SHERWIN WILLIAMS®

PROTECTIVE COATINGS FOR WIND ENERGY

FROM SPEC TO PROTECT

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PROTECTIVE COATINGS FOR WIND ENERGY

Humankind has used the natural energy of wind for over 2000 years. Windmills were used, among other things, to power sawmills and grain mills, pumps to water and in the disposal and supply of water.

The principle is still the same today, but the capabilities have multiplied. Worldwide more than 837,000 MW of wind power (on- and offshore) had been installed – 64,542 MW of it in Germany onshore (as of 2021) – to produce clean energy. Due to their exposed locations, they are subject to many stresses, for example, marine – or industrial atmosphere, extreme variations in temperature, strong UV-radiation or high humidity. Worldwide, Sherwin-Williams products protect wind turbines reliably from head to toe – on the high seas, in coastal and inland areas, with maximum safety and quality, from rotor blades, nacelles, hubs and generator frames, to towers and foundations.

CONTENT

WIND TURBINES ONSHORE

Modern wind turbines produce electricity from the wind. They use the boost the wind creates when it flows past the rotor blades. The average nominal power of a modern wind turbine for use in inland areas is 2–3 MW, the current maximum being plants with 7.5 MW available power.

A significant contribution to the economy of this form of energy is provided by corrosion protection. As sought after by manufacturers, a service life of up to 20 or 30 years is only possible with high requirements put on the coating systems.

Electricity generation from wind power has significantly increased in the last three decades. Wind turbines installed in Europe can generate about 437 TWh of power per year. With this, wind energy now covers about 15% of total electricity consumption in Europe.

Wind provides the most significant part of renewable electricity, and the potential of wind energy is not yet exhausted.

The coating materials for heavy-duty corrosion protection will be produced in accordance with current German and European laws and regulations, certified by ISO 9001 (quality management), ISO 14001 (environmental management) and ISO 50001 (energy management).

CORROSION PROTECTION ONSHORE

The corresponding parts of the international standard ISO 12944 are used for corrosion protection of the tower segments and machine parts. The minimum requirement for the coating system is mostly C4 high according to ISO 12944-2 for exterior tower surfaces and C3 high for interior surfaces of towers and machine parts.

STEEL TOWERS

Sherwin-Williams corrosion protection systems protect and beautify steel towers with high-quality and coordinated products as a long-term solution. The protective paint systems are based on high-strength, modern binder resins, which enable very low solvent content formulations.

Primers with active pigments and thick-layer intermediate coatings ensure long-lasting corrosion protection, and the top coats based on polyurethane technology meet the highest weather resistance and colour stability requirements. Our corrosion protection systems have proven themselves in over 10,000 wind turbines in several decades of service.

Examples for tower coatings onshore

Component	Corrosion protection system	Corrosion protection tests	Total layer thickness
Interior surface of tower	1 x **Macropoxy® 2440 MFN**	C3 high	180 µm
Interior and exterior surface of tower	1 x **Macropoxy® 2440 MFN** 1 x **Acrolon® EG-5**	C3 high	180 µm
	1 x **Macropoxy® 2440 MFN** 1 x **Acrolon® EG-5**	C4 high	240 µm
	1 x **Macropoxy® 2440 MFN** 1 x **Acrolon® EG-5**	C5 high	300 µm

MACHINE COMPONENTS FROM STEEL AND CAST IRON

Sherwin-Williams coating systems guarantee long-lasting, economical corrosion protection in the interior of nacelles. The cast iron and steel components, such as hubs, base frames, generator carriers, rotor shafts, machine housings, etc., are protected from severe mechanical damage during transportation and installation. Subsequently, during the years of operation, the coating prevents the formation of corrosion, acting as a dirt repellent and is easier to clean.

Examples for the coating of machine components

Component	Corrosion protection system	Corrosion protection tests	Total layer thickness
Steel and cast-iron components in the interior of nacelles	1 x **Macropoxy® 2420 EMK** 1 x **Acrolon® 2230 VHS**	C3 high	180 µm
	1 x **Macropoxy® EG Phosphate Rapid** 1 x **Acrolon® EG-5**	C3 high	180 µm
	2 x **Macropoxy® EG Phosphate Rapid** 1 x **Acrolon® EG-5**	C4 high	240 µm

CORROSION PROTECTION ONSHORE

REPAIR SYSTEMS ONSHORE

Transporting and assembling the sometimes very heavy parts and components can cause damage to the corrosion protection coating. To repair damaged components, 1-pack coating materials are used in the onshore area to ensure the highest possible corrosion protection and easy usage.

