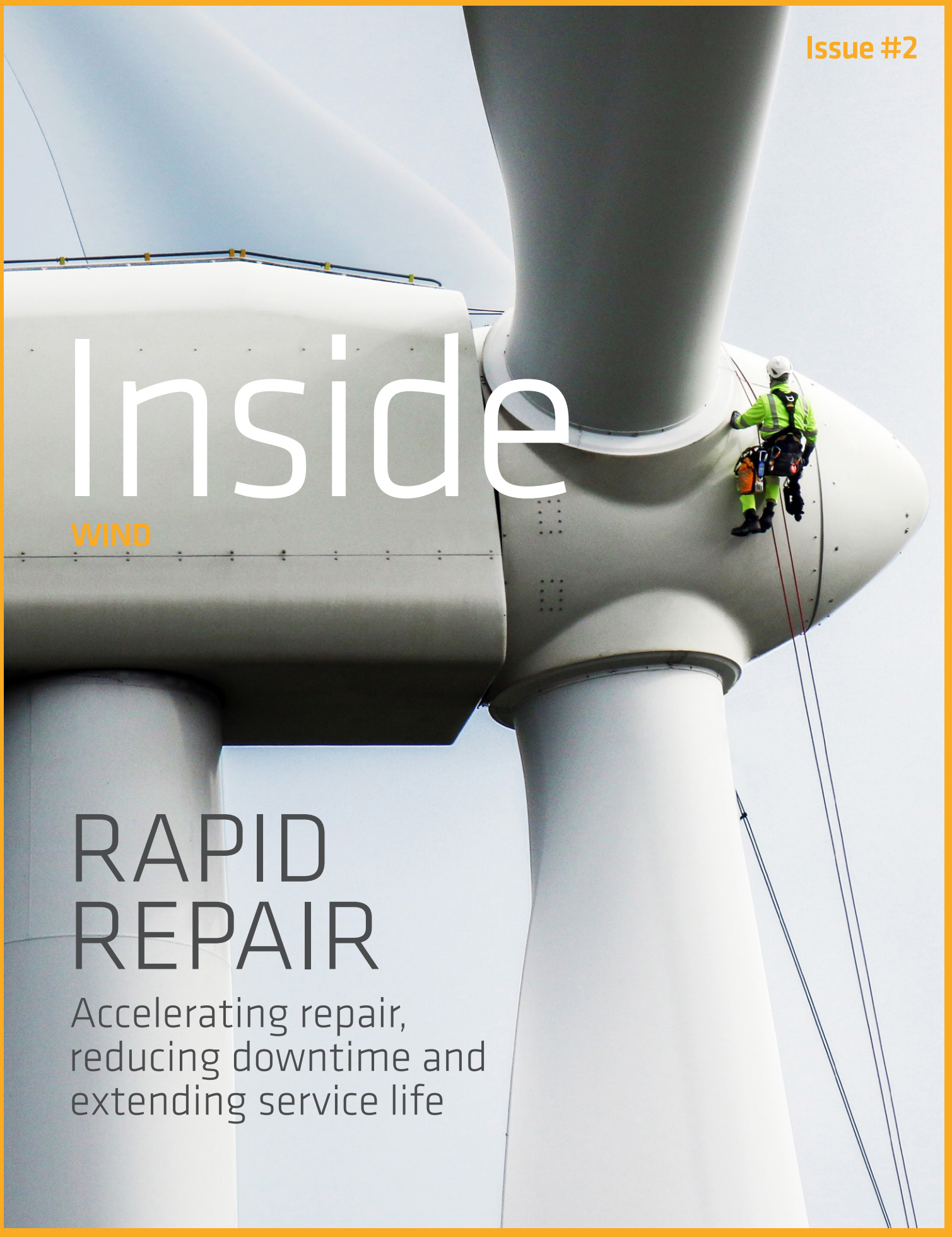
Issue #2

Inside

WIND



RAPID REPAIR

Accelerating repair, reducing downtime and extending service life

BUILDING TRUST

Over 1TW of cumulative installed wind energy capacity is expected by the end of 2023

500,000 technicians are required for construction and maintenance by 2026

33% rise in recruitment and training needs for wind turbine technicians over the next five years

15% growth Positive outlook with 15% annual growth in installations in the coming years

Over 25 years The expected 25-year lifespan of a modern wind turbine can be extended to 30 years or more, depending on environmental factors and good maintenance

45% renewable energy by 2030 is the European goal

75% of all installed capacity may soon be out of warranty and require maintenance

MOVING THE WIND INDUSTRY FORWARD

Welcome to the second edition of INSIDE WIND Magazine, where we take a deeper look into the repair and maintenance of wind turbines. We will be exploring various repair techniques, dissecting the challenges they entail, and giving you an exclusive look into the innovative solutions shaping the future of sustainable wind energy.

Looking ahead, long-lasting and efficient repair solutions will be vital to accelerating the rate of annual wind installations and extending wind turbine service life.

In 2023, the world is expected to reach a major milestone with the cumulative installed base of wind power exceeding one terawatt. Up to 75% of this installed base may be out of warranty, requiring as many as 500,000 repair personnel to maintain within just a few years. Additionally, in order to achieve Paris Agreement and COP26 targets, another terawatt of wind energy will be necessary to install in the next seven years.

The tasks ahead for repair technicians encompass routine inspections, the identification and rectification of critical defects, and the resolution of mechanical or electrical issues as they arise. This entails not only repairs but also the implementation of essential upgrades or replacements when debilitating defects emerge. Adding to the complexity is the challenging environment in which these services are conducted, particularly in offshore settings.

To answer these demands, the industry will need vast amounts of training. Not only do repair systems need to be proven and certified, but also customized to suit new conditions and cover extended work temperatures. With all of this come new packaging solutions, the build-up of supply chains, and much more.

At Sika, we have supplied both wind turbine factories and field repair teams with tailored repair solutions from the earliest days of the industry. To enhance cost-efficiency, safety, and overall effectiveness, we remain at the forefront of innovation, collaborating closely with repair service teams to enable a seamless transfer of knowledge and maximize the potential of our products. Recognizing the logistical challenges of assembling skilled service teams at remote wind parks, we've witnessed a surge in the adoption of robotic repair services and inspections in recent years – an advancement poised to reshape material perspectives.

