



# Protectosil® DRY-CIT Corrosion Protection

February 2014



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# Protectosil® DRY CIT at a glance



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## Product description

- white, free flowing powder
- odorless
- redispersible in waterborne systems
- total chloride content < 0,1 %
- bulk density 350 ± 100 g/l

## Properties

- part of mix design, prior blending necessary
- protects rebar in concrete from pitting corrosion
- ensures homogeneous distribution of active ingredient
- non-toxic
- mass modification
- water vapor permeable protection
- no influence on surface appearance
- easy handling
- excellent storage stability; frost-resistant



# Protectosil® DRY CIT at a glance



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<p><b>Application fields</b></p>	<ul style="list-style-type: none"> <li>• modification of cement based materials</li> <li>• steel reinforced prefabricated concrete units</li> <li>• concrete structures exposed to high chloride marine environments, e.g. tidal zones and harbor constructions</li> <li>• concrete structures exposed to deicing salts, e.g. tunnels, highways, bridges and parking decks</li> <li>• concrete repair mortars according to EN 1504-3 and EN 1504-7</li> </ul>
<p><b>Consumption</b></p>	<ul style="list-style-type: none"> <li>• 2,0 – 4,0 w% based on cement weight in concrete mixes</li> <li>• 0,5 – 1,0 w% based on weight of dry mortar</li> </ul>
<p><b>Storage/ Packaging</b></p>	<ul style="list-style-type: none"> <li>• storage stability 12 months</li> <li>• 15 kg paper bag</li> <li>• pallet with 45 bags, respectively 675 kg each</li> </ul>

Innovationspreis

Architektur und Bauwesen



**Urkunde**

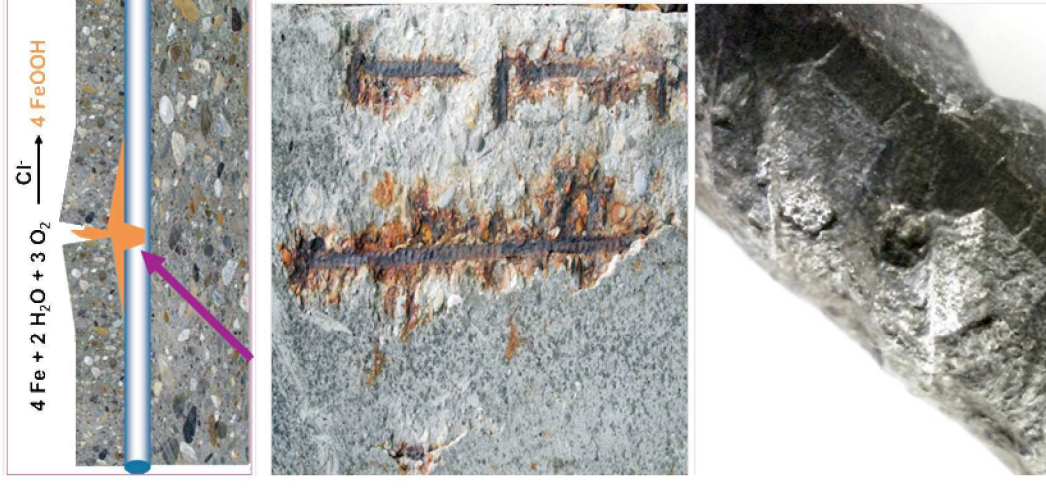
In der Kategorie  
**Produkte von hoher  
architektonischer Qualität**  
wird der Firma  
Evonik Degussa GmbH  
für das Produkt  
**Protectosil® DRY CIT**  
eine  
**Auszeichnung**  
erteilt.

Frankfurt, 08.01.2008



Michael H. Neumann  
Vizepräsident  
Evonik Degussa AG  
Frankfurt am Main

# Effectiveness and durability of standard corrosion inhibitors for mass modifications



## Chemistry of corrosion inhibitors/protection additives used for mass modification

Chemistry	delivery from	leaching over time	durability / long term effectiveness	further comments
Nitrites (mainly Ca-nitrite)	powder	yes	medium	toxic, concentration needs to be adjusted to chloride content.
amino alcohols	liquids	yes	medium	odor
amino carboxylates	liquid on substrate	yes	medium	retardation of cement setting

- Corrosion inhibitors currently available in the market are water soluble and leach out over time
- No proven record of long term effective corrosion protection
- Contaminating and toxic for the environment

# Protectosil® DRY CIT offers long lasting corrosion protection



## Challenges faced by long lasting corrosion protection additives for cement based materials:

- Compatibility of a water insoluble active component with a waterborne system
- Homogeneous distribution through the entire layer to ensure effective performance at all depths independent of surface damage
- Long term protection of reinforced structures with proven chemistry