Repair systems				
System	Type	Layer thickness	Corrosion protection system	Colour
Version 1	Primer	2 x 60 µm	2 x **Kem Kromik™ Aktivprimer Rapid**	beige yellow
	Top coat	1 x 60 µm	1 x **Kem Kromik™ CorroTop**	RAL 7035, RAL 7038
Version 2	Repair coating	1 x 500 µm	1 x **Repacor™ SW-1000**	RAL 7035, RAL 1023

*Further information about Repacor™ SW-1000 on page 14.

WIND TURBINES OFFSHORE

The future of wind power generation lies in the offshore area.
With maintenance periods of 20 to 25 years, the lifetime of the corrosion protection coatings must be particularly high, even under extreme conditions:

Due to the exposed locations, permanent water, tidal and splash zone, pollution in marine environments, extreme temperature variations, intense UV exposure, and mechanical impact and abrasion are all possible.

Comprehensive rules and regulations especially drawn up for this, for example, from the oil drilling industry (e.g. for the protective paint systems used on oil platforms), simulate these extreme conditions and provide the operators with security when selecting products.

Jack-up platform Goliath

Transition pieces Windfarm Butendiek

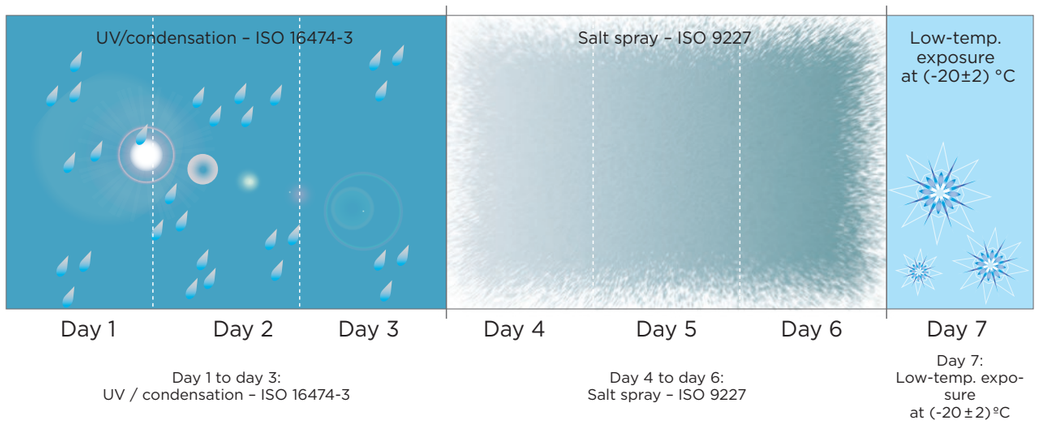
Research platform Fino 1

STANDARDS AND REGULATIONS OFFSHORE

INTERNATIONAL REGULATIONS

NORSOK STANDARD M-501 is used as a standard for the Norwegian oil industry, which acts as a basis for the requirements of the International Standard ISO 12944-9 pre-qualification. ISO 12944-9 is the offshore standard that quantifies testing corrosion protection coatings used on offshore structures. The standard is based on the corrosion testing cycle shown below.

CYCLIC CORROSION TESTING ACCORDING TO ISO 12944-9



The cycle shown is repeated 25 times. The test time is, therefore, almost half a year. Furthermore, in Part 9 of ISO 12944 for submerged areas, a cathodic disbonding test method, according to ISO 15711 and a long-term seawater immersion, according to ISO 2812-2, is needed.

GERMAN NATIONAL REGULATIONS

For hydraulic steel structures, the underlying stresses are divided into in the following three categories of corrosivity, described below. Category **Im2** being the most crucial for the **offshore** sector:

- **Im1 Fresh water**
  River structures, hydroelectric power plants
- **Im2 Sea or brackish water**
  Immersed structures without cathodic protection
- **Im3 Soil**
  Buried tanks, steel piles, steel pipes
- **Im4 Sea or brackish water**
  Immersed structures with cathodic protection

In Germany, tests and approvals according to the categories Im1 – Im4 are processed following the rules of the ZTV-W and the related „Richtlinien zur Prüfung von Beschichtungssystemen für den Korossionsschutz im Wasserbau (RPB)“. Aside from lab testing, our systems are fully tested in long-term immersion. If they test positive, they are included in the BAW quality evaluation list, available online at: **www.baw.de** in the **'Quality Evaluation' category.**

The Federal Waterways Engineering and Research Institute in Karlsruhe is responsible for this. The ZTV-W, 'Additional Technical Terms and Conditions – Hydraulic Engineering' for corrosion protection in hydraulic steel structures are valid for all firm and movable parts of hydraulic engineering, as well as metallic pieces of equipment of waterworks, both in construction and maintenance during the plant and construction stage.