At the end of the day, it is all about tailoring our solutions to customers' needs in order to ensure that every technician and every product is as reliable and productive as possible. Our goal is to minimize wind turbine downtime, supporting wind energy customers with the cutting-edge products and process expertise they need to reach their sustainability targets, in line with our own.

Exciting times lie ahead for the wind energy industry. Together, we are forging a safer and more efficient path towards repairing wind turbines, pushing the limits of performance and longevity to better respond to the world's sustainability demands and move the industry forward.

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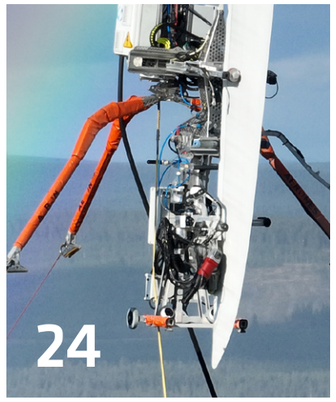


»TIME ISN'T JUST MONEY – IT'S ABOUT GENERATING AS MUCH CLEAN ENERGY AS POSSIBLE.

FASTER TURBINE REPAIRS ARE A VITAL PART OF THIS.«

SIMON LEU,
MARKETFIELD MANAGER,
WIND ENERGY, SIKA

PUSHING THE LIMITS IN WIND BLADE REPAIR

TPI Composites, the world's leading independent blade manufacturer, knows better than most the technical challenges associated with wind turbine blade rework and repair. To reduce cycle times in blade production and uptower repairs, Global Technical Program Director Roger Schütt turned to Sika's latest hand lamination system to enable faster curing than their previous epoxy resin. The SikaBiresin® CR910 system, developed, tested and qualified together with Sika, is now in the first phases of serial production.

Sika's Simon Leu recently caught up with Mr. Roger Schütt, Global Technical Program Director at TPI Composites, to hear more about his experiences working with Sika on this exciting new advancement in the field of blade production and rework:

Simon Leu: During the past year (2022) you've been working with Sika on the material qualification of the new resin system SikaBiresin® CR910. Could you share how you discovered the product and what prompted your interest?

Roger Schütt: The initial trigger for TPI to begin looking for solutions in the market is usually efficiency, cost optimization or both. The overall goal we set out for this project was to enable more consistent cycle time in serial production through faster reworks. As wind blades have become the giants we know today, and considering the complexity and high amount of manual labor any serial production faces, occasional defects requiring reworks will arise. The majority of reworks in serial production are small in size but still need completion to resume progress in the mold. A very significant element of the rework process is curing time which takes multiple hours to complete – impacting cycle time. In our mind, this posed a significant potential to tap into. We set out to identify a resin system enabling faster cure time while still allowing enough pot-life to wet the fabrics in a capable and secure manner.

What kind of defects are we talking about? And what rework materials were you using before?

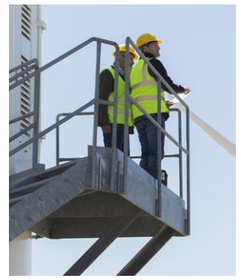
RS: Cycle time is something special for TPI. We are one of the very few companies who can consistently build modern blades in an average of 24 hours or less. We have been looking at process steps on which defects impact cycle time the most. On our sites the shell molds are the drivers for cycle time. A statistical analysis showed that most defects are of small size and would be found after infusion. As a result, the sanding and lamination work do not take a long time. Curing, on the other hand, is nearly unimpacted by defect size. Speeding up cure time for those defects would impact cycle time in a way that would drive consistency by reducing the time influence of rework.

TPI COMPOSITES *The world's leading independent blade manufacturer*

- *Specializing in high-quality composite solutions for leading wind and automotive OEMs*
- *Headquartered in Scottsdale, Arizona*
- *Factories in the US, Mexico, Turkey and India*
- *Engineering centers in Denmark and Germany*
- *Service training centers in the US and Spain*

ROGER SCHÜTT *Global Technical Program Director, TPI Composites*

- *Oversees configuration of all Nordex blade types*
- *Also responsible for customer communication, joint technology projects, design-for-manufacturing of future products, cost out projects, account development, new product launches and cross-functional collaboration*



The resin systems we typically apply for rework are the same epoxy systems we use to build blades. There are options for faster hardeners, but usually those also reduce pot-life significantly, introducing time constraints to mixing, exotherm reaction and lamination.

We have been looking for a resin system enabling significant improvements in cure while retaining a reasonable pot-life – increasing the ratio between pot-life and cure time, if you will.

Our expectation in finding a system with a better ratio would be outside of epoxy chemistry, so we screened and in-house-tested all systems on the market.

In the end we were very surprised to find a winning combination in the properties of the SikaBiresin® CR910 – an epoxy system.

Despite the low expectations towards an epoxy system, you actually found one that had the best performance. Why is the ratio between curing time and open time crucial for this job?

RS: A good hand lamination takes time, depending on the size of the defect. In order to retain process capability while making sure we do the reworks the right way, there needs to be enough pot-life to mix and apply the material. Enabling faster cure time, on the other hand, is safe and reduces cycle time impact.

The higher the ratio of pot-life to cure, the faster the rework process becomes without sacrificing capability or introducing new risks.

We need to give the workers enough time to make the repair. With the SikaBiresin® CR910 we have found the best solution on the market.

During the testing phase TPI Composites really tried to test the behavior of the material in all applications. For example, TPI Composites was the first customer doing infusion rework with this system, which was originally designed only for hand lamination rework. How did that go?

RS: The challenge for infusion is primarily dominated by flow rate, which is affected by permeability and viscosity. As stated earlier, the majority of the defects are small in size, so we figured that, by using enough flow media, we would be able to enable infusion even with the higher viscosity of the SikaBiresin® CR910. It worked.

So this means that the new material would allow you to do all three targeted resin applications: hand lamination and infusion rework, both in service and in the factory, as well as adhesive joint overlaminations, with one material?

