

Protectosil® Building Protection



Protectosil®

The global brand for building protection.



Protectosil® - Your Partner in Building Protection

We have been researching, developing, and producing silanes for more than 60 years. This focus on silanes takes us into a highly complex world of almost endless possibilities. It is in the field of building protection that silanes give the materials a special degree of durability and resistance. And this is done without having an adverse effect on the function or major changes in the aesthetics of the building material. With various Protectosil® products, a perfect solution for almost every requirement can be realized – a solution which makes successful long-term investment possible.



Protectosil® is one of Evonik's best known brands and has been used in building protection for decades. Protectosil® building protection products are well known and valued as hydro- and oleophobic products, as corrosion inhibitors, and as effective products for preventing graffiti or other surface-damaging effects.

Constant research and development means that Protectosil® is continually bringing a whole range of innovations onto the market: Protectosil® SC products that are easy to apply and that effectively reduce surface soiling. Protectosil ANTIGRAFFITI® SP is a new semi-permanent graffiti control system which expands our existing graffiti protection range.

Silane-based building protection products enable you to protect your investments. Protectosil® – your partner in building protection.

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Building Protection - Why?

Protectosil® building protection products secure your buildings and your investments. With Evonik building protection products you can gain:

- an increased service life
- lower maintenance costs
- an attractive appearance
- a more durable structure

Many well-known buildings throughout the world are protected with Protectosil® building protection products. Why? Because these high-performance building protection products can prevent serious problems such as:

- corrosion of reinforcing steel
- efflorescence
- salt burst and sulfate attack
- freeze-thaw damage
- acid rain attack
- algae, mildew, and moss
- graffiti

The wide spectrum of Protectosil® building protection products enables you to choose the optimal product or product combination for almost every type of application and substrate:

- concrete
- brick
- natural stone
- split-face block
- sand limestone
- marble
- granite

The problems described above can be solved with Protectosil® products, which can be divided into the following categories:

- water repellents
- surface protection (easy-to-clean and graffiti control)
- corrosion inhibition





Protectosil®. A Global Success Story

There are many reasons why Protectosil® is a brand which has gained an excellent reputation in the field of building protection. Excellent product performance, reliable service, measurable effects, and long-term experience are the basis of our success.

Protectosil® is designed for a wide range of materials and the challenges of innovative constructions, as well as historic buildings.

The Sydney Opera House (Australia), the Louvre in Paris (France) and the Hang-zhou Bay Bridge (China) are just a few of our best-known projects.

Not all of our success is really visible to the public, but there's one thing all treatments have in common: Benefits exceed costs.



Water Repellents - the Trick Is to Keep Water Out

Moisture is the root cause of almost all mechanisms that damage mineral building materials. The porous nature of many substrates allows water and dissolved contaminants to penetrate via capillary suction into the pores. This may cause various problems such as corrosion of reinforcing steel, salt burst, or freeze-thaw damage.

There is no doubt that by preventing water ingress into a structure, damage is drastically reduced. But the key question is how?

Treatment with water repellents – called „hydrophobation“ - using Protectosil® building protection products is unique. Protectosil® water repellent products penetrate deep into the substrate. They keep water out and maintain the substrate's water vapor permeability.

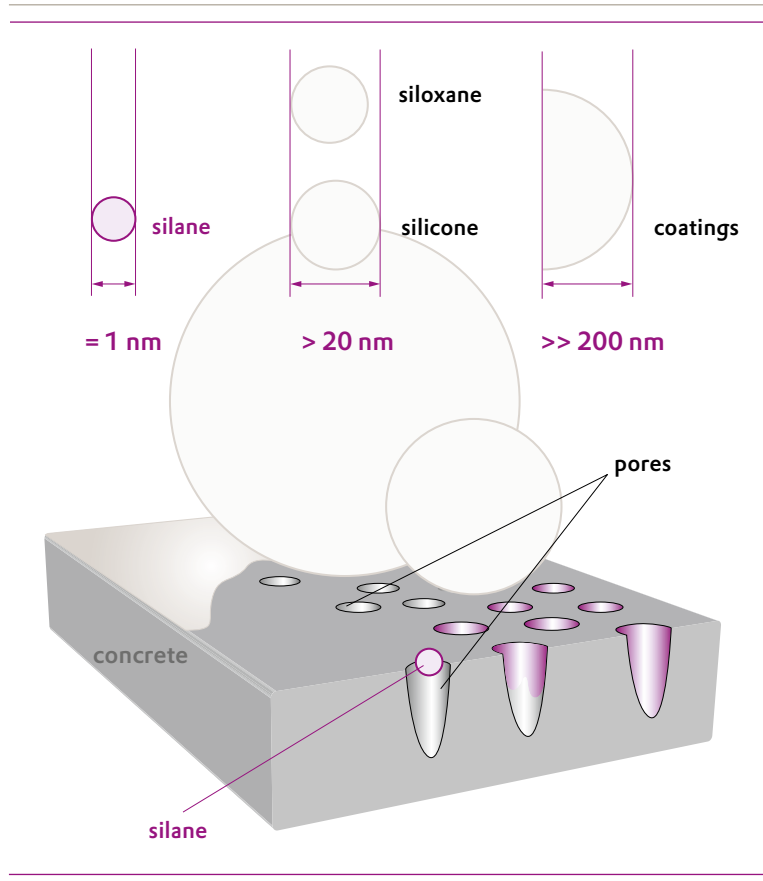
By contrast, film-forming coatings may block the pores of the surface. The large molecules in polymeric water repellent coatings seal the pores of the substrate and may stop it from breathing. Water is kept out, but water vapor generated from within remains trapped, causing damage such as spalling. In addition, the surface coating breaks down due to UV radiation, allowing water to penetrate once again.



Protectosil®: Depth hydrophobation for optimum protection

Protectosil® water-repellent molecules are smaller than the pores of the substrate. Due to this and the low viscosity, they penetrate deep into the building material and chemically bond to the inner pore walls, rendering the substrate hydrophobic. External water is kept from entering the pores, while water vapor generated from within the structure can still escape. The structure remains breathable. The following is a simplified illustration of this.

The deeply penetrating protection has two major advantages: Neither UV radiation nor mechanical wear can erase and thus weaken the Protectosil® protection. Silicones and siloxanes, due to their molecular size of >20 nm, do not penetrate and may be weakened by environmental stress.





Two test specimens were used to carry out a comparative test. One specimen was treated with Protectosil® BHN the other remained untreated.



Both specimens were dried for two weeks and then exposed to water in a basin for three hours.

Efficient Hydrophobation - Advantages at a Glance

Critical for efficient hydrophobation is the use of low-viscosity high-efficiency molecules. Protectosil® uses liquid, monomeric alkylsilanes to create an internal barrier which prevents water from penetrating into the substrate.

These molecules penetrate the substrate and chemically bond to it. This has various advantages:

- Protectosil® water repellents offer deep protection which is not affected by UV exposure or abrasive load (e.g., traffic).
- Protectosil® maintains the water vapor permeability.
- Protectosil® hydrophobation products do not change the surface appearance of the substrates, so paints can still be applied.

As Protectosil® hydrophobation creates a deep barrier against water, the efficiency of Protectosil® is not measured by the beading effect of the surface. It is measured by the reduction of water uptake. Non-destructive testing can be carried out on existing buildings using a Karstens (or Rilem) tube. Another possibility is to take drill cores and to visualize the penetration depth with water based inks.



The specimens were cracked open in order to examine the water uptake.



The unprotected specimen shows major water uptake after 3 hours (right cube-darkened concrete) while the Protectosil® BHN hydrophobized specimen (left cube) shows no water uptake. The inside of the Protectosil® BHN treated cube remains dry.



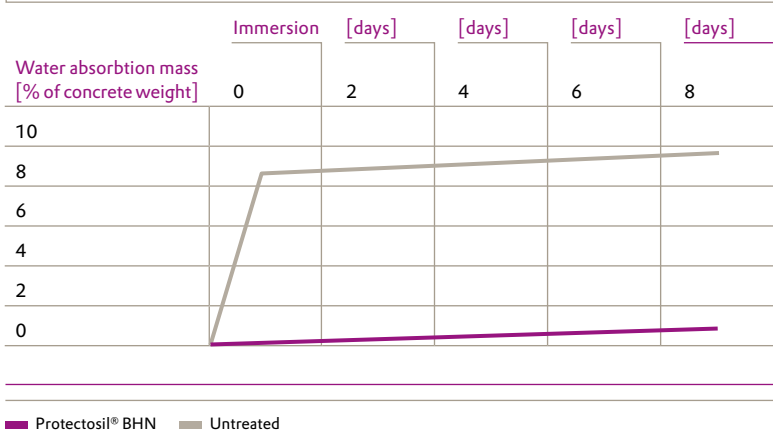
The unprotected specimen was thoroughly soaked after 12 hours, while the Protectosil® BHN hydrophobized specimen showed no visible water uptake.