Correspondingly, they can also be used for corrosion protection in ships, swimming devices, navigation, and steel sheet piles in hydraulic structures and offshore plants. Together with other federal agencies, the minimum requirements for German offshore plants and all the necessary parameters are enumerated in a catalogue in addition to the abovementioned test parameters, all of which are important for applying our coatings to foundation structures and towers.

CORROSION PROTECTION OFFSHORE

REQUIREMENTS OFFSHORE

High demands for corrosion protection exist for the construction of facilities on the high seas. From other locations, we have seen that accessibility makes partial on-the-spot replacements almost impossible. The coating systems must therefore be designed in such a way as to withstand the climate over the entire lifetime of the construction, about 20–25 years.

Further standards relating to corrosion protection in offshore environments, in addition to the ISO 12944-6, are ISO 12944-9 and NORSOK Standard M-501. The minimum requirement for the coating systems for tower exterior surfaces is qualified in the ISO 12944 part 9 and for interior surfaces of towers and machine components in part 5..

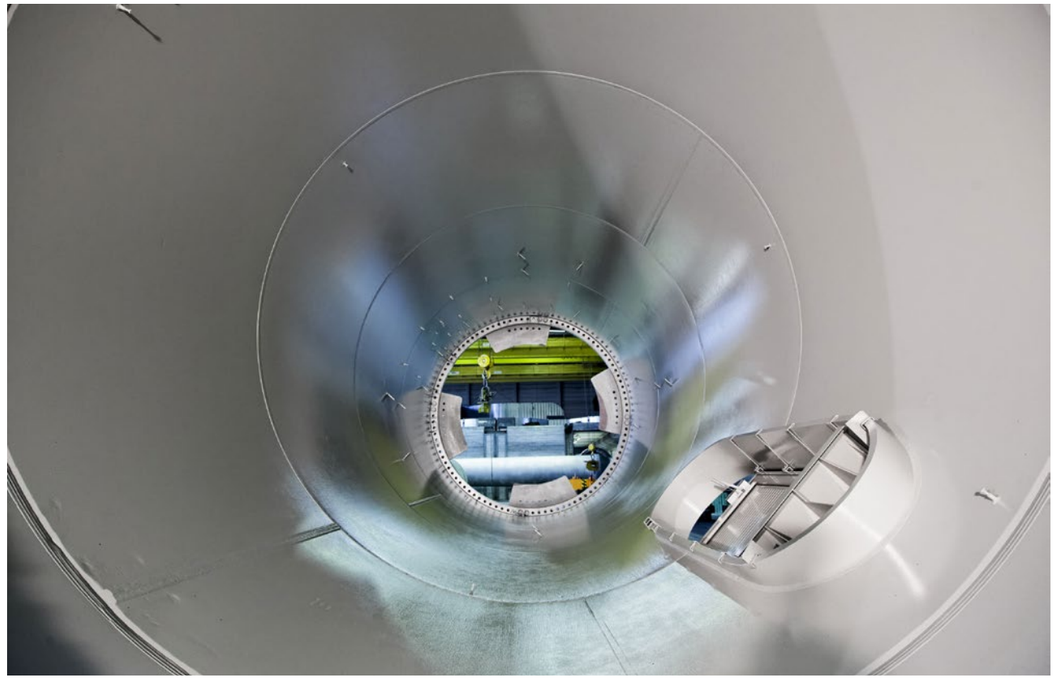
STEEL TOWERS ON THE HIGH SEAS

Sherwin-Williams protective coating system is applied according to the highest corrosion protection standards. Due to its very high mechanical durability, the tower sections are already protected during transport, especially during construction.

The main advantages:

- Long-duration corrosion protection under stresses on the high seas. Offshore: Norsok standard M-501, system No. 1.
- High mechanical durability.
- High quality top-coats with long-term colour stability and gloss retention.
- Low emission by using very low-solvent content coating materials.

