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What you should know about....

Corrosion of iron and steel structures & protection against corrosion

Presentation by:

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Corrosion & Corrosion Protection

AGENDA

1. Corrosion of iron and steel structures
2. Standards & terms
3. Protection against corrosion –HCP by Sikla
4. Applications

Corrosion & Corrosion Protection

1. Corrosion

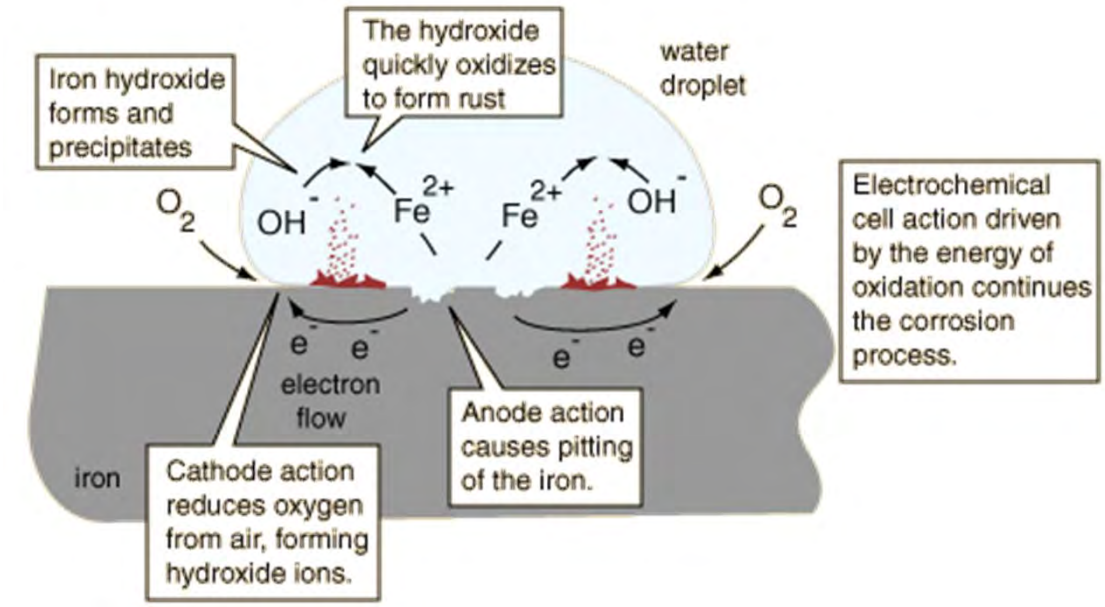
Corrosion as an electrochemical process

RUST

„Corrosion is a natural process that converts a refined metal to a more chemically- stable form, such as ist oxide, hydroxide or sulfide… Rusting, the formation of of iron oxides, is a well-known example of electrochemical corrosion.

Source: Wikipedia

Corrosion as an electrochemical process



RUST

2. Standards & Terms

- **Standards**
- **Duration of protection- Service life**
- **Corrosivitiy categories**