Protectosil® BHN is an efficient water repellent

A water-immersion test using two standard concrete test specimens (60x60x60 mm construction concrete) is shown above. The test shows the efficiency of Protectosil® BHN as a water repellent. Even after 12 hours of soaking, no significant uptake of water could be detected (Picture 5).

Protectosil® BHN protected and unprotected concrete samples were exposed to a water pressure equivalent to a 10 cm water column. In this test Protectosil® BHN was successful over a seven-day period and reduced water uptake by more than 90%.

Water absorption of concrete

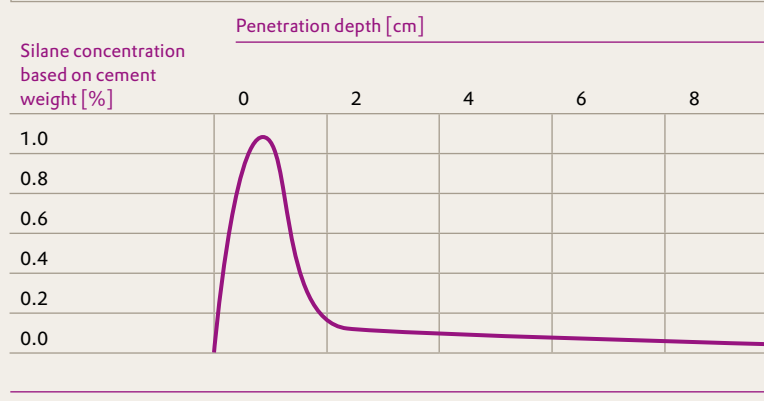


Protectosil® Does the Job. Today, Tomorrow, and in Decades

Durable protection is important where weather and mechanical stress is high, for example, on bridges, parking decks, or

buildings. UV radiation, mechanical abrasion, or deicer salt cannot keep Protectosil® from doing its job.

Silane concentration profile in concrete



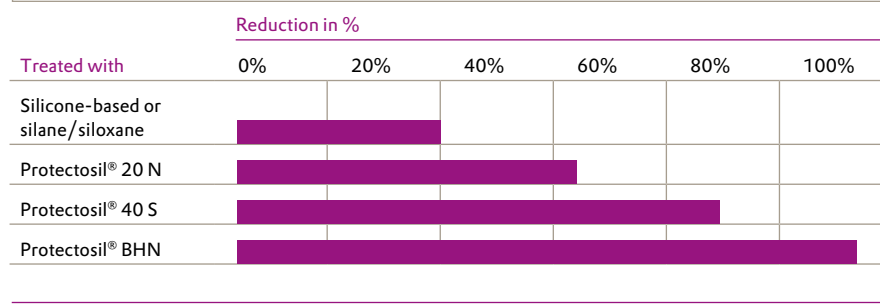
With solvent-free Protectosil® products, high and therefore effective penetration depths can be obtained, also in the case of very dense building materials, such as engineered concrete. How deep the concentration of the created water barrier is inside the structure, can be determined accurately by means of pyrolysis GC* or FT-IR**.

Efficiency of various water repellents on concrete subjected to constant traffic abrasion

The water uptake of the concrete was measured before and after 10 years of constant traffic exposure. The higher the

reduction in water uptake, the more the concrete was protected, even after 10 years.

Reduction of water uptake



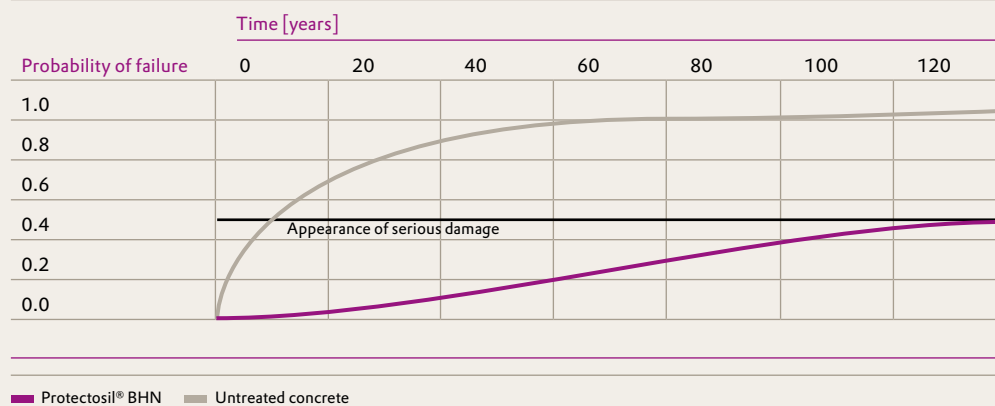
* C.Herrmann, H.Rotzsche: Determining Silanes in Inorganic Matrices by Pyrolysis - GC; Proceedings of Hydrophobe II, Zürich (1998) pp. 231.

** A. Gerdes et. al. Quality Control by FT-IR-spectroscopy, Proceedings of Hydrophobe II, Zürich (1998), pp.237.

Case Study: "Container Terminal Zeebrugge"

Protectosil® BHN can prolong structure service life by up to 107 years

Service life prediction for the Zeebrugge Quay Wall



The University of Leuven (Belgium) has monitored the results of the Protectosil® BHN protection on a quay wall in Zeebrugge (Belgium). Measurements of concrete properties and chloride profiles after 12 years were used to develop a service life prediction model based on a time-dependent reliability analysis. This is applicable to concrete deterioration based on various failure mechanisms.

The graph above shows the results of a comparison between a Protectosil® BHN treated and an untreated area. The predicted occurrence of damages is illustrated. The hydrophobation of the quay wall leads to significantly reduced maintenance costs and an extended service life of up to 107 years.*

The standard Protectosil® hydrophobation is done by spraying the product onto the structure surface. For this purpose, for example, an airless spraygun for liquids can be used.



*Schueremans et. al, Chloride penetration in RC-Structures in marine climate: Proc. Int. Workshop on durability of reinforced concrete, (2005 Qingdao, China) p. 169-179.

Mass Hydrophobation - Efficient and Cost-Saving

The absorption of water by capillary suction of concrete is known to be suppressed by standard hydrophobation. In the past, monomeric alkylalkoxysilanes have proven to be particularly effective in achieving this effect. Unfortunately, this standard hydrophobation represents an additional step in the construction of concrete surfaces. This is sometimes not possible due to scheduling, curing of the concrete, or other job site restrictions.

A silane emulsion that offers the benefits of reduced water uptake without an additional step in the construction is Protectosil® MH 50. This water repellent

agent is directly added to the uncured concrete mixture. A homogeneous distribution of the silane ingredient can be easily obtained as the emulsion is sufficiently stable to the high pH of the concrete mixture.

Practical example for mass hydrophobation



Concrete Metal
Silane modified concrete

- removal of old concrete
- renewal of the steel reinforcement
- filling with repair concrete including Protectosil® MH 50
- quality control

Advantages of mass hydrophobation compared to standard hydrophobation

- reduction of production steps
- no problems with penetration depth
- no dependency on weather conditions

The influence of mass hydrophobation on the concrete properties can be as follows:

Fresh concrete

- reduced viscosity
- unchanged air content
- constant density
- slower concrete reaction ("curing")

Crosslinked concrete

- slightly reduced resistance to pressure
- major reduction in water uptake



Case Study: “Gundeli Parking” in Basel

The parking garage “Gundeli-Park” in Basel (Switzerland) was built in 1966/67 and had to be renovated in 2002. Due to decades of exposure to chlorides brought into the garage by cars, corrosion of steel reinforcement bars had resulted in major damage. During repairs, a 15–20 mm layer of concrete was removed. The upper reinforcement bars were completely replaced.

The thickness of the new concrete was of 50–100 mm. It contained 2.7 wt% of Protectosil® MH 50 relative to the cement weight (Cement CEM I 42.5) and achieved good processability and excellent compressive strength after 28 days. Comparative data from other projects prove that the water uptake was dramatically reduced by the mass hydrophobation with Protectosil® MH 50.

