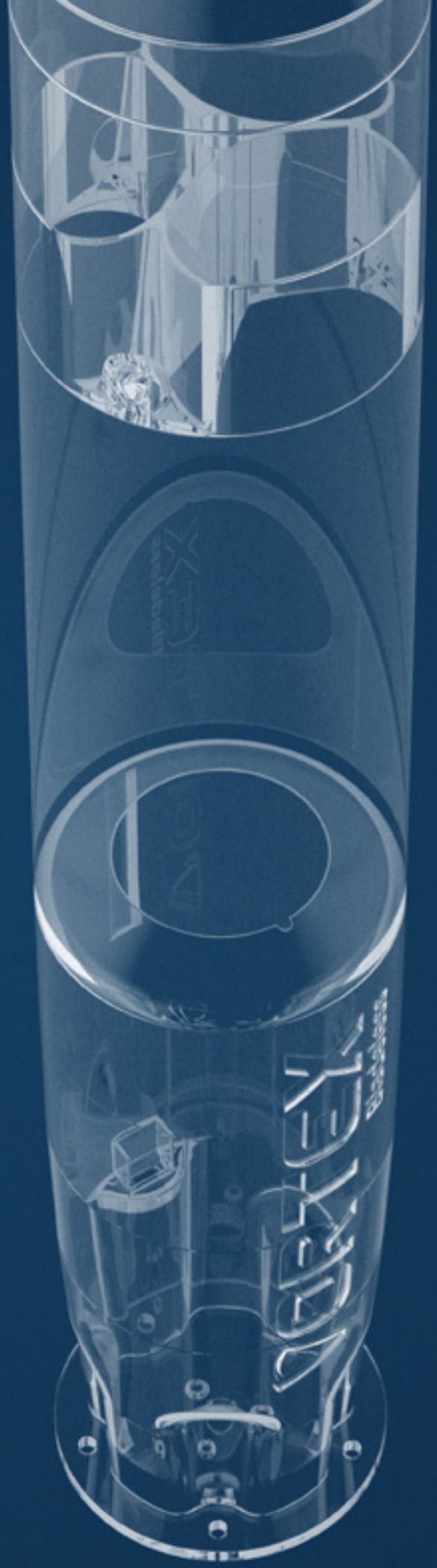
True to the company name, the Vortex Bladeless turbine doesn't use the giant rotor blades of HAWTs. In fact, the first Nano prototypes are just 0.85 metres high. And they are not really turbines either. Maybe this makes you sceptical, but the bladeless wind turbines were never meant to compete with HAWTs.

David Yáñez, co-founder, president, and CTO, says: "After renewable energy has become an indisputable and competitive reality, the immediate future will be distributed and even decentralised energy."

"Individuals or families will become major players in producing and marketing the energy generated on their roofs. We want our technology to help them cover their energy needs."

With their vertical construction, bladeless wind turbines have a tiny footprint, and they are practically noiseless. It makes them an excellent fit for urban and residential areas. They are also no threat to birds.

David Yáñez
CO-FOUNDER, PRESIDENT AND CTO, VORTEX BLADELESS S.L.



A durable and low-cost design

So, how does bladeless technology work? The Vortex Bladeless website explains that their innovation is “a vortex-induced vibration-resonant wind generator. It harnesses wind energy from a phenomenon of vorticity called Vortex Shedding.”

The construction uses an elastic, conical mast inside a vertically fixed two-part, rigid cylinder. The bottom part of the cylinder is firmly fixed to the ground while the top part moves freely and has the maximum oscillation amplitude.

The mast reacts optimally to wind velocities and adapts quickly to wind direction changes and turbulent airflows. As the cylinder oscillates, it captures mechanical energy, which is then transferred to an alternator that converts it into electricity. The alternator is a relatively simple construction with coils and magnets, and with no gears, shafts or moving parts, it is cheap and easy to produce. In operation, the risk of turbine breakdowns and downtime is reduced significantly, lowering maintenance needs.

The bladeless turbine is designed to withstand harsh weather conditions, including rain and snow, and wind speeds up to 30–35 m/s – violent storms or near-hurricane forces.