## Concept of Protectosil® DRY CIT:

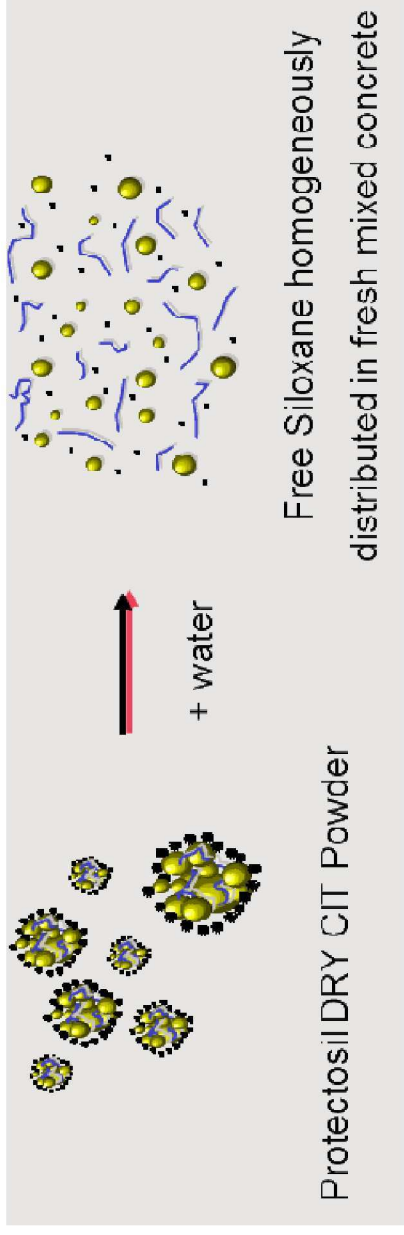
- Encapsulated siloxanes as water redispersible powder
  - Taking advantage of siloxanes proven long term effectiveness
  - Homogeneous distribution ensured by dry premixing before application
  - In situ development of corrosion protection of concrete or mortar, no further treatment necessary.

# Silanes in powder form ensure homogeneous distribution in waterborne systems



## Composition and mechanism of Protectosil® DRY CIT

Protectosil® DRY CIT is a white, free flowing powder consisting of a highly efficient siloxane encapsulated in a water soluble polyvinyl alcohol matrix.



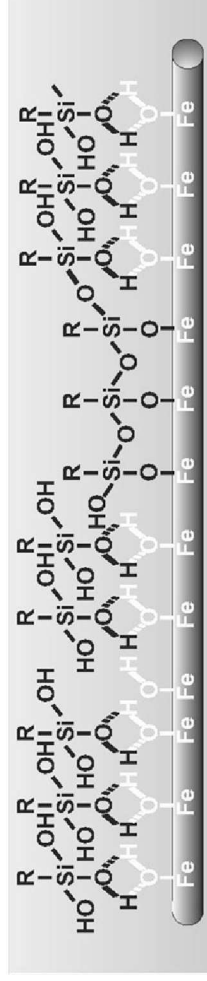
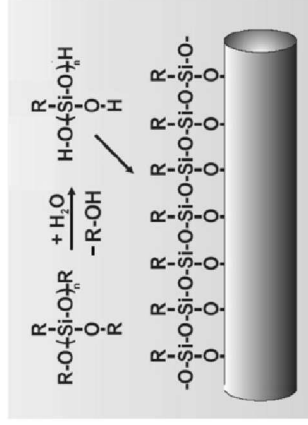
Note: Protectosil® DRY CIT must be part of concrete or mortar mix design

# Protectosil® DRY CIT forms a protective layer at the rebar



During the mixing of the cement based material with water, the polyvinyl alcohol dissolves and releases the encapsulated silanes which are automatically distributed homogeneously throughout the entire mixture.

Siloxanes immediately hydrolyse at alkaline pH-values present in cementitious systems forming silanols. These reactive intermediates will condensate and chemically bind to the surface of the steel rebar.