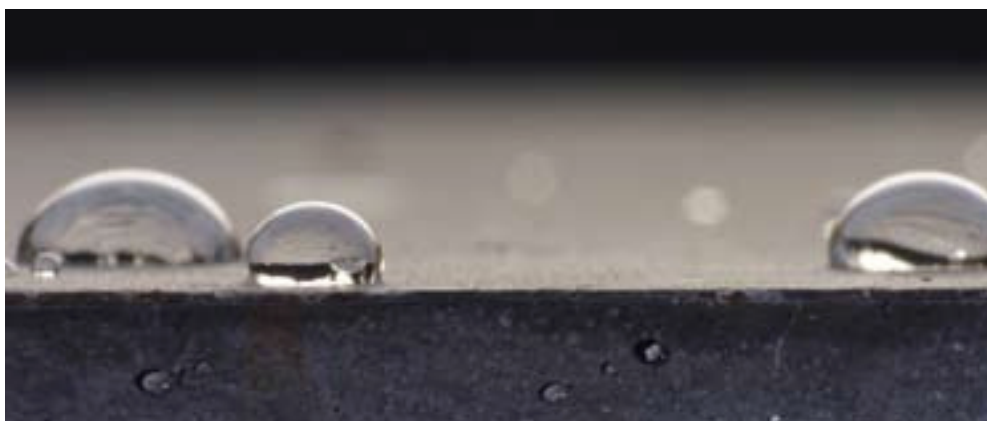


Hydrophobation Does Not Rule Out Other Surface Treatments

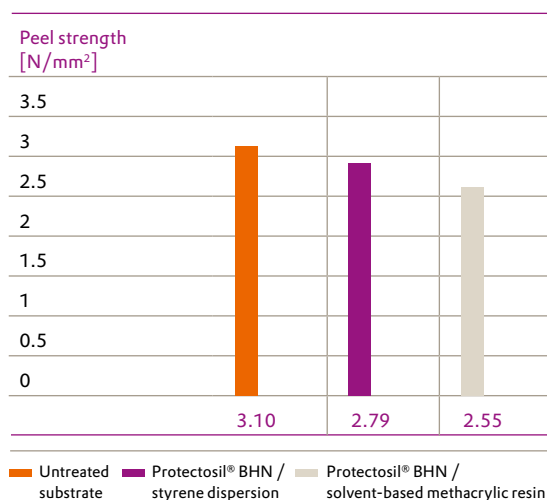
In many cases Protectosil® hydrophobation is used together with other surface treatments, such as paints, coatings, or other Protectosil® surface protection materials. In all of these cases, the key concern is surface adhesion. For some of the most common paint and coating systems, various Protectosil® water repellents have proven their compatibility. Tests were performed according to TPOS¹⁾, ZTV-ING²⁾ and EN 1504-2. Additional treatment with antigrffiti or easy-to-clean surface protection materials is also possible. In the following tables,

results are shown for different binder-based coatings. The systems tested were based on styrene acrylate dispersions, solvent-containing methacrylic resins.

1) Technical test specifications for surface protection systems
2) Additional technical terms of contract and guidelines on the protection and repair of concrete parts of the Federal Ministry of Transport, 1990



Peel strength after freeze-thaw and cyclic temperature loading



Even under challenging weather conditions, Protectosil® BHN is an excellent base under paints. A test after freeze-thaw and various temperature cycles proved that the adhesion of styrene dispersions or solvent-based methacrylic resins is sufficient for good long-term stability.

Combination of Protectosil® BHN and various coating on concrete specimen*

Average consumption in g/m ²			
System	Hydrophobation with Protectosil® BHN	Coating system	
		1st step	2nd step
Protectosil® BHN / styrene acrylic dispersion	130 g/m ²	305 g/m ²	305 g/m ²
Protectosil® BHN / solvent based methacrylic resin	120 g/m ²	310 g/m ²	310 g/m ²
Waiting period between application steps	1 day	1 day	

*30 x 30 x 6 cm according to TP-OS 5.2



Protectosil® for Surface Protection

Effective and durable

Private and public buildings have to be considered in terms of functionality and their representative function. Little to no construction is carried out today without considering this representative aspect. Banks, train and subway stations, shopping malls – all of these buildings represent form and function and need to be protected and maintained.

The Protectosil® building protection range offers some products specially for the surface protection of buildings and constructions. The right Protectosil® SC product can protect the surface of building facades, concrete facades, walls, and so forth with high reliability and long-term efficiency. Various environmental influences such as water staining, moss, algae, mildew, as well as soot and oil stains can be reduced. Furthermore, special Protectosil® products are available which protect the building surface against graffiti. This is achieved by creating low-energy surfaces, which make the building surface highly hydro- and oleophobic.

However, these oleophobic and hydrophobic surface effects do not replace hydrophobation. Protectosil® surface protection molecules show low penetration depths as they are larger than Protectosil® water-repellent molecules.

Protectosil® surface protection molecules bind chemically to the surface and are stable against weathering. Both features grant an efficient long-term protection.

Unlike standard coatings, which seal the surface like a film, Protectosil® products allow water vapor to escape. The building can breathe, moisture is not trapped, and the building material is efficiently protected.



A Range of Products for Various Needs

The Protectosil® SC product range creates an easy-to-clean surface and a cost efficient solution, where stains, moss, and soiling are reduced, and quick and easy cleaning is allowed. The Protectosil® SC product range represents tailor-made solutions for long-term protection of various mineral substrates. Depending on the kind of surface protection desired and the application method preferred, there are various products available. Protectosil ANTIGRAFFITI® and Protectosil ANTIGRAFFITI® SP: the products against graffiti attacks. These graffiti-control systems are used with Protectosil® PROFICLEAN GEL, a highly efficient graffiti cleaner.



New constructions

Protectosil ANTIGRAFFITI® and Protectosil® SC CONCENTRATE offer outstanding protection against graffiti and all kinds of stains and surface soiling.



Historic landmarks

Protectosil® offers a range of products for protecting sandstone and other porous surfaces.



Engineering structures

The variable application technologies allow efficient and quick protection of large surfaces.



Monuments

With Protectosil® the surfaces of monuments are efficiently protected against graffiti attacks, but remain largely unaltered.

Reduced Maintenance Costs for Attractive Facades

Even where graffiti is not a problem, dirt and stains can damage attractive structures. Whether mildew, algae, moss, or soot, the Protectosil® SC product range provides an "easy-to-clean" surface and reduced maintenance costs for cleaning. These products have become one of the leading technologies for facade protection, because they guarantee excellent results, are solvent-free, and easy to apply. The Protectosil® SC product range provides very good properties for protecting porous substrates such as sandstone and concrete.

The molecules of the Protectosil® SC product range chemically bond to the substrate surfaces, forming an invisible film which allows the substrate to breathe. Due to the inherent UV stability of these molecules, protection is long lasting.



Treated with Protectosil® SC CONCENTRATE (not cleaned)



Untreated (not cleaned)

The upper wall was treated with Protectosil® SC CONCENTRATE, the one below was left untreated. After eight years of outside weathering the difference is immediately obvious.

Case Study: "Train Station Stadelhofen, Zurich"

The train station Stadelhofen is a concrete building which is heavily used by travelers and is exposed to harsh weather conditions.

During renovation in the year 2002, all surfaces were cleaned and protected with Protectosil® BHN and Protectosil® SC 60 via airless spraying. The beautiful appearance of the station is therefore maintained.

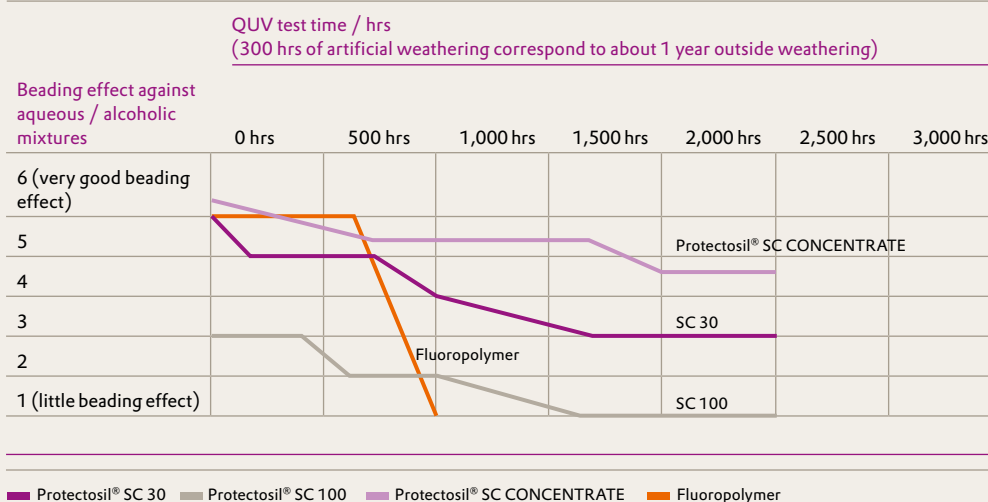


For Every Substrate and Requirement a Tailor-Made Solution

Weathering stability is essential for the long-term effectiveness of the Protectosil® SC product range. This can be tested outside, which is very time consuming, or in QUV test chambers in accordance with EN ISO 11507. Tests indicated that the correlation between outside weathering and artificial weathering is 1 year = 300 hrs (conditions south/west Germany). Tailor-made products ranging from Protectosil® SC CONCENTRATE to Protectosil® SC 100 cover the whole range of long-term effectiveness. The diagram above shows the beading properties of different Protectosil® SC products. The beading effects, which

give an indication of the easy-to-clean properties, decrease over time due to weathering (e.g., abrasion through rain, snow, and UV radiation). Various aqueous and alcoholic mixtures were used for the test. Mixture 1 (water/alcohol mixture) is repelled more easily from the surface compared to pure alcohol (Mixture 6). The beading effect of Protectosil® SC CONCENTRATE is better than Protectosil® SC 30. Both products have a much greater weather stability than fluoropolymers, which are also suitable for this kind of application. Fluoropolymers are not weather resistant and break down over time.