Collapsing bridge planted the seeds

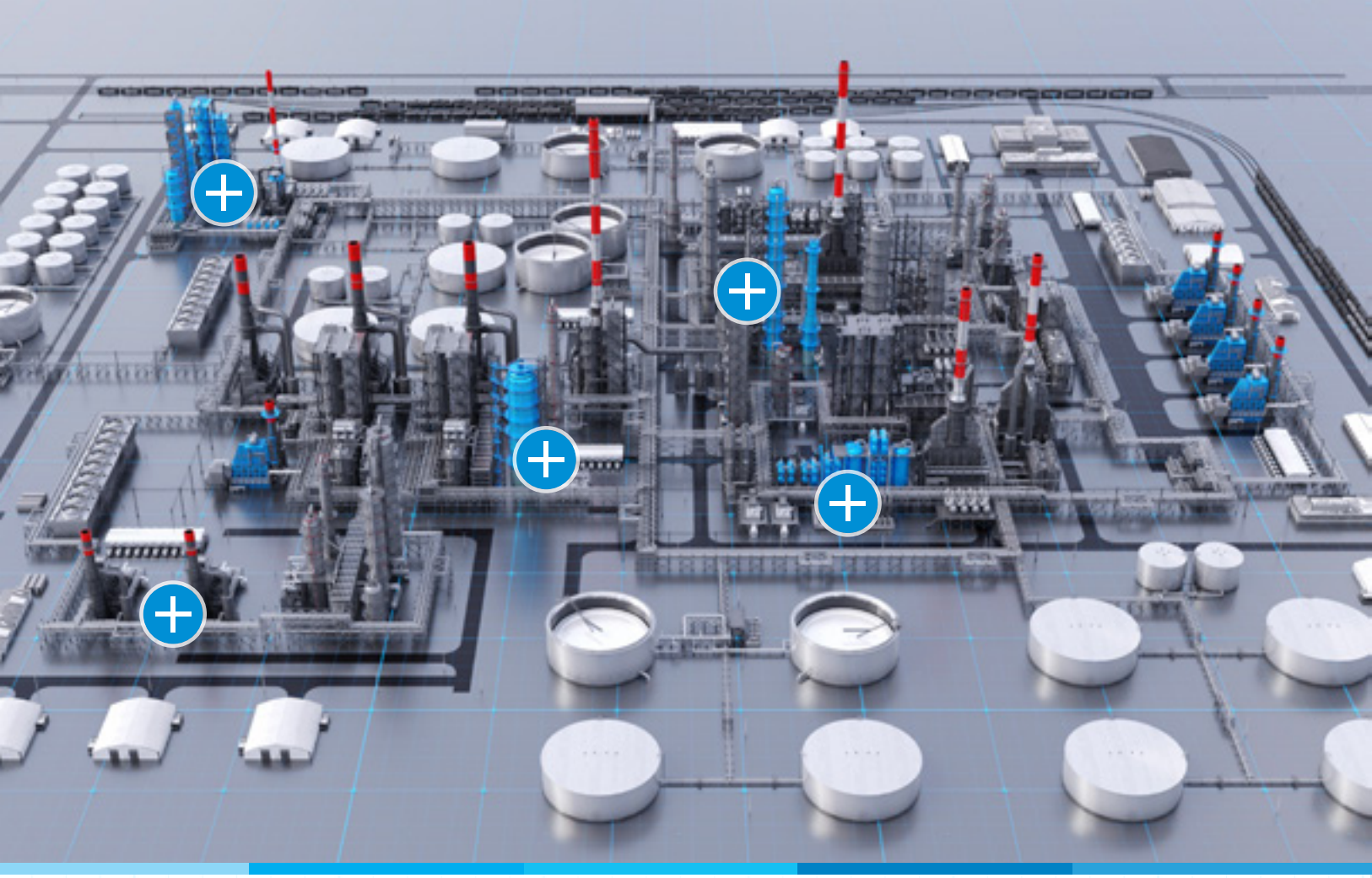
Yáñez got the idea while still an engineering student at Valladolid University, seeing a 1940s film of the Tacoma Narrows Bridge oscillating wildly in the wind. The bridge collapsed just four months after being opened to traffic.

He remembers thinking: “That bridge is collecting a significant amount of energy. I wonder if there’s a way to create a technology that could take advantage of it? Then, I realised a vertical structure can reach winds far from the ground, therefore at greater speeds.”

Today Vortex Bladeless holds six families of registered patents. The company was founded in 2014 with the help of business angels and other funding. Since then, it has been an exciting journey, including crowdfunding, awards, media coverage, exciting collaborations, and prototype-building.

Finally going to market

The development is at an exciting stage, Yáñez says: “After more than half a decade of developing the technology ‘in the lab’ and manufacturing some pre-series, we have reached sufficient maturity to make the first modest incursions into the market.”



OPTIMIZE RELIABILITY WITH SECURE BOLTED CONNECTIONS FOR DOWNSTREAM OIL & GAS

Use Nord-Lock Group's new online environment to discover the common issues affecting heat exchangers, compressors, flange applications, reactor covers, structural applications, and more to come as we continuously develop the tool with industry-leading bolting experience.

See how our bolting solutions have helped the world's top oil & gas companies to increase reliability, maintain uptime, improve safety, and reduce maintenance costs.

Scan the QR code to explore the downstream environment, or visit **www.nord-lock.com/downstream**

Getting Superbolt into space was a big deal, but it's suitability to secure critical bolted joints hasn't always been applied in such awe-inspiring fields.

The journey is still unfolding, from an industrial fix in the beating heart of US manufacturing to a global brand that is synonymous with industrial multi-jackbolt tensioning, and now a leader at the forefront of predictive maintenance and digital bolting.

SUPERBOLT'S CULTURE OF INNOVATION AND ALL EYES ON SMART BOLTING

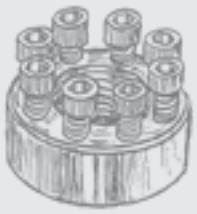
Sébastien Bruyas
STRATEGIC SALES MANAGER EMEA, NORD-LOCK GROUP

Max Bastiaansen
R&D PROJECT COORDINATOR, NORD-LOCK GROUP

Steve Busalacchi
GLOBAL PRODUCT MANAGER, NORD-LOCK GROUP

Amaris Neidich
GENERAL MANAGER LATIN AMERICA, NORD-LOCK GROUP

Pierre Kellner
BUSINESS DEVELOPER, SMART PRODUCTS AND SERVICES, NORD-LOCK GROUP



The origins of multi-jackbolt tensioning
In 1974, the mills of US Steel in Pittsburgh were tormented by machine breakdowns and maintenance downtime. Large conventional nuts and bolts were frequently loosening due to vibrations and rotations in the equipment, and the operators often required sledgehammers to do the retightening because of high torques needed on bolt diameters larger than M24.

Owing to the sometimes-spontaneous nature of innovation, it was a routine workday when Rolf Steinbock imagined breaking up the high torque requirements of these problematic nuts into several, smaller torques with multiple jackbolts threaded through the nut body.

In doing so, Steinbock invented the original Superbolt multi-jackbolt tensioner (MJT), an innovation that made it possible to tighten large bolts with a simple torque wrench instead of the sledgehammer. This technology made more accurate preload possible, plus the new MJT maintained clamp load, meaning a revolution for the productivity of heavy industry machines by eliminating bolt loosening.

Now proven in tens of thousands of successful applications worldwide, operators choose Superbolt to solve the toughest bolting challenges in everything from production plants to major construction, mining, and groundbreaking power-generation projects. Thanks to fast and flexible production, in-house engineering expertise and technical centres around the globe, solutions can be tailor-made specifically for the customer.

Easy to choose. Easy to use.
An evolution of the multi-jackbolt tensioner
Put simply, a Superbolt MJT makes the application of large bolts easier and maintenance less demanding. So, speed and accuracy are the guiding principles for further innovation.

EASY TO CHOOSE. EASY TO USE.