Examples for tower coatings offshore			
Component	Corrosion protection system	Corrosion protection tests	Total layer thickness
Surface of tower	1 x **Zinc Clad® IV EU** 1 x **Macropoxy® 646** 1 x **Acrolon® 7300**	CX (offshore)	280 µm
	1 x **Zinc Clad® IV EU** 1 x **Macropoxy® 267** 1 x **Acrolon® 7300**	CX (offshore)	280 µm



CORROSION PROTECTION OFFSHORE

STEEL FOUNDATION STRUCTURES

The construction of offshore wind turbines is carried out primarily on steel foundation structures such as monopiles and jacket constructions. These surfaces are permanently immersed in seawater and require a coating system which, in addition to corrosion protection requirements, is also extremely mechanically durable. Dura-Plate® SW-501 and Dura-Plate® SW-501 GF meet all these requirements. Furthermore, both are solvent-free and, therefore very environmentally friendly.

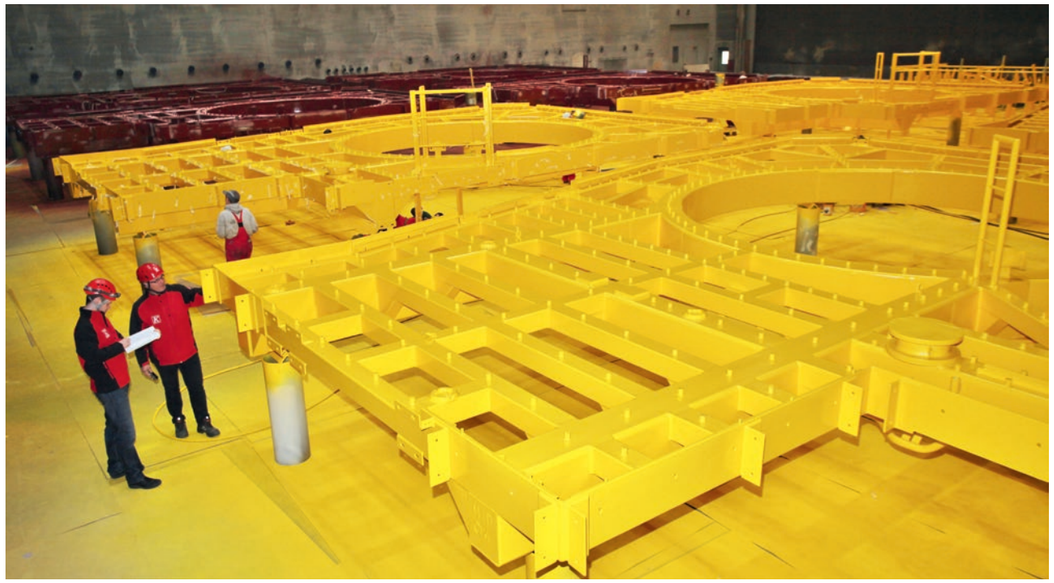
The main advantages:

- Highest corrosion protection under permanent stress by seawater and in tidal areas. Offshore: Norsok standard M-501, system No. 7A.
- High abrasion resistance, as well as mechanically sturdy.
- Suitable for application in combination with cathodic protection systems (CP).
- 2-pack epoxy resin coating, solvent-free and environmentally friendly.
- Dura-Plate® SW-501 GF contains lamellar glass flakes.

Examples of protective paint systems for foundation structures

Components	Corrosion protection system	Corrosion protection tests	Total layer thickness
Jacket **Monopile** **Transition pieces**	2 x **Dura-Plate® SW-501***	Norsok M-501, system No. 7A BAW: Im1 – 4, GL-Certificate	600 µm
	2 x **Dura-Plate® SW-501 GF***	Norsok M-501, System Nr. 7A	1000 µm

* Optionally, for special requirements on the colour and the UV resistance, it is possible to apply **Acrolon® 2230 VHS** or **Acrolon® 2330** as a top coat.



REPAIR SYSTEMS OFFSHORE

To repair damage which has occurred to the corrosion protection coating, unique protective paint systems are used for offshore structures. These systems must meet high requirements against corrosion protection and exhibit ease of application in various challenging conditions, including climate, weather and accessibility. As a result of this, Repacor™ SW-1000 is precisely the right choice for these applications. More information is on page 14.

Reparation systems

Element	Corrosion protection system	Corrosion protection testing	Total coating thickness
Steel structure	1 x **Repacor™ SW-1000**	ISO 12944-9	500 µm

THE OFFSHORE REPAIR REVOLUTION

2-PACK REPAIR COATING FROM THE CARTRIDGE

In the cooperative research project 'RepaKorr', the project partners drew up the basic material-related, technical, conceptual and organizational principles for an 'on-site repair' concept.