Long-term effectiveness of various Protectosil® SC products on red sandstone

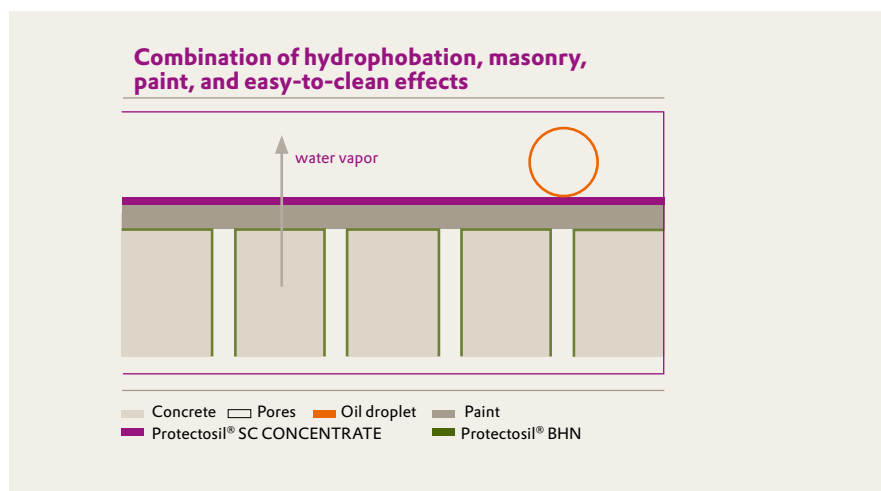


Protection Systems Combined with Masonry Paint

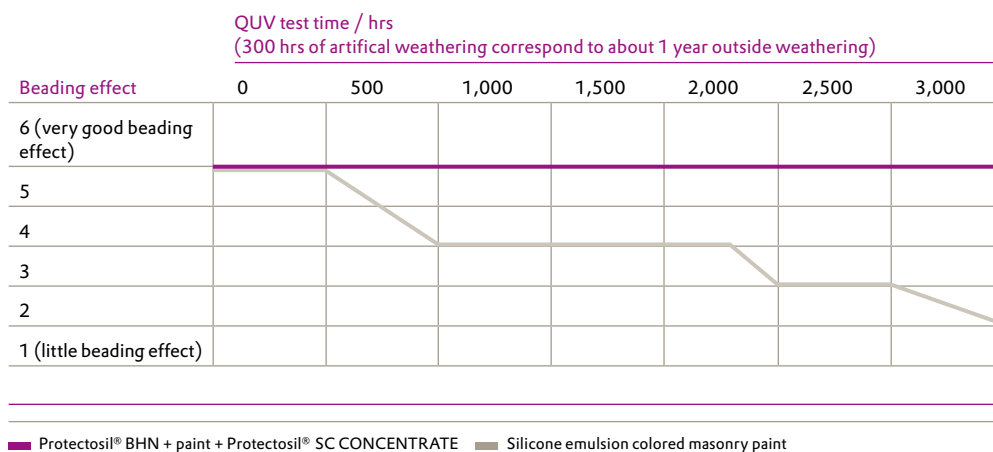
The brand Protectosil® offers a variety of building protection products. Most of them may be combined to achieve overall protection. In many cases, buildings need to be protected against damage caused by water or other pollutants, such as sulfate. They can be treated with paints and may need an easy-to-clean or antigraffiti surface treatment.

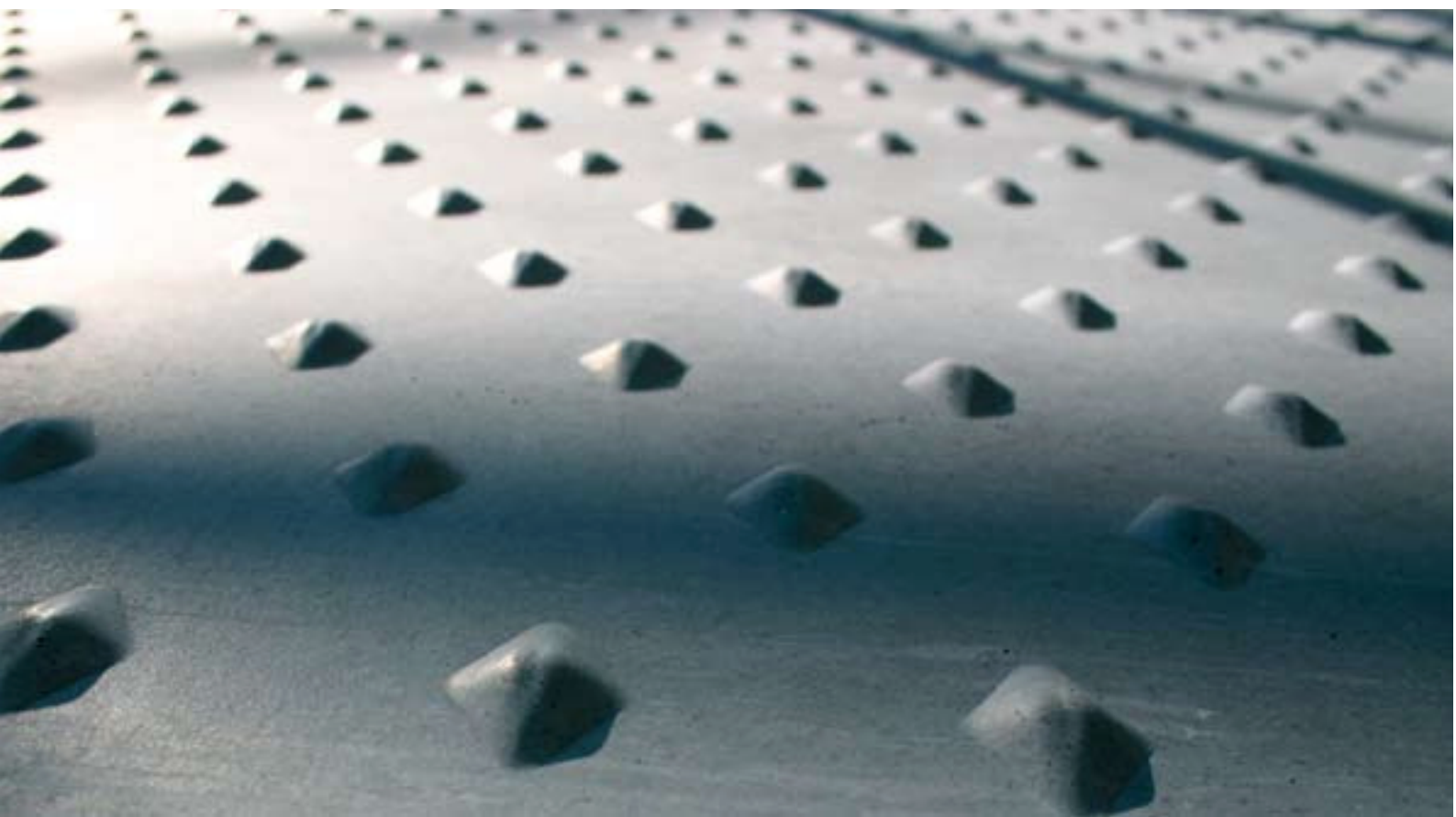
Protectosil® shows that a combination of hydrophobation (Protectosil® BHN), paint, and surface protection (Protectosil® SC product range) can be easily achieved. For example, by using Protectosil® SC CONCENTRATE on a silicone emulsion

colored masonry paint, the paint is protected against staining or bleaching so that a recoating can be postponed. If the paint is damaged through UV radiation or cracks, the mineral substrate is still protected against water or pollutants through the depth hydrophobation. For such a combined system, the water repellent is applied first (e.g., Protectosil® BHN) followed by the masonry paint. To protect the paint, Protectosil® SC CONCENTRATE is applied on top. This combination offers very good overall and long-term protection for attractive breathable facades.