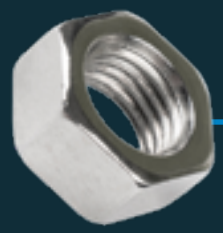
Superbolt NXT

6 mm
Wrench size

220 kN	8.8	M30
Preload capacity	Grade	Size

97% less torque!

36 Nm
Required torque



Regular hex nut

46 mm
Wrench size

220 kN	8.8	M30
Preload capacity	Grade	Size

1,300 Nm
Required torque

In 2019 the Superbolt Tool, which won the prestigious Red Dot Design Award for Nord-Lock Group, was introduced. A compact drive mechanism makes it possible to tighten multiple jackbolts simultaneously to the correct load, as used by EDF Energy (see page 4).

Now it's Superbolt NXT, a brand new multi-jackbolt tensioner that is taking those fundamental values of speed and accuracy to the next level.

"It started with a strategic initiative to improve the customer experience when using a Superbolt multi-jackbolt tensioner," says Sébastien Bruyas, Strategic Sales Manager EMEA at Nord-Lock Group.

The key improvement has been reducing the number of jackbolts required to tighten bolted joints, as a small decrease in jackbolts can deliver a significant reduction in both installation and removal times. To achieve this, design engineers had to rethink this critical component.

"We worked with steel mills and heat treatment partners to get the right materials and processes to increase the strength of our jackbolts. Now, we can offer the customer an equivalent preload with fewer jackbolts, so it's faster and easier to install with less torque" says Max Bastiaansen, R&D Project Coordinator for Nord-Lock Group.

Superbolt NXT also features a black oxidised coating for corrosion protection, laser-markings to guide installation and an anti-slip knurling grip layer. It is instantly recognizable in comparison to the grey tensioners available on the market until today.

"Take two products side-by-side, and you will see a visible difference between Superbolt NXT and a conventional multi-jackbolt tensioner — it might have two, four or six fewer jackbolts. To design something that just looks good, it's a bit limited, but we've added features that bring a great benefit to the user. Superbolt NXT is easy to recognise, but it's even easier to use," adds Bruyas.

"I've said many times, there are only so many ways to configure a Superbolt nut body in terms of size, number of jackbolts and a washer. But this new MJT completely breaks down that barrier."

Steve Busalacchi, Global Product Manager at Nord-Lock Group.

A growing range of load-sensing, internet-connected bolts

Besides mechanical tensioners, the Superbolt Load-Sensing Tensioner (LST) has been on the market since 2019, and in the previous issue of Bolted we covered how Nord-Lock Group and Revotec collaborate to provide digital preload monitoring and cutting-edge structural maintenance, using LST on railway noise barriers in Austria.

This year, the Superbolt Load-Sensing Flexnut (LSF) has been added to the range of smart bolts. LSF is a counter nut on the reactive side of a bolted connection and can be used opposite any type of tightening method (tensioning, torquing, heating etc.) for maximum flexibility.

The Superbolt Load-Sensing Flexnut (LSF) is the newest addition to the Load-Sensing portfolio and can be used in conjunction with any type of tightening method.

"For me, the biggest advantage with LSF is the versatility. It doesn't matter which tightening method you use, it is still able to measure preload."

Amaris Neidich, General Manager Latin America at Nord-Lock Group.

The LSF's built-in sensors automatically measure and communicate preload values, allowing for seamless remote monitoring during installation and throughout the lifetime of the application. Users don't even need to be on-site with the operators to see the live data on screen in real time, plus they can set automatic warnings when preload falls outside of a predefined range (indicating a loose bolt, for example).

The ability to continuously measure preload with an accuracy that is better than ±5% adds confidence to the installation process, but the ongoing monitoring adds priceless value to optimizing the use of assets and maintaining uptime.

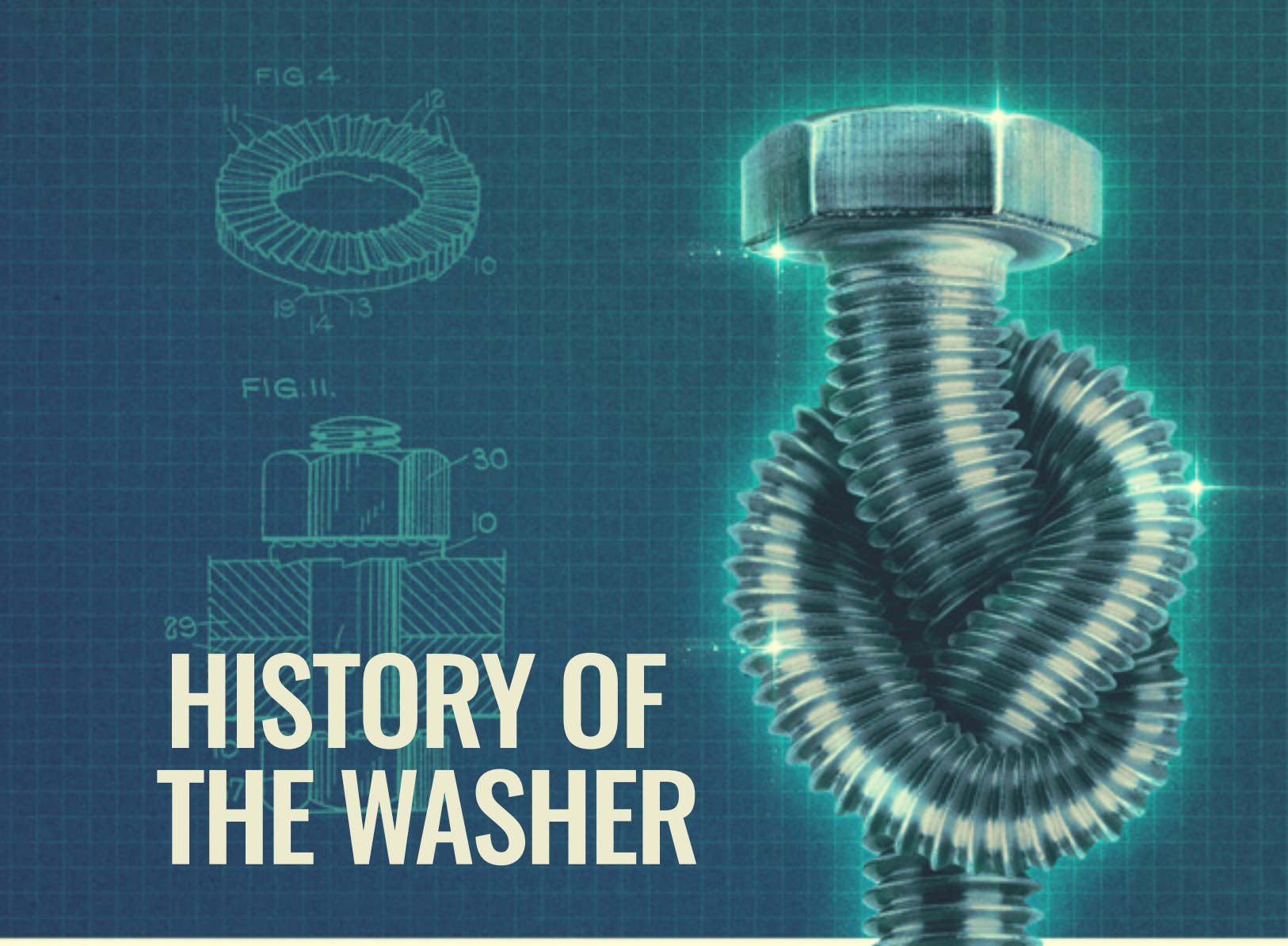
Text Kelvin Slesser-Marriott **Photos** Jörgen Lindström