RS: Yes, that's true, as it can be used for all these applications. In production we use it with both hand lamination and infusion, depending on defect location and size. However, its strongest feature is most certainly hand lamination application.

Restored blade tip after lightening event.

I totally agree. Infusion is complex in contrast to hand lamination. But during the material qualification at TPI Composites you for sure also had some obstacles to tackle. Can you give an example?

RS: There were no obstacles in terms of hand lamination, dripping, wetting, or mixing of the product. Everything really worked well. To enable a wider range of application we explored the mix of the faster and slower hardener types. We found the fast hardener is ideal for small hand lamination rework, and a mix of both hardeners is a good fit for small infusion rework.

How did Sika support you with this inquiry then?

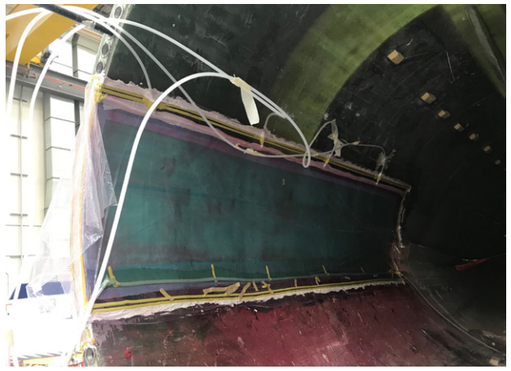
RS: As we wanted to have the benefit of lower viscosity for infusion application, which is provided by the slower hardener, while also keeping a fast cure time, we explored the options for mixing hardeners. As rheology and interaction between different hardeners can be complex, we reached out to Sika to ensure we achieve the right mixing rate of all 3 components.

Your team responded to our inquiry quickly and with clear guidelines. This was really helpful in order for us to continue the testing phase. And finally, we could conclude that the quality and results were in line with our expectations. During this testing phase, we also very much appreciated that Sika, as a big global player, was able to deliver material easily to our production and test sites all over the world.

Nice to hear that you had a really good collaboration between the teams across the globe. We also highly appreciated your efforts. You mentioned in the beginning that the ratio between pot-life and cure speed was the major reason for the qualification. Were you able to justify a decreased cure time in the field after introduction of the material as well? And if so, how much was it?

RS: We are still in the implementation phase for serial production. But when we mentioned we had a product in the pipeline for standard rework, our production sites were excited as it enabled more consistent and lower cycle time. Initial feedback from the sites is very positive. The resin provides enough time for the application while accelerating the cure process.

Grinding of a blade tip after applying the filler material SikaForce®-800 Red.



Overlamination of the root end bonding joint by infusion.

In summary, would you recommend this new resin for others? And if so, who would benefit most?

RS: Well, I think anyone interested in a fast-curing, versatile system with the potential to reduce cycle times for rework application in serial production should have a look.

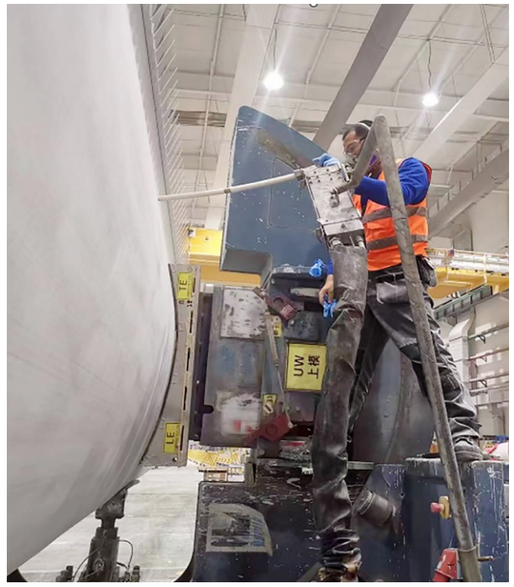
Thank you, Roger, for the talk. Sika wishes you all the best and is looking forward to the next development in collaboration with TPI Composites.

RS: Thank you. TPI Composites is looking forward to continuing the good collaboration as well. ■

RESTORING EQUILIBRIUM

Blade balancing in wind turbines

The challenging operating conditions experienced by wind turbines often result in wear and tear on the turbine blades. Thankfully, skilled technicians can often repair these wind blades, and replacement becomes necessary only when structural defects are severe, or in-field repairs are unfeasible. In case of extensive repairs or when replacing a wind blade, it is essential to ensure that the blades are properly balanced. Unbalanced wind turbine blades can lead to excessive vibrations, which, in turn, result in increased mechanical stress on various components and reduced overall turbine performance.



Balancing of a wind turbine blade after production.

Repair technicians finishing a blade repair.

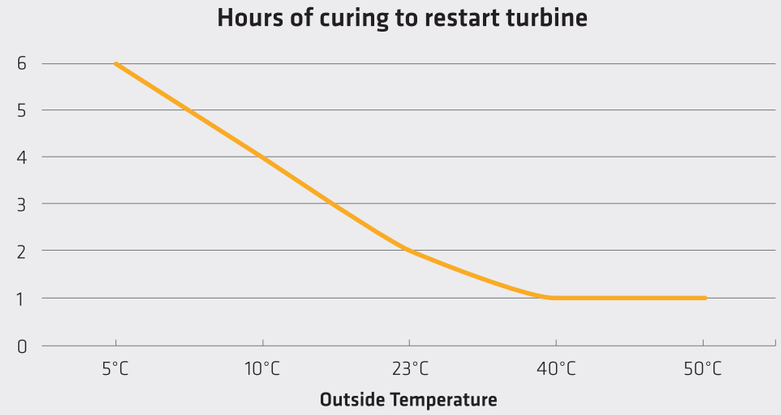
Balancing chamber as found in some blade types.

Detecting imbalances

Before taking any corrective measures, technicians must accurately identify imbalances in the field. Imbalanced wind turbines exhibit distinctive characteristics, such as unusual vibrations in gearboxes and bearings, reduced power output, or increased noise levels from the rotating blades. By analyzing the data collected through a sophisticated monitoring system, which includes installed strain gauges, load cells, and an assessment of overall turbine performance, maintenance teams can pinpoint existing imbalances.