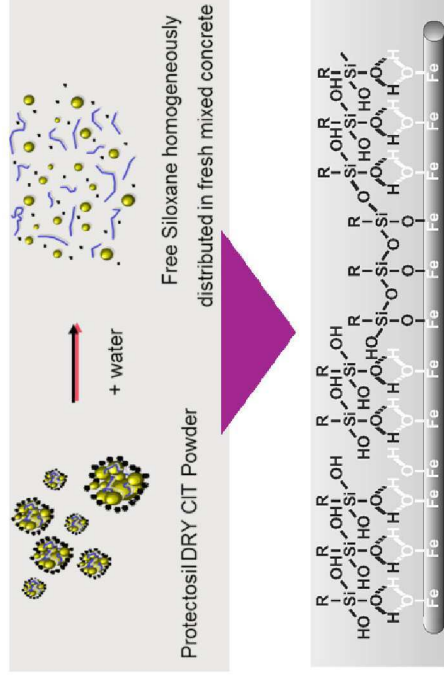
**A protective layer around the steel rebar is formed.**

# Protectosil® DRY CIT in mix designs provides key advantages



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- Homogeneously distributed in the entire layer
- Corrosion protection layer built in-situ
- No additional treatment necessary
- Nontoxic
- Absolutely water insoluble
- No leaching
- Long lasting effectiveness
- Structure remains protected even in case of surface damage or delaminations





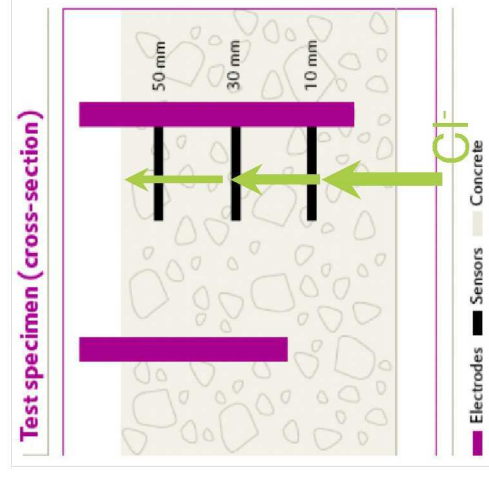
# Monitoring of corrosion activity directly at the rebar is key



## Suitable test method for chloride ion induced corrosion

The Swiss Society for Corrosion Protection (SGK) in Zurich has developed a test method that uses corrosion sensors embedded in concrete exposed to wet immersion and dry phases.

This test setup resembles a classical battery. Once corrosion is initiated and electrons move from the rebar (anode) to the cathode, the intensity of the electronic current allows to conclude on the corrosion activity.



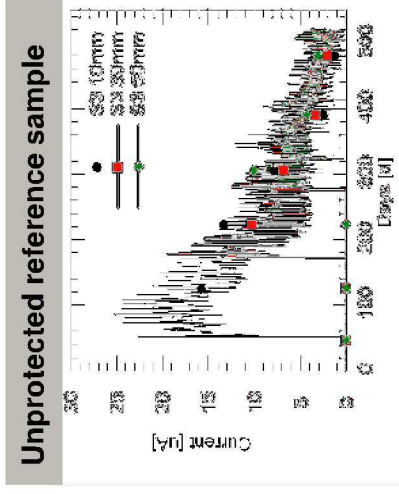
Their findings suggest that exposed structures are on average subjected to two chloride ion penetration periods per year.

## SGK test results show outstanding corrosion protection performance of Protectosil® DRY CIT

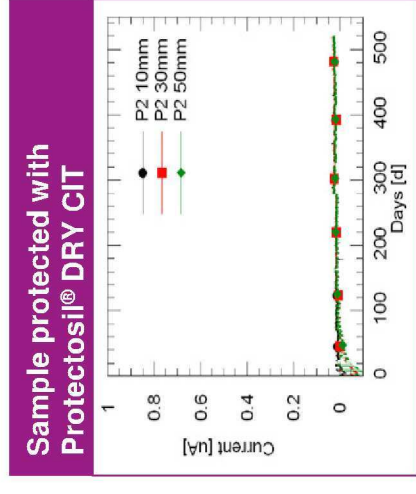


- Test was stopped after 520 days (corresponding to 30-35 years of outside exposure).

- Reference had showed heavy signs of pitting corrosion at all depths.



- Protectosil® DRY CIT showed an outstanding performance, no signs of corrosion were detected on all three test sensors despite an chloride ion content that significantly exceeds the critical chloride threshold.