"We're only scratching the surface in terms of the potential for connected bolts. In offshore wind, for example, we receive many requests from customers who want to use our load-sensing technologies to better predict maintenance schedules; they see a great possibility for cost savings."

Pierre Kellner, Business Developer, Smart Products and Services at Nord-Lock Group.

So, from a humble fix in the steel industry to a de facto name in industrial tensioning, Superbolt is driven by a customer demand for flexible, fast and accurate bolt installation and maintenance. Today it is used from subsea to space, securing bridges, monitoring railway structures and much more.

Tomorrow, it will be used to remodel maintenance planning in hard-to-reach places, such as offshore wind and mining. And in the future, Superbolt is sure to continue innovating – perhaps even with bolts that are able to re-tighten themselves as needed. Rest assured that this culture of innovation and proximity to customers will continue to be a driving force for better bolted joint security, wherever it's needed next.



HISTORY OF THE WASHER

Text Ulf Wiman **Illustration** Ju Sting

Loosening or slackening have been intrinsic problems since the invention of nuts and bolts. So, while washers may not be the most glamorous mechanical innovation, they certainly play a critical role.

Whether it's to secure a 17th century wooden wagon wheel or an aerodynamic airplane wing, washers have been the go-to solution for securing bolted joints.

The concept of joining objects together is surely almost as old as humankind. It can't have been long — relatively speaking — until someone joined maybe two sticks, or a stick and a rock together. Not only seeing the need to do so but finding a way to do it.

For thousands of years, presumably, various types of primitive strings and ropes, were the preferred solution in making tools and weapons as well as various constructions, such as primitive buildings and rafts. Neolithic man (roughly 9,000 BC to 5,000 BC) surely made the best of whatever materials were available during the so-called "New Stone Age", likely including parts of plants and animals.

Read the article about the history of the bolt

Later in our evolution, woodworking and joinery brought a broad range of ingenious joints. Glue and simple fasteners, such as dowels and nails, were critical developments.

Tracing the first use of washers

The use and development of washers are closely intertwined with threaded steel bolts and bolted joints. However, it is anyone's guess when an engineering forefather saw the advantage of adding some type of washer to a bolted or screw joint.

Although opinions differ, the invention of screw threads can probably be traced back to around 400 BC. The technique was, for example, used in presses. This invention opened for the development of the tapered screw, maybe by the Egyptians or the Romans, and set the stage for a revolution in woodworking joints and other fastening applications.

The threaded steel bolt with a matching nut probably dates to the 15th century. While thread-cutting machines had been in relatively wide use since the 17th century, it wasn't until the first industrial revolution, starting in the mid-18th century, that things began to gather momentum. Development was driven by the opportunity to manufacture and use machines for mass production.

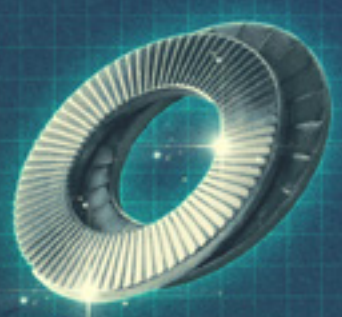
A washer for each use

The etymology of the word "washer" relating to bolted joints is also lost in the mists of time. However, the term is found in writing from 1346. Another source, from 1611, uses the word and describes the use: reducing wear on an axle hub in an artillery application.

Current uses of washers are a clue to the invention of them. Keeping bolts from loosening — which must have caused massive wheel problems back in the days of animal-drawn wagons — and reducing wear and tear were likely the primary uses. Other, modern uses, include distributing load over a larger area, acting as a spacer or locking device, reducing vibrations, and protecting against liquids.

Today, washers come in a huge number of variants, materials, surface treatments and coatings, and sizes – many catering to very specific applications. In general, they can be divided into three main groups:

- **plain (flat) washers**, which spread load and protect against wear;
- **spring washers**, which use axial flexibility to reduce bolt loosening due to vibrations;
- **locking washers**, which prevent bolt or nut loosening or slackening.



Emergence of the most effective locking method

Of course, engineers have tried other methods than washers to prevent loosening and slackening of bolted joints, such as adhesives and various nut types. And when it comes to locking washers, lots of variants have been tried, including conical washers (Belleville), curved disc spring, wave washers, split washer/spring lock washers, toothed lock/serrated washers, tab washers, and wedge-locking washers.

Wedge-locking washers are regarded as the most effective to prevent bolt loosening. Patent applications date from the early 20th century, but it is fair to say that the breakthrough came when Nord-Lock started refining the design and commercializing them in the 1980s.