Long-term effectiveness of combined systems on concrete





Long-term effectiveness of Protectosil® SC CONCENTRATE on silicone emulsion masonry paint

The combination of building protection products serves functional and aesthetic purposes. For functional reasons, the substrate is protected against moisture by Protectosil® BHN. For aesthetic reasons, it is painted and protected against algae, mildew, moss, and staining by Protectosil® SC CONCENTRATE.

The diagram on the left side shows that Protectosil® SC CONCENTRATE is an efficient building protection product that helps to maintain clean surfaces and improves the resistance of silicone emulsion masonry paint against aqueous and oily mixtures. While the beading effect on masonry paint decreases over time (< 2,000 hrs.), the protective effect of Protectosil® SC CONCENTRATE remains very good for more than 3,000 hours.



Graffiti-Control Systems

Graffiti control begins with effective surface protection

It is a difficult task to keep buildings graffiti-free. This task has to be accomplished quickly, efficiently, and with low application costs. Protectosil ANTIGRAFFITI® and Protectosil ANTIGRAFFITI® SP are the right products to do this job. The more attractive, more visible, and less protected a building is, the greater the temptation to graffiti sprayers to vandalize it with sprays. The longer the graffiti remains visible on the building, the more other sprayers will consider the building to be an attractive surface to attack. Protectosil® offers a broad product range to counteract graffiti.

On a building treated with Protectosil ANTIGRAFFITI®, it's the vandal who becomes frustrated. Colors do not adhere, the paint runs, and the desired

result cannot be achieved. Many sprayers give up their attack.

But even if the picture or the "tag," a short signature, is placed, removal is easy. When the surface has been protected with Protectosil®, the paint or felt-tip-marker can be removed with little effort quickly. Even ugly tags can be easily removed by the graffiti cleaner Protectosil® PROFICLEAN GEL.

This combination of efficient protection and quick reaction are important factors in discouraging further graffiti attacks.



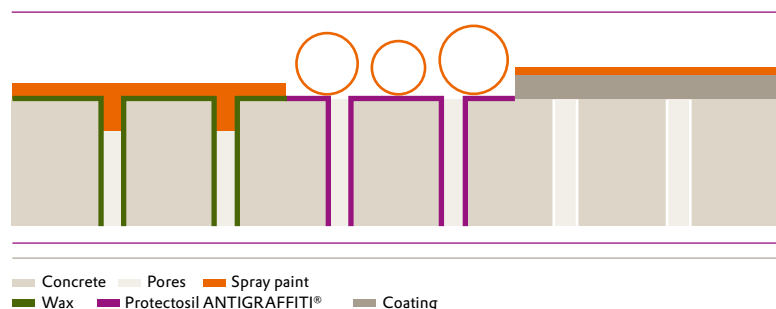
Protectosil®: How to Protect a Surface Effectively Against Graffiti

One major strength of Protectosil® is its ability to offer unsurpassed protection without causing major change to the surface appearance of the substrate. This is due to an innovative mechanism of action: silane-based chemistry, one of the core competencies of Evonik.

Protectosil ANTIGRAFFITI® and Protectosil ANTIGRAFFITI® SP are hydro- and oleophobic, so surfaces easily repel dirt and oil. Neither water nor solvent-based paints and markers can enter the pores of the building material. Graffiti is repelled and runs down the surface. Because the paint does not penetrate the substrate, cleaning is in the

majority of cases easy. Sprayers are frustrated by the "running" effect, as they are no longer able to create the desired image with their spray paint. To create a more or less legible "Hi!" the sprayer requires more than three times as much paint and time as usual. And both are generally not available.

Mode of action of various antigrffiti systems - Substrate after a spray attack



The diagram shows schematically that Protectosil ANTIGRAFFITI® has a different and very effective way of protecting surfaces against liquid or oily substances. The distinct beading effect can be clearly seen. Unlike polyurethane systems, Protectosil ANTIGRAFFITI® does not seal the surface and allows full water vapor permeability.

Protectosil ANTIGRAFFITI® Is Durable

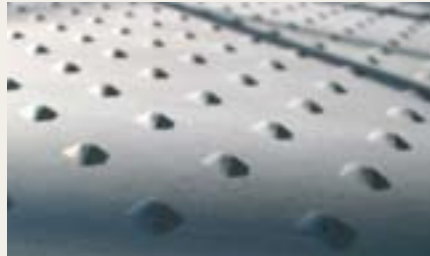
Durable, attractive, breathable – natural surfaces combine all of these attributes. Nature is a model for Protectosil ANTIGRAFFITI®.

Antigraffiti treatment systems are divided into three different classes: temporary or sacrificial systems, semi-permanent, and permanent systems. Sacrificial systems

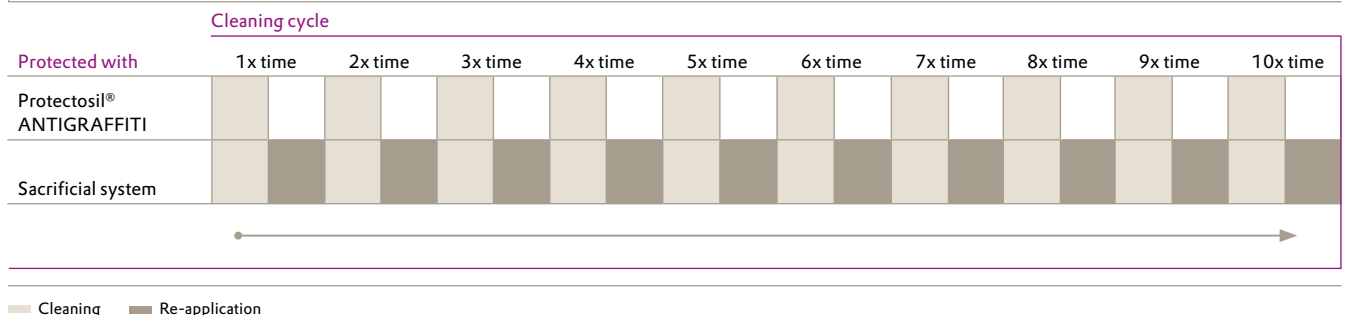
have to be re-applied after every cleaning step, whereas permanent systems withstand about 10 cleaning cycles. Protectosil ANTIGRAFFITI® molecules bind chemically to the surface and are weathering stable. This makes efficient long-term protection possible, which sacrificial systems do not offer at all.

Permanent means:

- stable against UV radiation
- stable against weathering
- no re-application after repeated cleanings



Protectosil ANTIGRAFFITI® withstands up to 10 cleaning cycles



Various sandstones or dense concrete are sensitive to darkening. For these kinds of substrates it is recommended to apply a base coat, such as Protectosil ANTIGRAFFITI® PRIMER, before applying Protectosil ANTIGRAFFITI®. With this primer, the good long-term effectiveness of the

antigraffiti treatment, as well as the water vapour permeability (breathability) of the substrate, are not affected. The Protectosil ANTIGRAFFITI® PRIMER is listed and commercial only in Europe.

Protectosil ANTIGRAFFITI® is cost-effective

Protectosil ANTIGRAFFITI® is a unique product. The basic product and application costs per square meter are comparable to those of permanent polyurethane-based graffiti-control systems. Sacrificial systems appear inexpensive at first

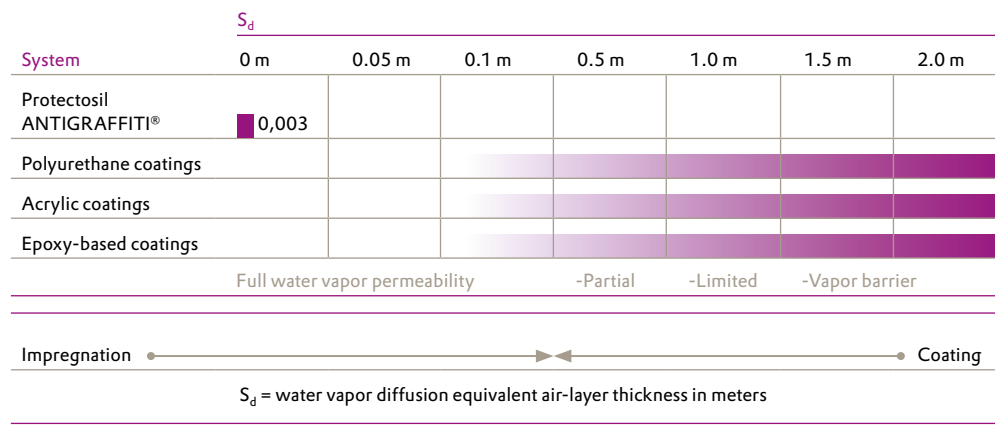
glance, but the labor costs of reapplication after each cleaning must be considered. When overall costs are considered, Protectosil ANTIGRAFFITI® offers significant advantages.