## In house corrosion test setup enables in-situ investigation of corrosion activities in mortar

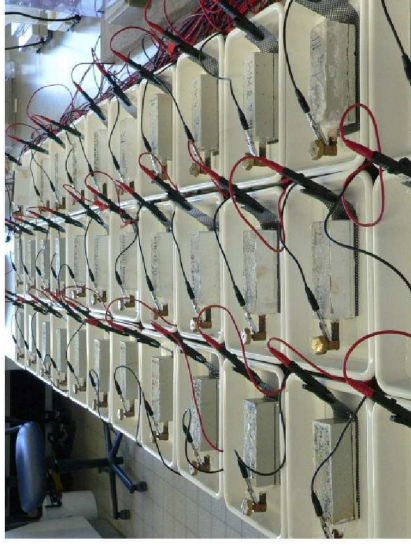


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**A “lollypop” test method was developed based on SGK test setup to measure corrosion activity in mortar samples, following EN1504-3:**

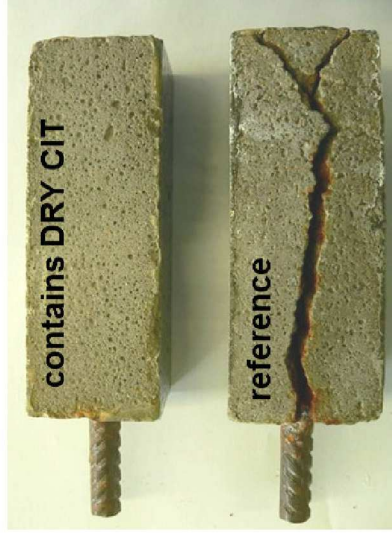
A rebar is fixed in the center of a mortar sample. After the mortar test sample has fully cured it is subjected to corrosion cycles. Each cycle lasts for 7 days and consists of an immersion & drying phase:

- Immersion in NaCl solution
- Drying at 35°C



After each cycle the samples are carefully inspected for possible cracks. Once pitting corrosion was initiated, the samples were generally damaged by large cracks reaching down to the rebar within approximately 4-5 weeks.

After further cyclic salt water ponding, the cracks widened leading to the destruction of the mortar sample, see lower example on the right. Both depicted samples were tested for the same period of time.

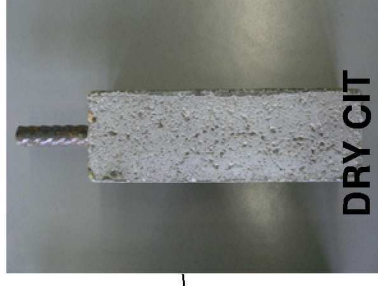
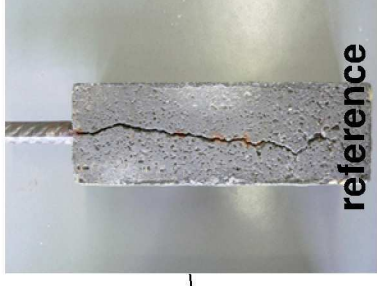
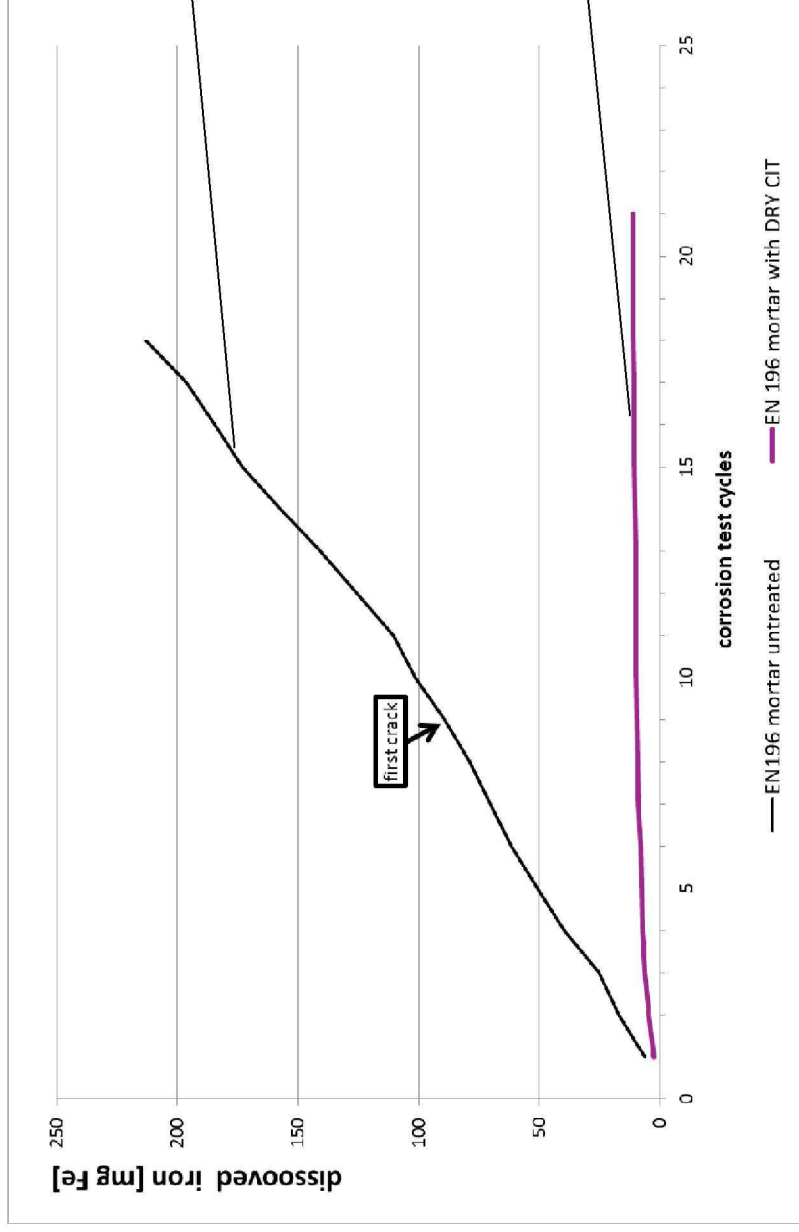