Counterweights and ballasts

Balancing can be achieved by either adding additional weight to specific areas inside the blade, accessability allowing, or by injecting high-density ballast materials from the exterior of the blade. This method involves incorporating specially designed compartments called balancing chambers, which can later be filled, within the blade structure. To accomplish this, a small hole is drilled from the outside through the blade structure into the balancing chamber. A predetermined liquid, fast-curing material is then injected. After the balancing process, the hole is sealed with fillers and re-coated with the topcoat. This injection of a liquid ballast system has proven to be an effective solution for quickly addressing blade imbalances.



Dependency of cure time from outside temperature to restart the turbine.

A fast and precise liquid ballast system

SikaForce®-710 L30 presents an optimal solution for this purpose. Its well-balanced viscosity allows substantial injection without the risk of draining into undesired places or generating excessive heat. While many teams are accustomed to manually mixing materials and injecting them through piping bags, SikaForce®-710 L30 significantly streamlines this process. The simple 4:1 cartridge facilitates swift and precise mixing using the static mixer, followed by fast and precise injection.

The injection speed can be further accelerated by lowering the product's viscosity through gently heating the cartridges to 40°C, enabling an injection speed of 40 sec/ctr (~10 g/sec). Overall, the process becomes faster and cleaner without wasting material due to imprecise application.

Thanks to the user-friendly SikaForce®-710 L30 cartridge, achieving fast and reliable balancing has become easier than ever before. It's just one example of Sika's continuous efforts to develop high-quality systems that enhance the efficiency and quality of blade balancing and other crucial field repairs.

Key advantages include:

- Turbine back in operation within 1 hour
- Low exothermic heat allows for high-volume injections
- Easy handling thanks to 415 ml cartridge
- High density reduces overall injection volume

Discover the latest pump equipment balancing system

Thanks to Sika's longstanding presence in the wind industry, our supply of balancing materials extends beyond service materials alone. In 2022, Sika also introduced SikaBiresin® F512, a high-density material (2.4 g/cm³) ideal for balancing from pump equipment in manufacturing sites. Would you like to learn more? Email Simon Leu at leu.simon@ch.sika.com. ■

UNBREAKABLE BONDS

Leak-proof sealing solutions

Leaking fluids can threaten both turbine operations and the environment, especially when the turbines are located in remote natural areas or offshore locations. Whether the challenge is to contain hydraulic oils, lubricants or gear oil, proper leak prevention requires adhesives and sealants with exceptional resilience and proven chemical resistance.

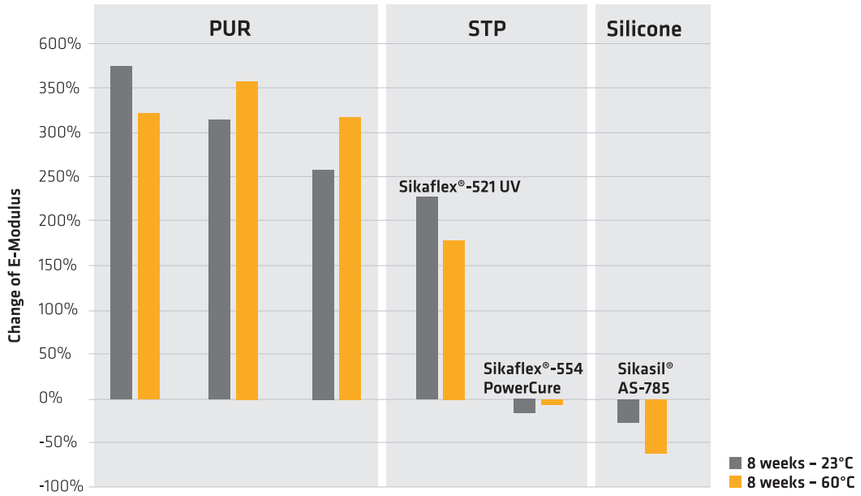
The oil leakage challenge

Wind turbines operate under extreme conditions, demanding precise monitoring and maintenance. Contamination with hydraulic oils, although just one of many maintenance issues, can adversely affect groundwater and sea life, and lead to costly turbine downtime due to accessibility challenges. While hydraulic oil leakage can be difficult to eliminate entirely, these factors make it critical to seal potential leakage areas effectively.
First, it is crucial to understand the key areas within a turbine that are susceptible to oil leakages. And when it comes to lubrication, hydraulic fluid and gear oil, the primary cause of concern is the gearbox. The main gearbox's task is to speed up the slow high-torque rotation for the generator.

A complex assembly of gears, it relies on oil for smooth rotation and temperature stabilization. In case of an emergency (e.g. overheating of components), hydraulic disk brakes are required to stop the rotating turbine. Furthermore, to optimize performance, wind turbines can rotate in two ways to improve wind capture. First, the yaw drive keeps the nacelle pointed to the wind. Next, the pitch drive rotates all the blades to the right angle. Both can be tuned to either maximize wind capture or minimize it if wind conditions become too harsh. These drives are often powered using hydraulics, and their intricate components necessitate robust seals to prevent leakages.

Oil spills from blade pitches.

Oil contamination at the blade to pitch connection.



Change of E-Modulus after long-term storage of adhesive samples in hydraulic oil at room temperature and at 60°C.

Testing the alternatives

At Sika, materials are therefore tested on a project basis to assess their resilience to chemical contamination, and extended technical information can be given on numerous products. In the case of wind turbines, hydraulic oil resistance is a commonly asked question which Sika's technical team has investigated thoroughly by evaluating the performance of various adhesives and sealants against hydraulic oils. The tested materials included three major types of chemistries: polyurethane (PUR), silane terminated polymers (STP) and a silicone-based adhesives. The adhesion performance was tested alongside specific mechanical properties after 8 weeks of immersion at room temperature (yellow) and at an elevated temperature of 60°C (grey).

A chemical-resistant solution

Among the various elastic adhesives tested, Sikaflex®-554 PowerCure demonstrated exceptional resilience, standing out in comparison to the widely used solutions available in the market. These conventional options experienced significant deterioration, losing most of their elasticity with up to 350% higher modulus. Sikaflex®-554 PowerCure, however, maintained a high level of elongation (>440%). Notably, it exhibited minimal changes in both strength (-8%) and modulus (-9%) over the complete aging cycle, all while maintaining a high level of adhesion performance. Based on these results, we can conclude that hydraulic oil resistance can be achieved through engineered adhesive design to prolong the service life and improve protection of assembled parts.