The history of Nord-Lock wedge-locking washers

After dealing in oil burners, hose reels, miter saws, and other tools since 1953, the Swedish company Nobex moved its production to Mattmar (some 600 kilometers northwest of Stockholm) in 1960. In 1982, they acquired the patent for wedge-locking washers and began manufacturing them under the Nord-Lock brand.

Kurt Persson, son of the company founders Bengt and Mary Persson, and for 26 years Nord-Lock's CEO, played an active part in developing the wedge-locking washers. He picks up the story: "With the washer business on our hands, you might say that we jumped in at the deep end. We knew nothing about the production, such as pressing, hardening, and surface treatment."

"We could see that the basic functionality was fantastic," he continues. "But at the same time, the product that we had was a catastrophe with the wrong material and design. We learned this the hard way and had to scrap everything and literally go back to the drawing board."

Perfecting the wedge-locking functionality

Nobex hired an engineer to redesign the wedge-locking washer and, with time, the company built up its in-house design and production skills. Persson says:

"Once we had perfected the basic wedge-locking functionality of the washer, the following developments and improvements dealt more with new materials, sizes, and surface treatments to resist corrosion, heat, and acidity."

The focus since then has been on steady, continuous improvements and specialization. For Nobex, it was critical to improve the production technique and redesign their machines to secure high quality across large washer batches. In addition, in-depth testing was — and still is — essential to maintaining a high and even quality level.

In 1984, as the first supplier, Nobex could offer all-purpose stainless-steel wedge-locking washers, which Persson says "brought a big improvement in product robustness and corrosion resistance. Before the launch, the washers had gone through extensive salt-spray testing."

A year later, the company started to offer wedge-locking washers glued together in pairs. This development not only ensured product quality but also simplified assembly for the customers.

Focus on robust production and expanding the range

In 2001, Nobex becomes Nord-Lock, with a singular focus on marketing wedge-locking washers worldwide. The company introduced special alloy wedge-locking washers in 2003, including washers in 254 SMO® for saltwater and chloride applications and nickel base alloys for high-temperature applications and corrosive environments.

New hardening and surface treatment lines were installed in Mattmar in 2007, leading to the introduction of Delta Protekt® coatings. Changes to the non-electrolytic applied coating enabled an increased hardness, improving the performance with high grade bolts.

Laser marking was added in 2011 to guarantee full traceability, followed by a major development of the Nord-Lock X-series washers, launched in 2012. This range combines the original wedge-locking technology with an innovative elastic effect. As a result, it significantly reduces the risk of spontaneous bolt loosening due to vibrations or slackening, such as in applications with short clamp length and multiple clamped parts gaskets, soft metals, plastic composites, coatings, or thermal cycling.

As of today, the Mattmar plant manufactures a range of hundreds of washers and can produce tailor-made customer specials. The focus has been on expanding capacity, continuously improving the core product and processes, and expanding the range even further by way of new washers and combi products.

In 2021, Nord-Lock Group celebrated the inauguration of a modernized and expanded production facility in Mattmar, built to ensure long-term production capacity amidst growing customer demand from all over the world.

Kurt Persson
FORMER NORD-LOCK CEO

The potential future of washers

Generally speaking, there are many interesting opportunities for remote preload monitoring of bolted connections, using sensor enabled smart technologies. Many already exist, such as Superbolt LST or Superbolt LSF, and are being used to monitor the most critical connections in industries such as rail and offshore wind.

However, Pierre Kellner, Business Developer Smart Products and Services at Nord-Lock Group, notes that most existing smart products within the bolting industry are monitoring elongation in the bolt or stud to measure preload. Some smart washers exist, but they're not preferred because they require much more space than a traditional washer.

"Nord-Lock washers don't measure preload, although the wedge-locking function is designed to eliminate any loss in preload over time," says Pierre

Pierre Kellner

BUSINESS DEVELOPER, SMART PRODUCTS AND SERVICES, NORD-LOCK GROUP

He adds that "we have seen experimental uses of piezo electronic crystals on very thin washers, but on a commercial scale the more immediate opportunities from industry 4.0 are in production. There, you might improve the efficiency and quality of the washers' production by investigating automated inspections, reducing waste, and improving speed with data integrated throughout the process."

The regular washer

a small flat metal, rubber, or plastic ring fixed between two joining surfaces or between a nut and a bolt to spread the pressure or act as a spacer or seal.

Source: Oxford Languages

The wedge-locking washer

Wedge-locking washers use tension instead of friction to secure bolted joints. In each joint, there is a pair of lock washers with cams on one side and radial teeth on the other. The wedge-lock effect prevents spontaneous bolt loosening.

Read more about the technology on www.nord-lock.com/nord-lock/technology/

BEHIND EVERY GREAT GAIN IS A THOUSAND HIDDEN EFFORTS

On the fortieth anniversary of Nord-Lock Group, we take this moment to acknowledge the thinkers, designers, engineers and operators behind the engineering marvels that have propelled society forward, and to champion the humble bolted joint as a fundamental component of safety in society and industry.

In the story of engineering progress, our chapter is a history of continuous innovation in bolted joint security.

Historically, the volume of great gains has been prolific. The wheel. The pyramids. Sanitation systems and underwater tunnels, airplanes and bridges linking continents. We can photograph atoms, sail the stars, create energy from nothing more than wind and ambition. The list of human achievements is long, unfolding and rightly heralded when brought to fruition. Yet each accomplishment would be impossible without the thousand hidden efforts behind them.

It is almost funny to think of the bolted joint as one of those efforts. They are ubiquitous in every element of industry, impacting every aspect of our daily lives. Yet they are an afterthought. Even for engineers, it can take years beyond their professional education and training to not consider the integrity of the bolted joint as a given, with little need for consideration beyond their basic function.

These small criticals are like the minor notes in the score of a classical composition — widely acknowledged as important when pointed out, yet chronically underappreciated as the core elements they are. Aside from the very curious and specialists, we can't afford to think about them constantly, to lionize them in a field of considerations competing for our attention. So we don't. We put our trust in the integrity of the little things without a second thought. To do otherwise would overwhelm.