The level of corrosion activity is directly related to the loss of iron mass



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Cumulative amount of dissolved iron during test cycles  
(calculations based on Faraday's law)



# Protectosil® DRY CIT in concrete mix designs



## Corrosion testing of concrete corresponding to 28 years of field exposure

Reference without additive

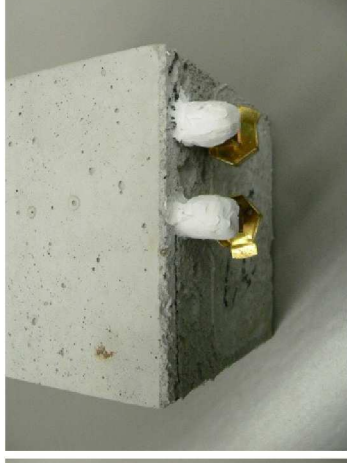


24 cycles  
(12 years):

2% DRY CIT on cement



3% DRY CIT on cement



56 cycles  
(28 years):

Cracks (after 33 cycles),  
significant rust staining

No cracks,  
marginal rust staining

No cracks,  
no rust staining

**Protectosil® DRY CIT modified concrete shows outstanding performance after 56 cycles of salt water ponding.**

## Protectosil® DRY CIT in shotcrete applications (SPCC)



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### **Shotcrete applications**

Protectosil® DRY CIT was added into a SPCC formulation at a ratio of 2% based on cement weight. The rebars were placed at a depth of 15 mm and 35 mm before application.

Protectosil® DRY CIT modified SPCC showed excellent spraying properties. The smoothing of the surface after the spray trials proved easier compared to the non-modified reference.



## Protectosil® DRY CIT suits for cement based system exposed at challenging environments



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### **Protectosil® DRY CIT provide key advantages in following applications:**

- modification of cement based materials
- steel reinforced prefabricated concrete units
- concrete structures exposed to high chloride marine environments, e.g. tidal zones and harbor constructions
- concrete structures exposed to deicing salts, e.g. tunnels, highways, bridges and parking decks
- concrete repair mortars according to EN 1504-3 and EN 1504-7



# Protectosil® DRY CIT corrosion protection agent



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## Product description

Protectosil® DRY CIT is a highly reactive, water redispersible corrosion inhibition agent in powder form based on encapsulated siloxane technology

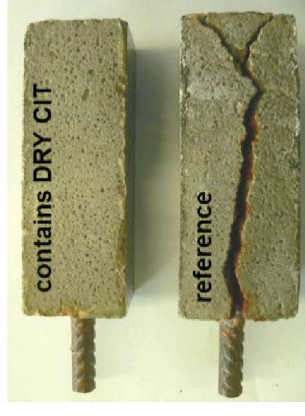
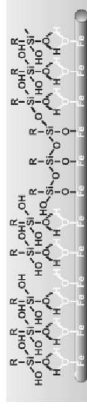
It can be used as mass modification in all kind of cement based applications.

Protectosil® DRY CIT has excellent storage and flow properties and is stable at high temperatures such as freshly produced cement.

Protectosil® DRY CIT is stable at high temperatures.

Main applications are

- Industry for precast concrete elements
- Modification of cement
- Concrete repair systems
- Special concretes for challenging exposures ( e.g. seaside, or high thaw salt exposures)



**Note** – Methods for polymer modification of mineral, hydraulic setting or cementitious coating agent and binder compositions using water-redispersible powders are protected by DE (No.195 42 443), US (No. 6,090,868) and TW (No.379207) patent. For use of said patents in the countries Germany, USA and Taiwan the consent of the patentee is required.





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