Benefits of Sikaflex®-554 PowerCure include:

- Outstanding resilience to hydraulic oils
- Increased cure speed compared to one-component adhesives
- Free from diisocyanates
- 60% less waste and up to 82% reduction of global warming potential compared to plastic cartridges

A fast-curing, scalable process

During maintenance procedures, it is crucial to minimize turbine downtime, associated costs, and rapid-curing systems like Sikaflex®-554 PowerCure address this challenge effectively. Sikaflex®-554 PowerCure is a one-component adhesive, accelerated with 2% water-based paste to speed up curing and ensure consistently fast through-curing. The accelerated curing does not change the final material properties and enables engineers to quickly scale an adhesive bonding process without re-engineering the joint design. PowerCure refers to the packaging and dispensing system in small pack size, while Sikaflex® Booster is used for the same materials for bulk dispensing.

More diisocyanate-free adhesives and sealants

In addition, the silane terminated polymer (STP) adhesives and sealants from the Sikaflex®-5xx and -95x series are free from diisocyanates and therefore do not require the REACH safety training for safe use.
To learn more about safe handling of diisocyanate-containing adhesives, see the previous issue of INSIDE WIND magazine.

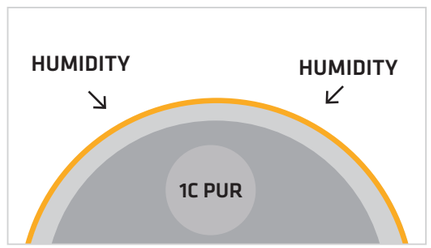
Sikflex® Booster & PowerCure solutions grow with your needs for more speed and higher output.

1C Dispensing
Small Pack Size

PowerCure Dispensing
Small Pack Size

Bulk Dispensing

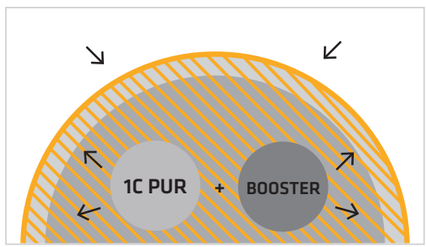
1C Technology



CURING FROM OUTSIDE ONLY

+ Easy handling
+ Reliable performance
– Slow curing in cold

Sikaflex® Booster Technology



CURING FROM INSIDE AND OUTSIDE

+ Fast strength development
+ Same final performance with/without Booster
+ Available in bulk and small pack (PowerCure)
+ Fail safe with curing by Booster or air moisture

ROBOTIC REPAIR

Towards a new era in automated blade repair

Wind turbine maintenance continues to evolve. New materials, new techniques and new service skills are constantly being deployed to maximize the efficiency and lifespan of turbine blades. Yet the rapid growth of wind energy in recent decades poses growing challenges for blade inspection and repair. Rope access teams are in high demand. And even in countries with advanced training programs, the industry is finding that the time, investments and personnel available fall well short of supplying the amount of skilled labor required.

Embracing automation

To supplement traditional rope teams, many are turning toward the latest robotic solutions to improve safety and efficiency in turbine blade maintenance. Advanced robotic technologies, once considered cutting-edge for blade inspection, are beginning to prove equally vital for repair. Emerging companies like Aerones, BladeRobots and BladeBug are leading the way in automating a range of tasks that were previously the domain of rope technicians. Examples include edge protection, such as grinding, cleaning and surface protection, as well as blade balancing, de-icing and simpler cleaning tasks.

These advanced robots are designed to conduct precise inspections, maintenance, and repairs on turbine blades, mitigating or even eliminating the need for human climbers. They can improve worker safety, reducing the risks associated with climbing in difficult conditions. They enhance efficiency, ensuring faster repair and reduced downtime when repair workers are unavailable. And perhaps as importantly, many are capable of collecting extensive data during inspections, offering valuable insights into blade health and performance for calculating potential blade lifetimes or maintenance intervals.

As a leading global materials supplier for the Operations and Maintenance (O&M) market, Sika is dedicated to supporting these innovations with the advanced materials, training support, collaborative R&D and expertise needed to improve automation in this highly challenging sector. Examples of Sika's contribution to automated repair and maintenance include:

Advanced material solutions

Sika's extensive range of materials for wind turbine blade repair and maintenance, including adhesives, sealants and composite resins, are being seamlessly integrated into robotic repair processes to ensure the quality, efficiency and reliability of repairs.

Training and support

Sika's local presence across all major global wind energy markets ensures comprehensive training and technical support for companies engaged in the deployment and development of robotic solutions for wind turbine blade repair. This knowledge transfer ensures automation processes are optimized for maximum efficiency and effectiveness.

Collaborative research and technology development

Sika collaborates actively with research institutions and technology providers to support the right knowledge networks for continuous innovation and enhancement of robotic repair technologies for wind turbines.

Environmental sustainability

Sika's unwavering commitment to sustainability aligns perfectly with the objective of the renewable energy sector. The integration of environmentally friendly products into robotic repair solutions is just one of the many ways that Sika is advancing the development of environmentally sustainable practices within the industry.

The adoption of robotic solutions for wind turbine blade maintenance represents a significant leap forward in the O&M market for the wind industry. As the world strives to maintain the condition and clean energy output of its vastly expanding wind energy infrastructure, Sika and its technology partners are committed to leading the way forward. Improving automated wind turbine maintenance for the benefit of workers, O&M customers and the transition to sustainable energy systems. ■

Aerones repair robot in action

ILLUMINATING INSIGHTS

Improving pre-treatment process control through UV luminescence

Over the past few decades, adhesive bonding technology has given engineers new opportunities to optimize and innovate their constructions and final products. Today, the use of adhesives has become a real alternative to traditional joining techniques such as screws, bolts, rivets or welds. This is why Sika is constantly working to support customers in defining and documenting safe and controllable processes for material bonding.