The Substrate Retains Its Water Vapor Permeability

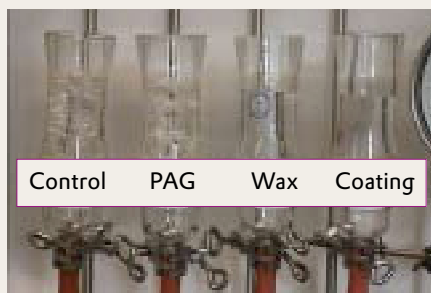
Molecular impregnation with Protectosil ANTIGRAFFITI® protects the surface while retaining its water vapor permeability. Unlike coatings which seal the surface like a film, Protectosil ANTIGRAFFITI® allows water vapor to escape freely. The building can breathe, moisture is not

trapped, and the building material is preserved. With Protectosil ANTIGRAFFITI® the water vapor diffusion equivalent value (s_d) of the substrate increases only by 0.003 m. Other permanent graffiti control systems can cause an increase in the s_d value to meter levels.

Graffiti-control systems compared: water vapor permeability



Unique water vapor permeability



PAG = Protectosil ANTIGRAFFITI®

Free movement of water vapor means:

- no damage to the substrate from trapped moisture
- optimal substrate climate is maintained
- the surface of the structure is not "sealed" and can breathe



Application of Protectosil ANTIGRAFFITI® or Protectosil ANTIGRAFFITI® SP with standard HVLP* equipment
* <http://www.wagner-group.com>



Application of
Protectosil ANTIGRAFFITI® SP
- by brush or roller-

Protectosil® is solvent-free and environmentally friendly

Protectosil ANTIGRAFFITI®, Protectosil ANTIGRAFFITI® PRIMER, and Protectosil ANTIGRAFFITI® SP were developed to be environmentally friendly. They are solvent-free, contain almost zero VOC (volatile organic compounds), and are not classified as hazardous.

Solvent-free means:

- water-based
- environmentally friendly
- no volatile organic components (VOC)
- no hazardous air pollutants (HAP)

Protectosil® is easy to apply

As Protectosil ANTIGRAFFITI® is not hazardous, it can be applied quickly and easily with HVLP-spraying technique (high volume low pressure)*. Depending on the type of building material, several coats may be required. Drying cycles between these "coats" will be as short as 10 to 60 minutes, depending on weather conditions. This means more efficient use of work crews who can complete projects in one day.

Protectosil ANTIGRAFFITI® SP is very flexible in application. It can be applied using the in HVLP-spraying technique, but also with brush or roller.

Easy application means:

- standard equipment
- fast drying time
- short waiting periods between application steps



Protectosil® PROFICLEAN GEL is an efficient graffiti cleaner

Often graffiti consists of just a word or two, called a "tag," applied with spray paint or a felt-tip marker. Such tags are easy to remove from surfaces protected with Protectosil ANTIGRAFFITI® or Protectosil ANTIGRAFFITI® SP. All that is required is Protectosil® PROFICLEAN GEL, a brush, and a water pressure cleaner (<12 bar).

Protectosil® PROFICLEAN GEL easily removes a large variety of graffiti paints. The viscosity of the cleaner prevents the cleaner and dissolved paints from being easily absorbed by the substrate.

Large, very smooth concrete areas that have been protected with Protectosil ANTIGRAFFITI® can also be cleaned quickly, easily and completely, and without chemical cleaners using high-water-pressure equipment – so called suction strippers.

Easy cleaning means:

- low labor costs
- no special equipment required for small graffiti cleaning



Corrosion Inhibition

Durable steel-reinforced construction and reduced maintenance

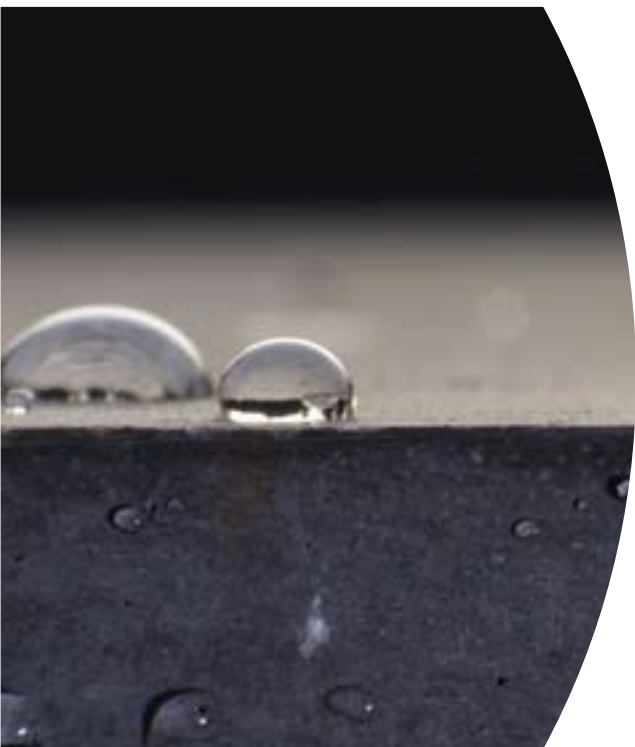
Buildings, bridges, parking decks – steel-reinforced concrete structures represent major private and public investments. Over time, however, reinforcing steel can corrode and rust, leading to a weakening of the structure if expensive repairs are not undertaken. The key to successful protection of valuable building structures is to stop water and chloride ions from entering the substrate. If the structure is already experiencing corrosion, there is still a viable cost effective solution.

Protectosil® CIT is an advanced silane based corrosion inhibitor system from Evonik with outstanding features. Like other Protectosil® products, Protectosil® CIT builds a deep and long-lasting barrier because it penetrates into the substrate and binds chemically to the concrete. It protects steel-reinforced concrete by

interrupting the corrosion mechanism. Even in concrete exposed to high corrosion conditions, Protectosil® CIT has proven its efficiency.

The best repair is one which does not have to be done. This is why we recommend using Protectosil® CIT, not only for repairs, but also on new constructions.

Evonik's application know-how helps you to optimize the results of your efforts.



Protectosil® CIT Interrupts the Corrosion Mechanism

Water entering into building substrates is one of the most significant causes of damage. In challenging weather conditions, this may result in freeze-thaw or salt burst. But water is only one reason for damaged steel-reinforced concrete.

The real cause of corrosion on steel-reinforcement bars and the consequent mechanical stress is chloride-induced corrosion. Water molecules bind electrostatically to concrete, forming the conductive medium for the chloride-induced corrosion process that dissolves the rebar.

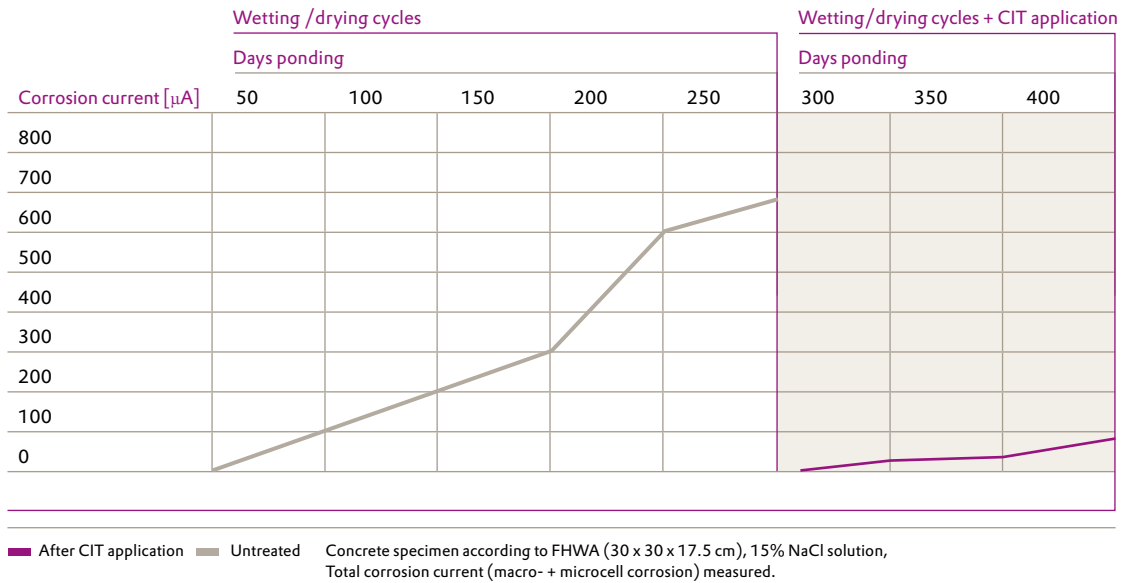
Protectosil® CIT efficiently counteracts both mechanisms. First, Protectosil® CIT

provides a deep barrier that blocks water, and thus chloride ions, from reaching the rebar. Second, Protectosil® CIT's organofunctional chemistry interrupts the electrolytic current, causing a substantial reduction in corrosion current and the by-product rust. An independent study has proved that three other commercial corrosion inhibitors "did not show any benefit in inhibiting the corrosion of chloride contaminated reinforced steel"* while "Protectosil® CIT by Evonik effectively reduced corrosion under the conditions of the ASTM G-109 procedure."**