We take airplanes for granted. But a plane is essentially a collection of technologies and materials fastened into a single-purpose unit. At risk for material and design inefficiencies. Prone to human error. A chain of components upon which no element supersedes the importance of the other — a mechanical system in which the limits of our own capacity to trust necessarily limits us to trusting the solution as a whole, rather than every one of its individual elements.

This blanket faith is necessary — we'd go crazy otherwise — but it's also fallible. Every new or separate element carries a risk factor. Their interdependency multiplies risk factors. And they culminate at the application's weakest point.

From an engineering point of view, the weakest point can be anywhere — but common sense — and history — tell us those failures are often traceable back to the bolted joint. Even more jarring: One customer's major internal study showed that failed bolted joints are due to installer error almost 80% of the time, in the incorrect application of preload for example. It only takes one bolt to seem to be tightened when it is not. Then it doesn't matter how secure the others are — the installation is at risk, putting the application at risk.

And risk is no small thing. It is lives we are talking about. Employees at the industry site, certainly. But back to our airplane, no passenger can comprehend the degrees of trust required to get them safely off the ground and to their destination. It would be overwhelming. It would require computing capacity beyond which our brains are capable. So, we buy our ticket, and we trust.

This trust represents an acute responsibility. It bestows on the suppliers of the various elements in a complex mechanical system a requirement to live up to a well-known mantra: integrity is doing the right thing, even when no one is watching.

Text Patrick Fitzgerald
Photos Monty Rakusen/Getty Images and Christian Frumol

As the design complications and critical importance of applications have grown, so too have the requirements on the integrity of bolted joints.

The advent of hydraulic tensioning for the offshore oil industry in the 70's, in particular, turned out to be a catalyst for lifting the importance of secure bolting — at least in the most dangerous and heavy engineering environments. While it made accurate tightening of the most demanding multi-bolt joint applications possible, it was also new and difficult to learn, and with pressures up to 1500 bar, quite dangerous.

But this new awareness put much needed emphasis on the security of the bolted joint. Where it once had been more of a means to an end, it was now a source of debate, if not concern, across many more applications than just the most obviously dangerous.

This led to some clever professionals developing new and formidable ways to establish that security during the 1980's — the Nord- Lock wedge-locking washer, with its applicability to preventing almost any nut from loosening, being the simplest yet one of the most impactful. But also to Superbolt to make multi-jackbolt tensioning possible with hand tools, and Boltight hydraulic tensioning for general and specialist applications across a growing number of industries. And the Expander pin that altered the service of construction, forestry and other heavy machinery so much that the Swedish Ministry of Industry compared it to ball bearings for its impact on modern industry.

Today, the security of bolted joints is key to almost any mechanical application or construction on the planet. It is fundamental to more recognized technologies — and by extension, to our way of life. Freeing us to trust without question. Quietly going about the business of holding our world together.

A story in progress, worthy of celebration.

What happens when bolts start to rotate?

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

Sooner or later bolts tend to move. Maybe tomorrow, maybe in two years, there is general risk of movement during the life cycle of a bolted connection.

Normally, we talk about how to prevent this rotation and loosening, but what if we instead take a look at the details of what happens when rotation starts to occur? What mechanisms are at play, and how are different locking solutions affecting the situation? This might seem like a small thing, but it is actually this detail that makes all the difference.

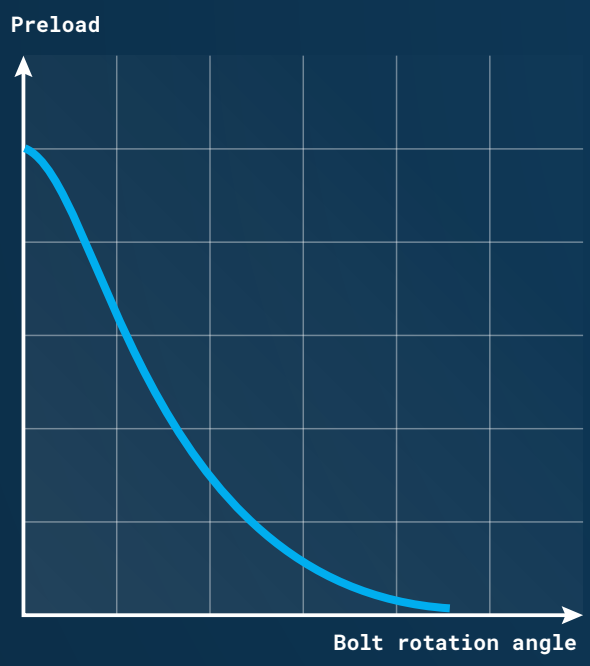


Figure 1. Relation between preload and bolt rotation

The problem with an unsecured bolted connection and rotation

Bolted connections are notoriously sensitive to vibrations and dynamic loads, as well as other important factors such as settlements, creep and relaxation which affects the preload.

When exposed to these external factors, there is a high risk of bolt loosening. For unsecured assemblies it is the friction between the components that prevents rotation. But as soon as the external factors are too severe, rotation will occur.

As soon as the rotation starts, even less force is required to cause further rotation, which will ultimately result in a complete loss of preload and loose bolts.

Preventing bolt loosening

A wide variety of common methods are used to prevent loosening, such as split rings, serrated washers or locking nut. Despite differences in function and performance, their basic principle is the same: these methods use increased friction to make it harder for rotation to occur.

But once rotation has started, we know there is nothing that will prevent additional rotation, and it takes less and less force for additional rotation to occur. Friction locking products basically function in the same way as an unsecured connection, just with a different level of friction.