Raising the standards in process control

Material bonding involves a sequence of operations, all of which need strict control and complete procedural documentation. And as wind turbine manufacturers, suppliers and sub-suppliers implement APQP4Wind standards, along with the introduction of DIN 2304 for the general manufacturing industry, the topic of safer and controllable processes continues to grow in importance.

APQP 4 Wind
Company Member 2020

The challenge of pre-treatment detection

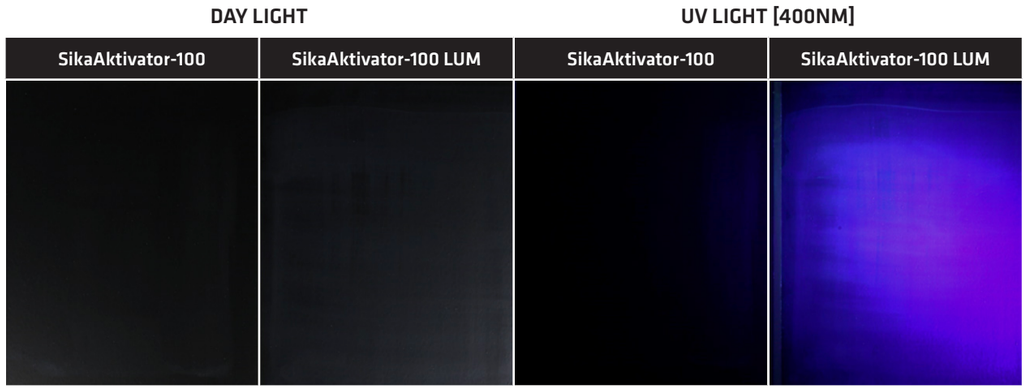
In order to achieve the best possible adhesion results, substrates must be at minimum cleaned, and often also activated and/or primed. However, since most cleaners and activators are as clear as water, it can be difficult to tell if, and where, the product has been applied. This difficulty in detection can cause a great deal of uncertainty or even lead to significant safety concerns in case of a forgotten pre-treatment step. It can also lead to disproportionate and costly added labor when such a mistake is identified, since numerous parts must often undergo additional safety checks.

Shedding light on pre-treatments

To address this challenge, Sika has developed a series of pre-treatment products that can be easily detected with UV light ranging from 320 nm to 420 nm, thanks to the addition of luminescent dyes. These luminescent properties can be used to assist with application verification, thereby improving process safety and lowering the risks for rework or damage. The portfolio of UV-luminescent products includes activators and a black primer, and covers pre-treatments of the most common substrates. The addition “LUM” in the product name indicates the luminescent function.

UV detection

In manual sealing and bonding processes, the pre-treatments containing a luminescent dye can be detected using a simple UV light that provides the required wavelength of 320 nm – 420 nm. The use of a vision system allows for automatic verification of coverage and location of luminescent pre-treatments, thereby helping to reduce scrap, and rework, improve quality eliminate manual inspection. The vision system can detect location, coverage, breaks or gaps, reduced width, and diagonal breaks. It works on all colors and is fully adjustable to meet each customer's specifications. These systems are highly customized to part design and manufacturing requirements, with full guidance provided to system integrators by Sika's System Engineering Department.

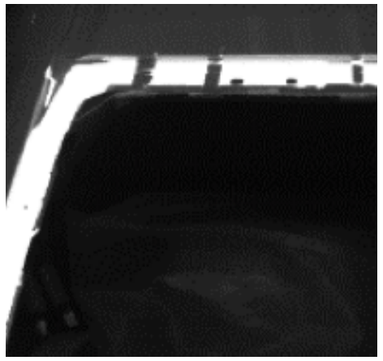


Product performance

The product performance is very similar to the standard pre-treatments available from Sika. This applies to all versions equipped with luminescent dye. Experience ranges from different paints, ceramic coatings, glass, specific metals like aluminum and steel grades as well as some plastics. However, adhesion trials prior to implementation must be conducted on specific substrates in use. Depending on the product and surface quality, the application quality can also be checked.

Example of production installation for automatic inspection using a vision system with luminescent effect.

Visual detection by eye using a UV lamp.



Detection with Cognex IN-Sight camera during fully automated control.

PORTFOLIO OVERVIEW

PRODUCT	DESCRIPTION
Sika®Aktivator-110 LUM	Improves adhesion on substrates such as float glass, ceramic screen prints and paints
Sika®Aktivator-205 LUM	Activates non-porous substrates such as metals, plastics, glass fiber composites, and paints
Sika®Aktivator-306 LUM	Enhances adhesion on substrates such as coil coated, powder coated, stove enamel and other painted or primed surfaces
Sika®Primer-207	Used on a broad range of substrates like glass, ceramic coatings, plastics, painted surfaces, E-coats, metals and glass fiber composites
Sika®Primer-507	Ultra low-diisocyanate pre-treatment based on Sika Purform® technology for glass, ceramic coatings, plastics, painted surfaces, E-coats and metals

Enhancing process quality

Thanks to their easy detection, luminescent pre-treatments can help to improve process quality, both in manual processes and in automated bonding system lines. By enabling early warning of missing or incorrect application during in-process controls, they can help manufacturers to reduce scrap, reduce the number of defective products, improve quality and reduce rework. ■

A guideline for repairing concrete foundations and grouted bases in wind towers

STURDY FOUNDATIONS

Wind turbines are designed to resist both static and dynamic loads, generated in large part due to the rotations of the blades. To withstand this loading, and to do so in the harshest and most isolated environments, a range of specially developed construction products must be used during the construction of foundations and the erection of turbines. Unfortunately, some damages to the concrete and to the grouted bases can always occur due to unexpected factors, the most common being the rise of cracks. These can result from factors like setting, shrinkage or water damages in existing structures, or even from unexpected stops during the concrete pouring in new constructions.

In the event of cracks arising, it may be possible to inject them with resin in order to recover the structural behavior of the wind turbine.

The repair procedure consists of the following steps:

1 Substrate preparation
Cleaning the surface helps the technician to identify the exact location and the width of the crack to be injected. Sometimes the concrete surface is hidden under a surface of mineral deposits left from long-term water leakage.