Corrosion

Corrosivity categories according DIN EN ISO 14713-1:2010-05

Loss of zinc layer thickness r_{corr} (µm /a)*)	Exposure / Impact	DIN EN ISO 12944-6:2018-06, Neutral salt-spray-test (NSS) (protection-period)	Example for typical environments / micro climate-DIN EN ISO 9223:2012-05 outdoor	inside
C1 $r_{corr} \leq 0,1$	very small	Not applicable	Dry or cold climate, atmosphere with little contamination and low humidity, e.g. some deserts or arctic regions.	Heated rooms with low humidity and very little contamination, e.g. offices, schools or hotels
C2 $0,1 < r_{corr} \leq 0,7$	small	480 h (interpreted as very high-VH)	Moderate clima, atmosphere with little contamination (SO_2 < 5 µg/m³), e.g. country side, small town. dry or cold clima, atmosphere with little rain, e.g. desert or subarctic regions.	Non-heated rooms with inconstant temperatures and humidity. Rarly condensation and low contamination, e.g. stock or sport hall.
C3 $0,7 < r_{corr} \leq 2,1$	medium	120 h (interpreted as low-L) 240 h (interpreted as medium-M) 480 h (interpreted as high-H) 720 h (interpreted as very high-VH)	Moderate clima, atmosphere with medium contamination (SO_2 5 µg/m³ to 30 µg/m³) and/or low contamination by chloride, e.g. urban areas, see-side with low chloride-impact, sub-tropical and tropical regions	Rooms with casual condensation and medium contamination, e.g. food-industry, laundries, breweries or dairies
C4 $2,1 < r_{corr} \leq 4,2$	strong	240 h (interpreted as low-L) 480 h (interpreted as medium-M) 720 h (interpreted as high-H)	Moderate clima, atmosphere with medium contamination (SO_2 30 µg/m³ to 90 µg/m³) and/or medium to high contamination by chloride, e.g. town, industrial areas, sea-side without moisting of salty water, e.g. sub-tropical and tropical clima with medium contamination.	Rooms with frequent condensation and large quantities of airborne pollution due to production processes, e.g., industrial plants, swimming pools, coastal near shipping yards and ports
C5 $4,2 < r_{corr} \leq 8,4$	very strong	720 h (interpreted as medium-M)	Moderate and subtropical climate, atmospherical environment with very high pollution (SO_2: 90 µg/m³ to 250 µg/m³), and/or with significant influence by chlorides ,e.g., industrial areas, coastal areas, protected locations at the coastline	Rooms with very high frequency of condensation and/or large quantities of airborne pollution due to production processes,e.g., mining, hollow spaces for industrial purposes, not ventilated halls in subtropical and tropical climate zones
CX $8,4 < r_{corr} \leq 25$	extreme	Not applicable See DIN EN ISO 12944-9:2018-06	Subtropical and tropical climate zone (very long duration of humidification), atmospherical environment with very high degree of pollution due to SO_2 (more than 250 µg/m³) including collateral and production related pollution and/or strongly affected by chlorids,e.g.,areas with intensiv industrial exploitation and extreme high level of pollution, coastal- and off-shore areas, incidental contact with salt spray mist	Rooms with almost permanent condensation or long duration to contermination including high level of humidity and/or rooms with high level of pollution due to production processes,e.g., not ventilated halls in humid tropical climate zones with extreme pollution from outside air, incl. contained chlorids and corrosion supporting dust

*) Average annual loss of layer (only of zinc-layer)

Corrosion & Corrosion Protection

2. Protection from Corrosion- HCP

HCP

The defintion "High Corrosion Protection" - stands for optimal corrosion protection for different connecting elements. HCP-finish is a special kind of coating with one result. Sikla is offering you for the applications in corrosive category C1 up to C4 according to DIN EN ISO 12944 the individual adjusted corrosion protection with the following available coating systems:

- hot-dipped galvanised according to DIN EN ISO 1461 resp. DIN EN ISO 10684
- High Performance corrosion protection consisting of zinc flake coating according to DIN EN 13858 resp. DIN EN ISO 10683
- Innovative zinc-nickel surface coating

The protective effect of all HCP-coating systems is corresponding at least to the well established hot galvanisation with hot dip metal coating.

To select the optimal surface coating for your demands, we attach great importance to the protective effect, the preservation of the functionality (e.g. mobility of the thread), market requirement and economic feasibility.

It is recommended that contact between the HCP finish and Stainless Steel is isolated to prevent bi-metal corrosion in accordance with EN 14713-1.

For projects with special requirements to the corrosion protection our customer service in collaboration with you will find the suitable surface coating.

HCP

Sikla - Corrosion-Protection Finishes

Update 01/ 2019

Technology	Parts	Standards / Description	Layer	Layer thickness [2]	First visible corrosion at salt-spray-test [3]	Suitable for corrosivity class [4] C1	C2	C3	C4	C5	CX
Electro-galvanizing	metal parts	acc. DIN EN ISO 2081:2008	Fe/Zn	12 µm [1]	~120 h	-	-	-	-	-	-
	threaded parts	acc. DIN EN ISO 4042:1999-10	Fe/Zn	~ 8-12 µm [1]	~120 h	-	-	-	-	-	-
Pre-galvanizing	channel	acc. DIN EN 10346	Z 140 [5]	10 µm [1]	~240 h	VH	H	M	L	-	-
			Material thickness								
HCP (High Corrosion Protection)	metal parts	**HDG** acc. DIN EN ISO 1461:2009-10	> 6 mm	70 µm [1]		-	-	VH	H	M	-
	SiFramo	**HDG** acc. DIN EN ISO 1461:2009-10	>3 to < 6 mm	55 µm [1]		-	-	VH	H	M	-
	Channels	**HDG** acc. DIN EN ISO 1461:2009-10	> 1.5 > 3 mm	45 µm [1]		-	-	VH	M	L	-
		Zinc flake coating acc. DIN EN ISO 10683 and DIN EN 13858		5- 15 µm [6]	~720 h	-	VH	VH	H	M	-
	threaded parts	**Zinc nickel coating** acc. DIN EN ISO 19598		8 - 10 µm [6]	~720 h	-	VH	VH	H	M	-
		KTL Multilayer special coating	Certificate [7]			-	VH	VH	VH	H	-
Aluminium	channel	EN AW 6060 T66 / EN AW 6063 T6	-	-	-	H	H	H	H	M	
	aluminium parts	EN AW 6060 T66 / EN AW 6063 T6	-	-	-	H	H	H	H	M	