With Repacor™ SW-1000, our research department has successfully established an abrasion-resistant, innovative 2-pack coating for maintenance or repair of (mechanically) damaged coating areas.

The main advantages:

- **Easy to use**
  2 pack-coating from the cartridge – less weight for applicator.
- **Fast**
  Curing in record time even under water, with only one layer. UV-resistance without top coat.
- **Safe**
  No waste, no emissions - Solvent-free coating consists of 100% solids.

Foto: Muehlhan AG

Foto: Muehlhan AG

Extended application field:
As a repair coating for corrosion protection, Repacor™ SW-1000 is also suitable for onshore steel structures (page 6) and hydraulic engineering (sluicegates, steel sheet piles etc.) if a simple, high performance and durable repair coating is required.

OFFSHORE PROJECTS

Germany’s first offshore wind farm, the testing site 'Alpha Ventus' (formerly known as Borkum West), located about 45 kilometres north of Borkum, with a water depth of up to 30 meters, is feeding the power grid with offshore wind turbines of the five-megawatt class since autumn 2009. The research at the testing site provides essential data for developing offshore wind energy in Germany.

Since 2003, the research platform 'FINO 1' has been located on the western edge of the testing site, providing essential data such as wind speeds, changing direction of the wind, bird migration, changes in soil around a steel structure in a marine environment and their colonisation by mussels and starfish.

FINO 1 is the oldest German research platform for offshore wind energy and is entirely protected using corrosion protection systems from Sherwin-Williams.

SUPPORT ON THE HIGH SEAS

An essential prerequisite for working on the high seas is the SeaSurvival Bill. The Frosio inspectors of our Wind service team have passed all necessary tests to not only advise but also play a supporting role on the spot where necessary.

The bill – in oil, gas and wind – enables our team to act in and around water – nationally and internationally.

OUR QUALITY PROMISE

Sherwin-Williams Protective & Marine has been a reliable partner in the wind energy industry for many decades. Thanks to the most advanced technologies, unique service orientation and a mix of proven and innovative coating systems.

Service

+

Innovation

+

Competency

+

Quality and Sustainability

OUR SERVICE – YOUR BENEFIT.

SPECIFIC ADVICE
for choice of the Sherwin-Williams coating system

ON SITE INSTRUCTIONS
during coating work on request

Execution of **SURFACE TESTS**

Experts - certified as **NACE AND FROSIO INSPECTORS**

PROVEN ASSET PROTECTION ACROSS THE GLOBE

After 150 years of being in the paint and coatings business, Sherwin-Williams Protective & Marine understands the challenges that assets undergo during their life span. By working closely with asset owners and applicators, we develop the solutions to help combat those problems.

Our high-performance coatings and systems are engineered to defend assets against corrosion, fire, chemical attack, wear, or high temperatures – helping our customers achieve smarter, time-tested protection. We support the entire value chain of the project – from the idea, to the specification, to the execution. Combined with thousands of cumulative years of expertise among our coating professionals who know your business inside and out, we are fully ingrained in your business.

Our global coating solutions help protect assets in many industries, including:

- **Infrastructure** - civil and commercial
- **Energy** - from oil and gas operations to wind, solar and biofuels
- **Manufacturing and Processing** – production facilities in most markets

LEARN MORE ABOUT SHERWIN-WILLIAMS PROTECTIVE & MARINE

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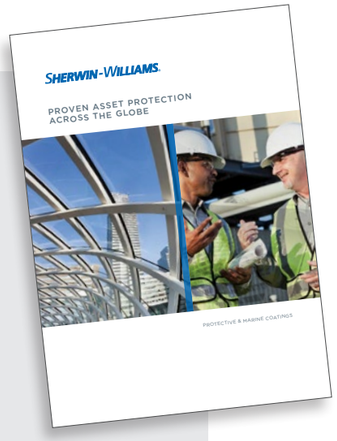

PROTECTIVE COATINGS FOR WIND ENERGY

THE SHERWIN-WILLIAMS DIFFERENCE

Sherwin-Williams Protective & Marine delivers world-class industry subject matter expertise, unparalleled technical and specification service, and unmatched regional commercial team support to our customers around the globe. Our broad portfolio of high-performance coatings and systems - including protective liquid and powder, fire protection and resinous flooring - excel at combating corrosion and help customers achieve smarter, time-tested asset protection. We serve a wide array of markets across our rapidly growing international distribution footprint, including Bridge & Highway, Energy, High Value Infrastructure, Manufacturing & Processing, Marine, Rail, Power and Water & Wastewater.

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