Anders Knutsson
PRODUCT MANAGER,
NORD-LOCK DIVISION
NORD-LOCK GROUP

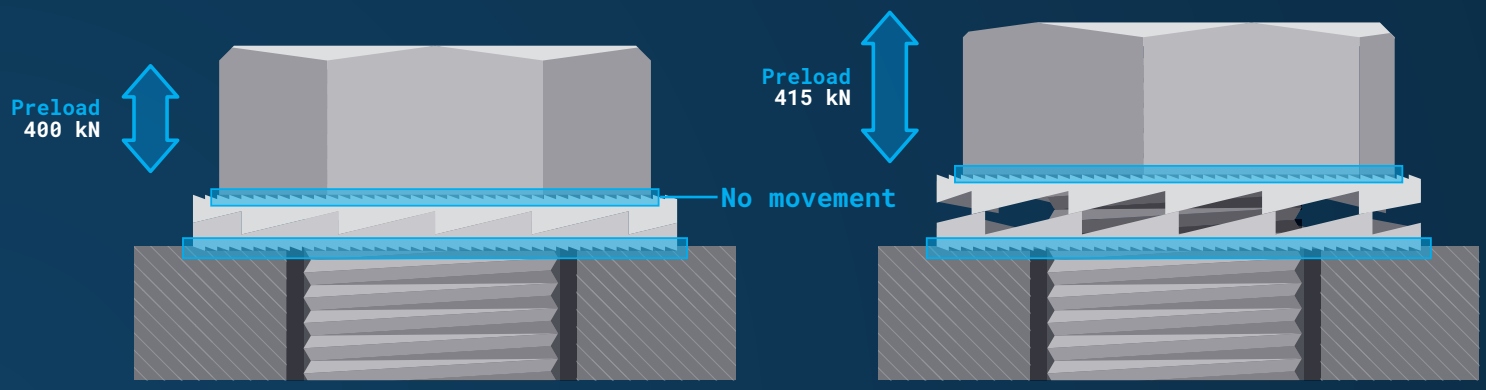


Figure 2. Where there's no rotation during untightening of a bolted joint secured by Nord-Lock wedge-locking washers

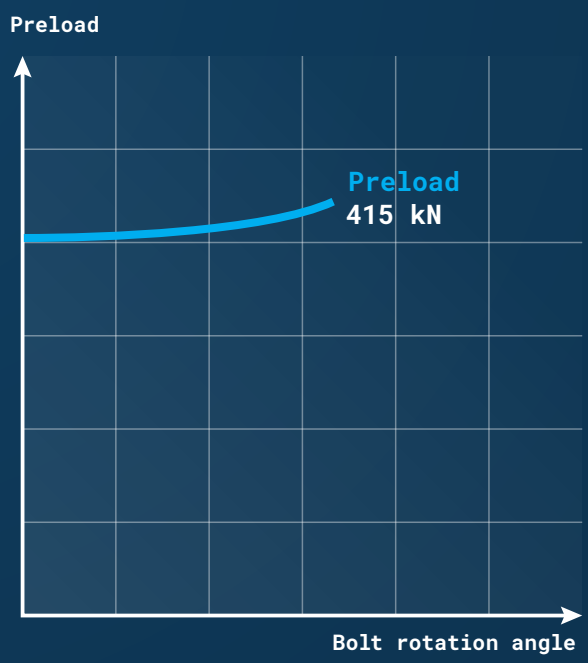


Figure 3. Preload during untightening

Alternative to friction locking

Nord-Lock washers use geometry instead of friction to prevent bolt loosening. You could even say that Nord-Lock washers welcome rotation; utilizing it to prohibit preload loss and bolt loosening.

The wedge-locking principle ensures that any rotational movement occurs between the cam faces. This means that as soon as there is the slightest rotation of the bolt, the upper washer will need to move upwards with the cam pitch.

As the cam pitch is greater than the thread pitch of the bolt, it causes the bolt to stretch, thereby increasing the preload in the bolt when rotation occurs. The increase in preload counteracts rotation, and thereby prevents bolt loosening!

For loosening to occur the bolt actually needs to stretch and increase in length. This is what sets the wedge-locking technology apart from other solutions.

Watch our Junker test video to compare our washers with alternative locking methods

THE SKY'S THE LIMIT

UAVS HELP FEED CHINA

Text Ulf Wiman **Pictures** SLZY

Feeding China's huge population is a massive challenge, and its agricultural sector is progressively modernizing to make it more effective. Unmanned Aerial Vehicles (UAVs) are one new technology that plays a critical role.

China is the world's largest agricultural producing country. This should come as no surprise given that it is also the most populous country on earth, with some 1.413 billion people, slightly more than the entire African continent.

Feeding that enormous population is a massive challenge. However, if you can grow it and eat it, China is almost certainly the world-leading producer. This goes for rice and most other grains, vegetables, and fruits.

The Food and Agricultural Organization of the United Nations (FAO) writes that, "China has succeeded in producing one-fourth of the world's grain and feeding one-fifth of the world's population with less than 10 percent of world arable land, which is a great achievement in pursuit of food and nutrition security not only in China but also in the world."

Technology makes farming more effective

The Chinese government has made agricultural development and modernization a top priority, aiming to make production more effective and optimize the entire agricultural value chain. Going from decentralized small-scale land operations to large-scale models that use efficient agricultural methods is essential.

It is also critical to speed up breakthroughs in, and adoption of, agricultural technologies. As a result, state-of-the-art equipment is increasingly used, such as UAVs (Unmanned Aerial Vehicles).

After ten years of rapid development; agriculture, forestry, and plant protection UAVs made up some 42 percent of the country's civil UAV market in 2020.

UAVs help ensure high yields

UAVs bring many benefits to agriculture, such as efficiently monitoring and analyzing fields and crops. To ensure high yields, they also simplify crop spraying/dusting with fertilizers, pesticides, and plant nutrients. Previously, this was generally done by farmers walking or vehicles driving through the fields or using agricultural airplanes.

With UAVs, farmers are not dependent on suppliers and can save time and money. They can operate the UAV themselves, or it can be done autonomously. One source states that a 15-minute UAV observation flight can sometimes accomplish as much as three or four hours of manual observation.

Add to that safety. Flying a crop-spraying airplane is not for the faint-hearted or inattentive. For example, keeping track of high-voltage electric lines takes alertness, and serious accidents are not uncommon. Using UAVs, this type of incident decreases significantly.

A very competitive UAV range

Agricultural UAVs used for large-scale crop spraying can typically lift a heavy load of liquids. The Chinese manufacturer Shangliang Zhongyi (SLZY) Hi-tech Co., Ltd. offers the Houji range of high-precision plant protection UAVs. These UAVs carry a very competitive 40-kilogram payload, offer long running times, have a good wind field effect, and are easy to operate and maintain.