* J.E. Bennett, Consultants Inc. / Investigation of topically applied inhibitors to mitigate corrosion in reinforced concrete using modified ASTM G-109 procedure / Report Feb. 2004

** J.E. Bennett, Consultants Inc. / Investigation of Protectosil® to mitigate corrosion in reinforced concrete using modified ASTM G-109 procedure / Report November 29th 2005

Protectosil® CIT decreases effectively the corrosion current by 90%



Protectosil® CIT Prevents Corrosion

WJE Associates¹⁾ carried out tests on steel-reinforced concrete slabs in accordance with methods of the US Federal Highway Administration. Some of the slabs were coated with about 600g/m² of Protectosil® CIT, whereas other specimens were exposed to a cyclic saltwater (15 wt% NaCl solution) ponding test without any protection. Corrosion current, the resistance and half-cell potentials were measured. The ponding test of an unprotected specimen

showed active corrosion after 250 days (see diagram above), which is indicated by a very high macrocell corrosion current.

The formerly unprotected specimens were dried after the 250 day test and Protectosil® CIT was applied. After one week of curing, the ponding test was continued. With Protectosil® CIT, the corrosion current in the formerly unprotected specimen decreased by 90%.

Protectosil® CIT is Effective in Cracked Concrete

WJE Associates¹⁾ carried out tests on concrete slabs with cracks of 0.3 mm width right above the steel-reinforcement. Some of the concrete specimens were treated with Protectosil® CIT before wetting-drying cycles with a 15 wt% NaCl solution were performed. Other specimens remained unprotected. After 12 weeks of testing the untreated samples clearly showed signs of rust, indicating active corrosion. By contrast, the Protectosil® CIT treated specimens did not show any signs of active corrosion.

Chloride ion content or corrosion currents clearly indicate the risk of rebar corrosion

It is important to identify the risk of rebar corrosion before substantial damage occurs to the concrete. One of the most common methods for identifying corrosion is to determine either the chloride ion

content or electrical potential/voltage differences. Convenient for on-site corrosion detection are corrosion measurements, for example, with linear polarization equipments.

The diagram below shows the correlation between corrosion rates and time to visible deterioration. After the corrosion of reinforcing steel has been identified, the application of Protectosil® CIT is an efficient measure for stopping the destructive process.

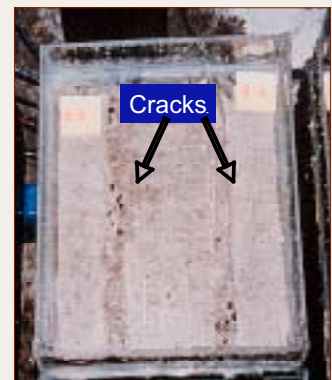
Correlation between measured corrosion rate and visible corrosion damages

Corrosion level	Corrosion rate $\mu\text{A}/\text{cm}^2$	Time to visible deterioration
Passive conditions	< 0.2	-
Low corrosion	0.2 – 0.5	> 10 years
Moderate corrosion	0.5 – 1.0	3 – 10 years
High corrosion	> 1.0	< 2 years

Test specimens after 12 weeks ponding with a 15 wt% NaCl solution



Untreated



Protectosil® CIT treated

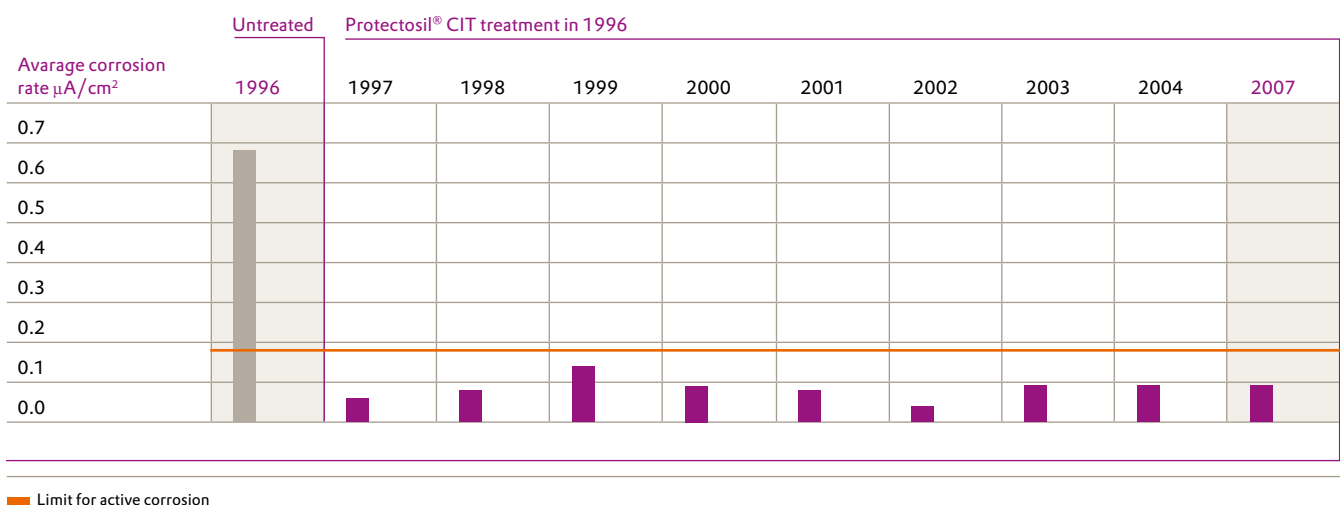


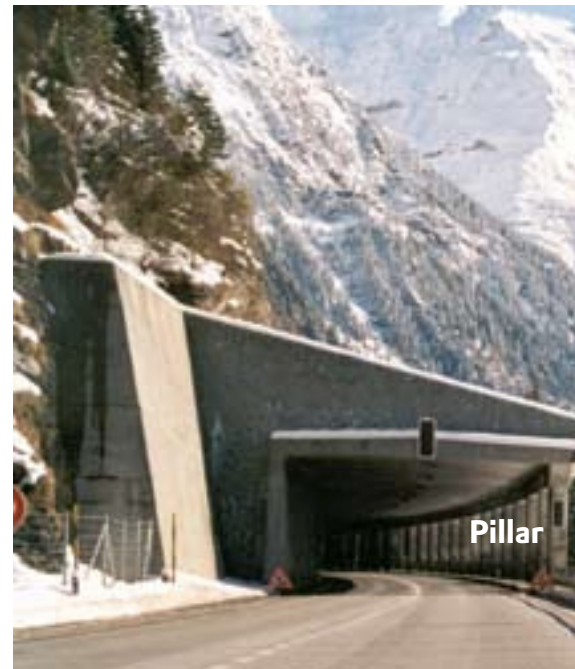
Case Study: "Monroe County Parking Garage"

In parking garages the corrosion conditions are challenging. In 1996, the average corrosion rate of Monroe County Parking Garage (a 30-year-old building in Pennsylvania, USA) was measured to evaluate the risk for corrosion of reinforced concrete. The corrosion rate indicates the risk of rebar corrosion. Below $0.2 \mu\text{A}/\text{cm}^2$ there is no significant risk of active corrosion. Above this, the steel concrete construction may be

significantly damaged. In the Monroe County Parking Garage, the corrosion rate before the Protectosil® CIT treatment was $0.68 \mu\text{A}/\text{cm}^2$ - a major risk. This may have been due to significant amounts of deicer salt brought in by cars in the winter. After the Protectosil® CIT treatment, the rate dropped to below $0.1 \mu\text{A}/\text{cm}^2$. And even though the treatment with Protectosil® CIT was not repeated, the protection is still strong – 11 years later.