2 Install inject packers
In order to inject the resin into a crack that reaches into the middle of the structure, mechanical injection packers are usually used. In some exceptional cases, such as very thin structures, heavily reinforced structures, and areas in which drilling is prohibited, surface packers are used. The objective of the repair depends on the degree of penetration (crack width/ thickness). For structural repair, more than 75% of the crack's volume must be filled. Correct installation is very important to ensure a continuous injection and durable crack repairing results.

3 Start pumping
Once the connection is made, start the pump and begin injecting through the Sika® Injection Packer.

4 Proceed with injection process
The injection material now fills the packer, then the drill hole (mechanical packers) and finally, the crack itself.

Injection can be successfully performed at the lowest possible injection pressures. The pump should be set to the lowest level. This allows for penetration that penetrates well into all gaps and even the finest hairline fissures down to approximately 0.15 mm (depending on the material used and application temperature).

Slow, low-pressure injections are more effective than rapid, high-pressure injections. A successful injection will be indicated by the pump's refusal of injection resin (quit pumping) or by the sight of resin seeping out of any of the open packers. When this happens, install a nipple at the next packer in the row and continue the injection in this way until resin is visible at the last packer.

Within the pot-life of the resin, a secondary injection should be done, ensuring the crack is completely filled (this step is optional).

In this case, injection is started at the first packer again. All nipples except the last one remain installed. Usually, the resin will be immediately visible from the venting hole/ last packer. If not, injection must be continued and again controlled by a secondary injection.

Finally, the last packer can also be closed, and a few strokes of resin injected at lowest pressure into it.

Attention: High injection pressure can damage the structure and cause additional damage to the structure (this is known as a zip effect).

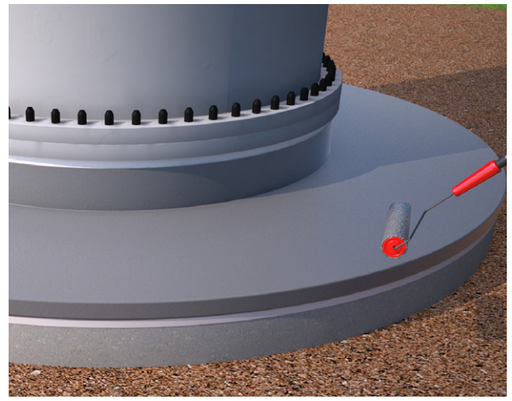
Injection progress can be checked by monitoring injection material coming out of the next packer.

5 Stop pumping
After the injection is finished, close the ball valve on the pump assembly and turn the pressure down. Disconnect the pump hose from the Sika® Injection Packer. Stop the pump and release pressure from the hose.

6 Clean
Clean pump and tools according to the PDS of the Sika® Injection Cleaning System. Uncured resins can easily be flushed out with Sika® Injection Cleaner C1. Then, fresh cleaner should be cycled through the pump for at least 2 minutes.

7 Finish
The crack is repaired after the material is fully cured. After curing, the packers can be removed (e.g. knocked off). Fill the drill holes with suitable mortar/ patching material. Clean the crack surface if required. Remove patching mechanically by grinding and/or with a hot-air gun.

For a more durable repair, it is recommended to apply a protective coating afterwards.



CASE

SikaGrout®-9800

Enhancing Offshore Wind Energy Infrastructure

MBCC group, now part of Sika recently embarked on an ambitious project: the construction of the Moray West offshore windfarm in the North Sea, Scottish waters, off the coast of Invergordon. A renowned Belgian offshore foundation installation contractor selected the offshore grout SikaGrout®-9800 (formerly known as MasterFlow 9800) for the installation of the monopile foundation structures.

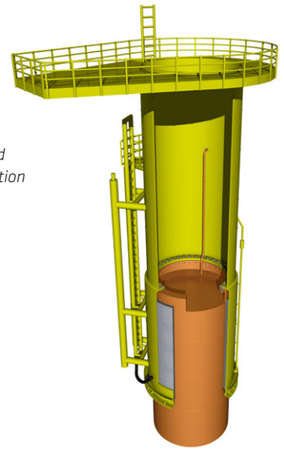
It is expected that the project volume will be in the range of 3,200 to 3,800 tons of grout material with a contract value of approximately 4 million euros. The installation period is expected to be carried out between Q4 2023 and Q2 2024, whereby the grout material will be delivered out of our production site in Belgium and the UK organization to the Port of Loading in Invergordon, Scotland.

Once operational, the 60 wind turbines are expected to yield a capacity of 882 MW and provide more than 1.3 million households with green energy.

The challenge: defying conventional limits

The wind turbines will be built on monopile foundations whereby a boat landing platform will be bolted to the top of those monopiles. Such bolted connections are typically using an offshore grout placed between the monopile and the skirt of a transition piece to protect the bolts from corrosion and to allow boat landings for crew access.

The wind turbines to be installed, i.e. Siemens 15 MW, are the largest that currently will be built in Europe. They pose such huge loads on the foundations so that a normal skirt backfill material is insufficient and a high-strength structural grout material like Sika Grout®-9800 shall contribute to the structural integrity of the structures in order to guarantee a 25-year lifetime of the windfarm. It is effectively an industry first, that the high-tension bolts, each weighing well over 30 kg each, are insufficient from a design point of view to distribute the loads generated by the 15 MW turbines. Hence, the need for the high-strength grout to participate in the load distribution from the turbine through the foundation into the seabed.



General Scheme of a bolted structural monopile-transition piece offshore connection.

The solution: SikaGrout®-9800

SikaGrout®-9800 is a specialized offshore grout with exceptional mechanical properties and excellent workability. It has been specially formulated for large-scale pump applications. It is the only product in the offshore market that can fully be processed in bulk, in production and on the entire logistics chain all the way to the offshore grouting works itself. The material is typically used in the installations of grouted connections in offshore installations such as jacket foundations, monopiles, leg filling, etc.

SikaGrout®-9800 is specifically designed for applications under harsh offshore conditions in the shortest possible weather windows, e.g. below water grouting works at temperatures ranging from as low as 2 °C up to 42°C. In addition, the material is the first ever bulk supplied offshore grout certified according the offshore standard DNV-ST-C502.