Protection until first revision acc. DIN EN ISO 12944-1:2019-01

L = "low"	up to 7 years
M = "medium"	7 to 15 years
H = "high"	15 to 25 years
VH = "very high"	> 25 years

Foodnotes:

[1] Theoretical minimum layer thickness
[2] Theoretical values
[3] Neutral salt-spray-test acc. DIN EN ISO 9227:2012:09
[4] Acc. To DIN EN ISO 14173-1:2010-05
[5] Theoretical layer thickness, table 11; DIN EN 10346
[6] Theoretical layer thickness- min.- max.
[7] Prüfzertifikat- Prüfbericht 150104/140641.1 iLF Forschungs- und Entwicklungsgesellschaft Lacke und Farben mbH

HCP- coatings

Loss of thickness rates for galvanised articles according to corrosivity category (cf. DIN EN ISO 14713-1:2010-05, Table 1)

Corrosivity category	Loss of thickness [µm/year]	Service life of corrosion protection (galvanised articles) for base material thickness > 3 to ≤ 6 mm with a local minimum coating thickness of 55 µm [years]
C1	≤ 0.1	> 100
C2	0.1 - 0.7	> 100 - 78
C3	0.7 - 2.1	78 - 26
C4	2.1 - 4.2	26 - 13
C5	4.2 - 8.4	13 - 6.5

Hot dip galvanising (of fabricated articles) according to DIN EN ISO 1461

A proven and well-known corrosion protection coating, which is used in categories up to C4 and C5. Tenders and projects often specify a minimum layer thickness. Less well-known is that the standard determines and specifies the layer thickness in relation to the thickness of the material being coated. The layer thickness ranges from 45 to 85 µm.

Hot dip galvanising is unsuitable for more delicate forms (such as small drilled holes or blind hole threads). Hot dip galvanising may also be unfavourable depending on the design. During the necessary pickling and subsequent drying process, acid residues can remain trapped in joints and gaps. After hot dip galvanising, these residues are not visible and lead very quickly to the formation of red rust and to "rust bleeding" from the gap after exposure to moisture for the first time.

Zinc layer thicknesses according to material thickness (cf. DIN EN ISO 1461:2009-10, Table 3)

Thickness of base material [mm]	Local minimum coating thickness [µm]	Average min. coating thickness [µm]
> 6	70	85
> 3 to ≤ 6	55	70
≥ 1.5 to ≤ 3	45	55

HCP- coatings

Zinc-nickel coatings according to DIN EN ISO 19598

This coating was originally developed for the automotive industry, which has stringent requirements for corrosion protection against exposure to temperature, salt and climatic influences.

Zinc-nickel coatings are applied using a so-called electrolysis method. This involves applying a voltage to a conductive solution containing metal ions, which causes a metallic layer to form on the electrodes. The cathodes used in the electroplating process are the components that require coating.

The corrosion resistance of zinc-nickel coatings is around 10 times higher than that achieved with hot dip galvanising. For this reason, the layer thicknesses can also be reduced by a factor of 10 (about 8 to 10 µm).

Properties of zinc-nickel coatings

Type of surface protection	Coating thickness [µm]	Loss of thickness/year in comparison to galvanised fabricated articles	Minimum test duration of salt spray test with no corrosion on base material [h]
Galv. zinc/nickel alloy coating	8 - 10	1/10	720

HCP- coatings

Zinc flake coatings according to DIN EN ISO 10683 and DIN EN 13858

These also have their origins in the automotive industry. They have also been used in the construction industry for quite some time, for protecting components made of high-strength steel (such as screws with strength class >10.9, high-strength nuts, structural parts with tensile strength >1,000 N/mm² etc.). The background to this is the risk of hydrogen embrittlement when using galvanic coating processes.

The layer thickness of 5 to 15 µm is also significantly reduced in comparison to hot dip galvanised components, since the resistance to corrosion is much better. This type of coating is called cathodic protection, whereby the coating "sacrifices" itself to protect the base metal. There is no undermining of the corrosion protection.
The excellent properties of this coating system have been tested and confirmed by MPA Stuttgart.