Protectosil® CIT essentially halted corrosion in a parking garage for over 11 years!





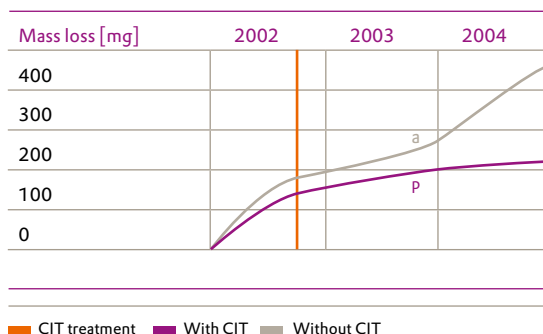
Case Study: “Treatment of Pillars of the Galleria Cianca Presella”

Online-monitoring for continuous control of effectiveness

Galleria Cianca Presella is a highway gallery in the Swiss Alps near the San Bernardino Pass, one of the most frequently used passes in the Alps. Protectosil® CIT was used to prevent rebar corrosion. The concrete surface was treated with 500 g/m² of Protectosil® CIT. As corrosion inhibitors have been available only for less than a decade,

longterm measurements are rare. Therefore, it was decided to monitor the electrical potential and corrosion current as an indicator of rebar corrosion. In Galleria Cianca Presella, sensors incorporated into the concrete during construction allow online monitoring of the corrosion behavior via Datalogger System (data are taken every 0.5 hr).*

Protectosil® CIT prevents active corrosion and facilitates the re-passivation of corroding elements



The sensors measured the corrosion current and the corrosion potential. For a more detailed analysis of the measured values, the amount of corroded steel was calculated. This makes it possible to estimate the development of corrosion damage. Shortly after the Protectosil® CIT application (September 2002) the treated concrete pillar showed, compared to the untreated pillar, only a small increase in steel dissolution. Later on, the treated pillar clearly flattens to reach a level corresponding to a passive corrosion level with no further steel loss (label p). Over the same period, a severe activation of the corrosion process is observed for the untreated area (label a). It can be surmised that water and additional chlorides from deicing salts are transported to the sensor elements, thereby significantly increasing the corrosion level.

*Report No 05048 SGK, Field Test with Protectosil® CIT, Swiss.



Mass Modification with Award-Winning Protectosil® DRY CIT*

Protectosil® DRY CIT is the first solid mass modifier for the corrosion inhibition of steel reinforced concrete. It can offer lasting protection to your buildings for decades.

The white free-flowing powder is easily dispersed in concrete mixtures, is easy to process, and requires no special after-treatment. Protectosil® DRY CIT is innocuous according to the German Chemicals Law (ChemG).

The unique mechanism of action of this corrosion inhibitor is twofold. First, the active ingredient reacts with siliceous material in the concrete, thus preventing the ingress of water and water soluble pollutants such as chlorides.

Second, Protectosil® DRY CIT reacts with passivating ferrous oxides around the steel rebar, thus strengthening this protective layer.

Mortars modified with this corrosion inhibitor show excellent wetting properties, while it has no influence on surface appearance, breathability, or paintability of the modified concrete.

*Innovation Award at the DEUBAU 2008 in the category *Product of high architectural quality*. Awarded by AIT, ABIT and Xia intelligente Architektur.



Swiss Society for Corrosion Protection Does 520-Day Stress-Test

External test at SGK
(Swiss Society for Corrosion Protection)

Specimen for measurement:

- concrete block
15 cm x 15 cm x 15 cm
- sensors at
10 mm, 30 mm and 50 mm in depth

Concrete formulation:

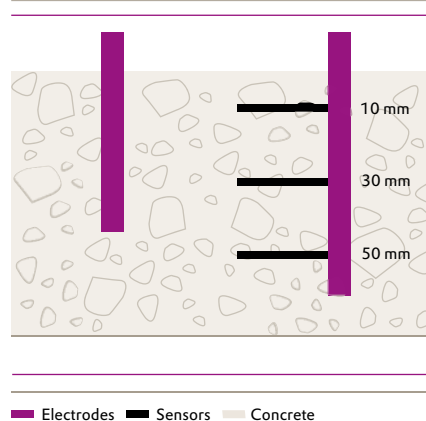
- 350 kg/m³ cement
w/c ratio = 0.6

Test cycles (wet / dry cycles)

- 5 days dry at 35°C and
- 2 days ponding in NaCl Solution.
- overall period of testing: 520 days.

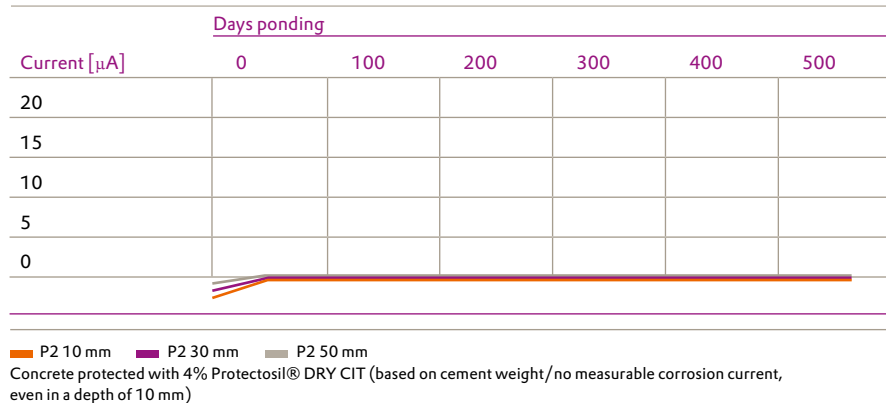
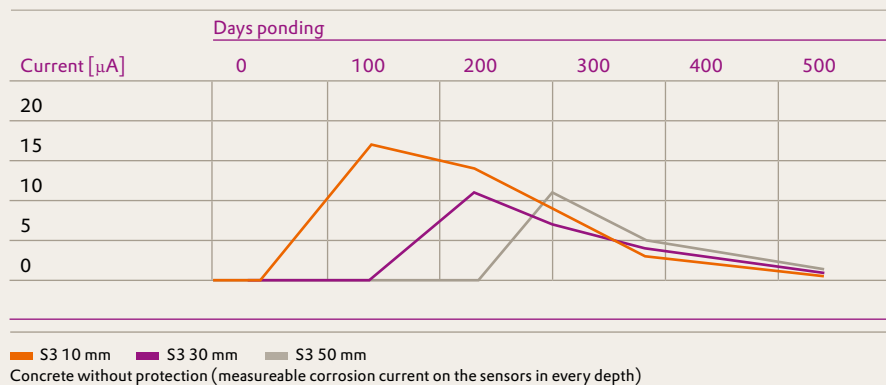
520 days of testing are equivalent to at least 35 years outside weathering.

Test specimen (cross-section)



Protectosil® DRY CIT Offers Perfect Corrosion Protection.

Even in cases where the concrete cover is very thin.



In the above graphs the ponding time of the test specimens is plotted against the current measured between the electrodes. The onset of corrosion is characterized by an observable rise in current on the sensors. In case of the unprotected specimen the onset and progression of corrosion is obvious in

every depth over the 520 days testing period. In the case of the specimen protected with 4 wt% Protectosil® DRY CIT, on the other hand, no onset of corrosion is observable. Even steel rebar at a depth of only 10 mm is perfectly protected over the whole testing period.



SGK Test: 4 wt% of Protectosil® DRY CIT totally prevents the initiation of corrosion of over more than 35 years

520-day testing comes up to at least 35 years outside weathering.

The use of 4 wt% Protectosil® DRY CIT as additive in concrete shows excellent protection:
no start of corrosion during the whole test period at all depths, even at 10 mm.

The unprotected concrete shows first corrosion activation after 50 days.

Technical Performance

- Extremely good storage stability of Protectosil® DRY CIT
- The additive is easy to process
- The additive is highly temperature stable
- Treated concrete shows no significant loss in compressive strength after 90 days of curing
- No special follow-up treatment required
- Concrete corrosion testing at the Swiss Society for Corrosion Protection was successful over 520 days



www.protectosil.com Is a Valuable Source of Information

The Evonik building protection website www.protectosil.com is full of information for professionals who need to keep up-to-date with the latest developments in building protection. If you are interested in learning more about innovative possibilities for protecting valuable constructions against damage and structural injuries, you may be interested in the video animations which explain the functionality of the Protectosil® products. If you have further questions our local sales managers will be glad to get in contact with you directly. By using our contacts directory on our website www.protectosil.com, you can easily find your contact person.

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Evonik. Power to create.