Mr. Zhang, the technical manager at SLZY, says: "The Houji series offers technical performance, efficiency, and effect advantages compared to competing UAVs when facing large-scale crop planting and protecting cash crops, such as fruit trees and cotton."

However, initially, the high-speed vibrations generated by the rotor often caused bolts to loosen. SLZY used spring gaskets and friction to prevent this problem, but the anti-loosening effect was unreliable due to uneven elasticity.

Looking for a better bolting solution

It was not uncommon for customers to need frequent maintenance as bolts were coming loose. As a result, their UAV operation time could be short and the workload heavy.

SLZY started looking for another way to secure the engines, rotors, and antenna fixtures to solve the problem. They found it in Nord-Lock wedge-locking washers.

Unlike the spring gaskets, Nord-Lock washers use geometry instead of friction to prevent bolt loosening. The system is composed of a pair of lock washers with cams on one side and radial teeth on the other. The wedge-locking principle ensures that any rotational movement occurs between the cam faces.

Greatly reduces maintenance

"Because of the excellent locking performance of the Nord-Lock anti-loosening washer, we no longer need to carry out frequent inspections or repairs. Our customers tell us that it greatly extends the UAV's running time and improves the stability," says Mr. Zhang.

The Houji UAVs are now used across China, meeting the different requirements and terrain challenges of large-scale plant protection for grain production, fruit trees, and cotton. Now more stable and robust, Houji series UAVs will continue to help develop efficient and modern plant protection in China.

CUSTOMER
SHANGLIANG ZHONGYI (SLZY) HI-TECH CO. LTD.

APPLICATION	LOAD CAPACITY	FULL LOAD ENDURANCE
HOUJI-SERIES AGRICULTURAL UAVS	40 KG	90 MINUTES

SPRAY PATTERN	THE SOLUTION
6-15 M	NORD-LOCK WEDGE-LOCKING WASHERS

Loosening of nuts and bolts is a problem that unites professionals and hobbyists in a quest for the ultimate, secure bolted joint. For spare-time drag racer Sam Retke, wedge-locking washers are the answer.

Text Ulf Wiman **Picture** Sam Retke

Wherever you find bolted joints, chances are you will also find loosening and slackening nuts and bolts. And no matter if you are designing for massive infrastructure construction projects or getting absorbed in your own spare-time pet project, you have a common goal: to secure the bolted joints as effectively as possible.

Sam Retke is an excellent example. In his free time, you will most likely find him in his garage back home in Las Vegas, working on his VW drag racer. A sales representative by profession, he has been racing since 2016 but got the car racing bug already as a boy.

"I used to watch track racing on TV," he says. "My uncle Brian was a VW guy when I grew up, so that's why I got into VW racing. But I'm self-taught, learned from reading articles and watching YouTube videos."

Extreme vibrations a challenge

Retke competes in quarter mile drag racing (approx. 400 meters), where often spectacularly rebuilt and painted VW models race each other. His current car, a 1984 VW Rabbit, hasn't made it down the track yet, but the initial goal is 10.5 seconds.

STAYING ON TRACK WITH WEDGE-LOCKING WASHERS

This kind of speed is very hard on race cars, especially as they are incredibly stiff and shake a lot. As a result, the extreme vibrations can easily make nuts and bolts come loose. For example, if critical components such as transmission mounts fail, or a bolt backs out, it can change the geometry of the engine or transmission, which leads to breaking.

"I have definitely 'ovaled' out some holes due to bolts coming loose," Retke says. "I did have an issue with a few bolts coming loose for accessories bolted to the engine, such as belt pulley tensioner and water temp housing."

Found a reliable go-to solution

Retke had tried threadlocker to solve the problem, but even that didn't fix it permanently. Then he learned about a more durable solution from a drag racing friend who had used Nord-Lock wedge-locking washers on his 1992 VW GTI with great success.

"I found a hardware store near me that stocks these washers, and I now have nearly one hundred in different sizes in my shop," Retke says.

I use them on basically every location that will accept them. I use them on critical components, such as the transmission mounts. They are incredibly well-suited for any suspension components due to the vibrations."

The only areas where he doesn't use the wedge-locking washers are "components that require a special torque procedure, such as 149 ft/lbs [202 joules], back off 180°, tighten to 50 ft/lbs [68 joules] and then turn 60°. The one I'm currently using outside of the official heat rating is my turbo connection to the exhaust manifold. I'm not aware of any problems, but I often check as the heat rating is up to 800°F [427°C] higher than the official rating."

A tight-knit community

Having VW car racing as a hobby brings much camaraderie and joy. "The VW racing community is pretty close," Retke says. "We go to car shows together and help each other out, for example, with parts."

He says that the preparing might be the most fun part: "Having your buddy over, drinking a few beers, ensuring everything's working, and then the lead-up to the events."

The hobby also helped him get through the COVID-19 lockdown with sanity intact. "I had nowhere to be and a lot more free time. So, I'd go out in the garage and work on the car for eight hours a day sometimes. It was perfect to have something to get super-deep into."

A never-ending search for perfection

With things yet again relatively normal, Retke looks forward to more racing. And there is always something else to do on the car, or cars, that he is working on. "When I have a hobby," he says, "I go all in, and I'm never satisfied. So I always go to a shop to get more things done, as far as the cage and more safety stuff, futureproofing the car to go faster in the future."

And your wife doesn't mind? "No," Retke laughs, "she always says she can't be mad when I'm working in the garage. At least I'm home."

NORD-LOCK®

PART OF THE NORD-LOCK GROUP

There's a reason engineers have asked for them by name since 1982.

New wave, big hair, shoulder pads — not everything from the 1980s was designed to last forever. On the other hand, Nord-Lock invented the original wedge-lock washers that have been trusted to secure bolted joints ever since we began innovating the technology in 1982.

By using geometry instead of friction, Nord-Lock washers prevent bolts and nuts from loosening unintentionally. Engineers ask for them by name, and they're a standard-bearer for safety in construction and industry. So, as the world changes through the decades, remember that a Nord-Lock washer is made to last.

40 YEARS ANNIVERSARY