Type of surface protection	Coating thickness [µm]	Loss of thickness/year in comparison to galvanised fabricated articles	Minimum test duration of salt spray test with no corrosion on base material [h]
Zinc flake	5 - 15	1/10	720

HCP- Salt Spray Testing

Cantilever Bracket 41/41 after 1,440 h salt spray test;
Above: zinc-lamella coated
Below: zinc-galvanised

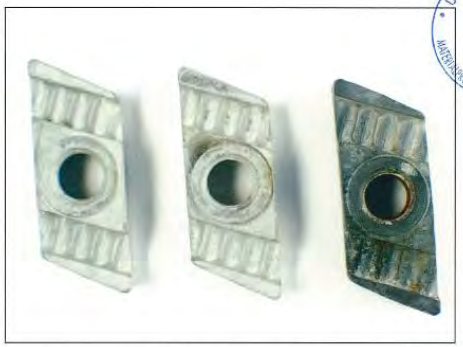


Abb. 27: Gewindeplatte HZ 41-M 10 nach 10 Zyklen KWF; links 2x EOT 400, rechts stückverzinkt

Abb. 1: Trägerklammer TCS M10/M10 nach 1440 h SS-Test; links EOT 40 rechts stückverzinkt

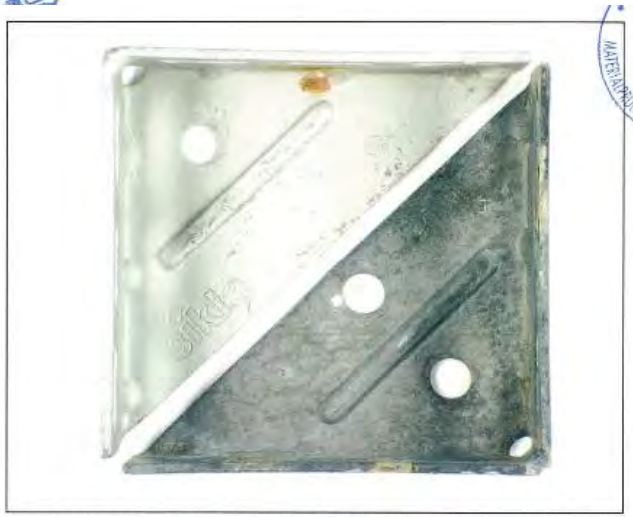


Abb. 32: Winkelkonsolen 100/100 nach 10 Zyklen KWF; oben EOT 400, unten stückverzinkt

HCP- Salt Spray Testing

sikla **Salt Spray Test as per DIN EN ISO 9227 (issue 10.06)**		Test order no..: 19/11	Up until red rust appears
		Date: 15/11/11	Tested by: tester 1
Client: 720814	Order no: internal Delivery note: internal	Coating: Zn Ni SIKLA-special 026/02	
Manufacturer:	item: channel nut code: GP 41 (180182 blk)		

SST – Test without thermal pre-treatment 3 parts tested Zn Ni Result: see below	**SST – Test without thermal pre-treatment** 3 parts tested Zn Ni result: see below
	
after 288 hours SS – Test – no red rust	**after 744 hours SS – Test – no red rust**

HCP- Testing of SiFramo for C5I

TEST CERTIFICATE

Test report-No.:	150104//140641.1
Client:	Sikla GmbH In der Lache 17 D – 78056 Villingen-Schwenningen
Subjects of testing:	coated test panels and coated end support STA and beam section TP F connect with self forming screws FLS according to the assembling instruction of the client
coating systems:	Substrate: Steel, Sa 2 ½ blasted Conversion layer: dip zinc phosphating, Granodine 958 company Henkel
Coating:	cataphoretic coating, Cathoprime QT 82-7035 company BASF top coat: RAL 7035 smooth, Code 87446 PE/P/HD company Inver

The tested coating system fulfils the requirements in accordance with DIN EN ISO 12944-6 corrosivity category C 5M high.

Magdeburg, 10.04.2015

iLF Forschungs- und Entwicklungsgesellschaft Lacke und Farben mbH

Dipl.- Chem. Cornelia Dreyer
Lab supervisor Application Technology

Subjects of testing: coated test panels and coated end support STA and beam section TP F connect with self forming screws FLS according to the assembling instruction of the client

The tested coating system fulfils the requirements in accordance with DIN EN ISO 12944-6 corrosivity category C 5I high.

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