This unique grout material was originally developed to overcome some of the typical problems associated with offshore grouting. Slow installation processes and unsafe handling of big bags during offshore works were overcome by supplying, for the first time ever, a grout material in bulk without the need of lifting operations during the grouting works. The bulk supply of SikaGrout®-9800 also allows to store the material in silos and mix and pump the fresh grout in a continuous process with output rates nowadays in the range of 20 to 50 m^3/hour. This is easily up to 5 times faster than earlier applications, which allows the offshore foundation contractors to install the windfarm foundations faster. Given that the installation vessels, typically used for offshore foundation installation, are rated at 250,000 to 350,000 euros per day, such time saving is a huge benefit for the contractor and the industry in general, while also contributing to more sustainable installations.

In addition to the Moray West offshore windfarm project, the Sika group is in final negotiations with the same Belgian offshore contractor for large offshore wind projects in Europe, USA and Taiwan, using SikaGrout®-9800 as well as SikaGrout®-9600 (formerly known as MasterFlow 9600).

Conclusion:

This case stands as a testament to the power of innovation and collaboration, showcasing how a specialized material such as the SikaGrout®-9800 can solve critical industry challenges and potentially reshape the future of offshore wind energy installations. ■

CASE

EXTREME OFFSHORE GROUTING

The challenge: Rough seas, strong wind conditions and high temperatures reaching 35° C made this large-scale windfarm installation particularly challenging. In addition, the water depth of approximately 30 m makes it one of the deepest installations of its kind in China. In total, it comprises 55 units of 5.5 MW wind turbines and a 220-kV substation, of which 10 are jacket structures requiring grouting, as well as the substation jacket.

The solution: The team successfully completed the grouting of the offshore jacket foundation installation using NaX® Q140-E UHPC grout on schedule and without any delays. Nautec's NaX® Q140-E has been developed specifically for grouted structural connections for offshore structures including wind turbine foundations situated in extreme cold and in hot tropical climates. NaX® dry-mix products have been used in more than 100 offshore projects primarily in South East Asia, India and the Middle East where the operational temperature often exceeds 35°C. The unique composition of our products allows us to pump the materials through several hundreds of meters of 2" and 3" hoses. This was verified in the DNV type approval for NaX® Q140-E where the hose temperature exceeds 35°C.

About UHPC
Ultra High Performance Concrete (UHPC) and Composites, have been developed by Sika for the renewable, civil construction, ports, offshore and energy industries. Our NaX® Premix Grouts are a portfolio of UHPC and composites with strength and durability ten times higher than those of ordinary cement products.

Three Gorges Yangjiang Shapa 300MW Offshore Windfarm Project, China

Project: Offshore windfarm installation, Guangdong province, China
Turbine manufacturer: Mingyang Smart Energy
Materials used: 880 MT NaX® Q140-E
Scope: Offshore grouting services and supply of UHPC grouting materials for 10 turbine jackets and one substation jacket installation

PRODUCT SELECTOR

ADHESIVES

FAST AND EASY – COMPOSITE REPAIR AND PROFILING

FAST SANDING FILLER
SikaForce®-800 Series

FAST SANDING FILLER
SikaForce®-812 L07 MR

COMPOSITE REPAIR
SikaBiresin® CR910

SAFER AND MORE RESISTANT – ELASTIC SEALING AND BONDING WITH Sikaflex®

THE ALL-ROUNDERS
Sikaflex®-521 UV

FAST CURING ASSEMBLY ADHESIVE
Sikaflex®-953 L15 & L30

THE RESISTANCE EXPERT
Sikaflex®-554

THE NEXT SPEED LEVEL
Sikaflex®-554 PowerCure

KEEP EVERYTHING IN BALANCE – IN FIELD BALANCING

MORE THAN JUST WEIGHT
SikaForce®-710 L30

DURABLE AND ROBUST – STRUCTURAL ADHESIVES

FASTER INJECTIONS
SikaPower®-800*

LONG LASTING BONDS
SikaPower®-1200

QUICKLY ATTACHED
SikaFast®-555 Series

IMMEDIATE FIXATION
SikaForce®-818 L07

* Available soon

LONG-TERM UV STABILITY – ELASTIC SEALING AND BONDING WITH Sikasil®

THE VERSATILITY SPECIALIST
Sikasil® WS-605 S

ACCELERATED SPEED
Sikasil® WT-66 PowerCure

RAPID ASSEMBLY
Sikasil® AS-785

CONCRETE

FOUNDATION CONCRETE REPAIRS CRACK REPAIR

Structural repairs
Dry substrates (Sikadur®-52)
Damp substrates (Sika Injection-458)
Damp and oily substrates (Sika Injection-456)

DAMAGED CONCRETE REPAIRS

Structural repairs
Sika MonoTop repair mortars

Fast setting repairs
Sika MonoTop repair mortars/
Sika FastFix repair mortars

CHEMICAL ATTACKED CONCRETE

Protection against aggressive soil
Sikagard protective coatings/
Sikalastic range/Sika Proof range

Protection against fluid spillages from nacelle
Sikagard protective coating range

Wind repair brochure can be found here.

GROUTED AREA REPAIRS CRACK REPAIR

Shrinkage cracks (Sikadur®-52 + Sikalastic® LAM systems)

DAMAGED GROUT

Repair with SikaGrout®3000 series and SikaGrout®-9000 series

Protect with Sikalastic® LAM systems

DAMAGED SEALS

Reseal connection between grout and flange with Sikaflex®

Coat connection between grout and flange with Sikalastic® LAM systems

CONTACT US FOR MORE INFORMATION

sika.com/wind

Sika AG, Switzerland, is a globally active specialty chemicals company. Sika supplies the building and construction industry as well as manufacturing industries (automotive, bus, truck, rail, solar and wind power plants, facades). Sika is a leader in processing materials used in sealing, bonding, damping, reinforcing and protecting loadbearing structures. Sika's product lines feature high quality concrete admixtures, specialty mortars, sealants and adhesives, damping and reinforcing materials, structural strengthening systems, industrial flooring as well as roofing and waterproofing systems.

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BUILDING TRUST