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Surface protection with ikorol® shield

Abstract:

The effective anti-corrosive protection of corroded surfaces, narrow gaps and the bottom of deep pits without possibility of their thorough cleaning is a significant challenge. Similarly, there are many problems when painting high skeletal structures (e.g. power poles) or devices whose abrasive blasting is not allowed (e.g. power station equipment).

*An anti-corrosive **ikorol®** shield, with exceptional penetration properties, developed by scientists from the Laboratory of Technological Processes of the Chemical Faculty of the Warsaw University of Technology, is intended for preparation of not completely cleaned, crevices and pits before painting.*

*Keywords: anti-corrosive **ikorol®** shield, surface preparation, protective coatings, corrosion protection, undercoating corrosion, penetration properties*

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INTRODUCTION

In practice of anti-corrosion coatings, there are cases where it is necessary to protect corroded surfaces that cannot be cleaned before applying paint coatings. What then?

Typical examples are the interior of narrow crevices or the bottoms of deep pits on very highly corroded surfaces, as well as tall frame structures (e.g. power poles), located in difficult terrain or devices where abrasive blasting is not allowed, (e.g. in power stations).

*In such cases, anticorrosive paints with corrosion inhibitors (mainly phosphate pigments) are used, which, however, do not always show sufficient protective features due to relatively **low penetration properties**. Air and moisture enclosed under the varnish coat cause the initiation of under-coat and crevice corrosion, which in turn leads to delamination or crazing of the coatings and corrosion of the steel substrate after a short operation period (usually less than 5 years).*

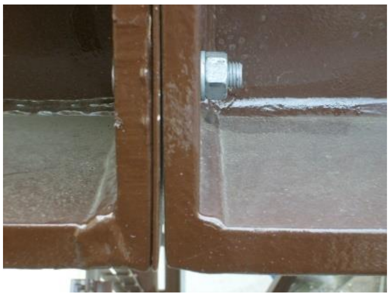
Attempts to use the so-called "rust convertors" popular at the end of the last century did not produce satisfactory results because the hydrophilic components of the convertors initiated blistering of the coatings.

*Therefore, there were concerns if the application of **ikorol®** shield would not reduce the adhesion of paint coatings to steel surfaces of various degrees of preparedness and whether exposure of coatings in atmospheric conditions would not reduce the adhesion of coatings to the surface.*

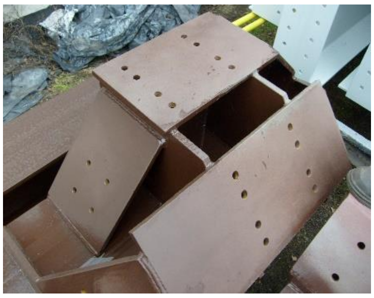
*On new elements of bridge structures, **often there are areas left, which after joining the structure are flooded with concrete** and enter the reinforced concrete structure. These elements after a very short time, already on the storage yard, **despite being protected with foil, are corroded** and look like in the photos below. Obviously, **corrosion continues on such elements**, after being flooded with concrete.*

*The most common mistakes in the construction of steel structures include: **failure to remove welding spatter**, **failure to process welds** or **failure to chamfer edges to the required radius**, as cleaning and painting contracts usually do not cover these activities.*

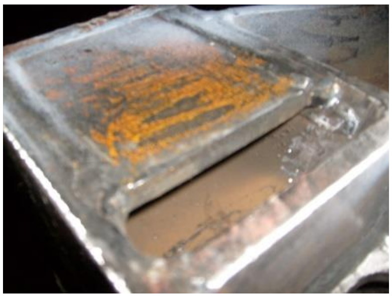
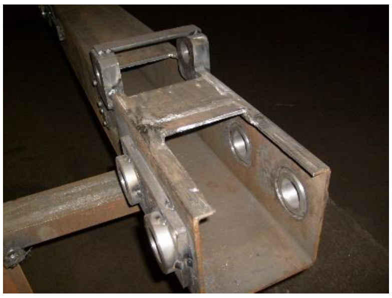
*The presented photos show a very important problem that almost always occurs during the assembly of steel structures on the construction site. It is associated with the **lack of contact of the rebate planes**, the **necessity to insert stabilizing sheets** – not always well cleaned and protected against corrosion – or the necessity to **cut holes in closed profiles** in order to make screw connections possible. Often, these cuts and the inside of the profiles remain, due to inability, **without anti-corrosion protection**.*
If we add to this transport or assembly damage being present also on the rebates, then we must be aware of serious risks.



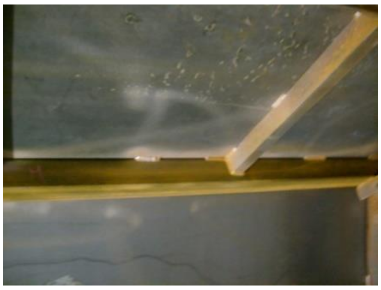
*Another problem is **hard-to-reach places** or **designing I-sections in such a way that the web welded diagonally to the column is a container for water** only because **technological holes have been forgotten** to enable it to drain. There is always condensation of water and other chemical compounds in these places.*

The photos below show that the contractor did not blast the individual elements prior to welding, knowing that they would not be closed profiles. Thus, the problem of good cleaning or other protection remains.

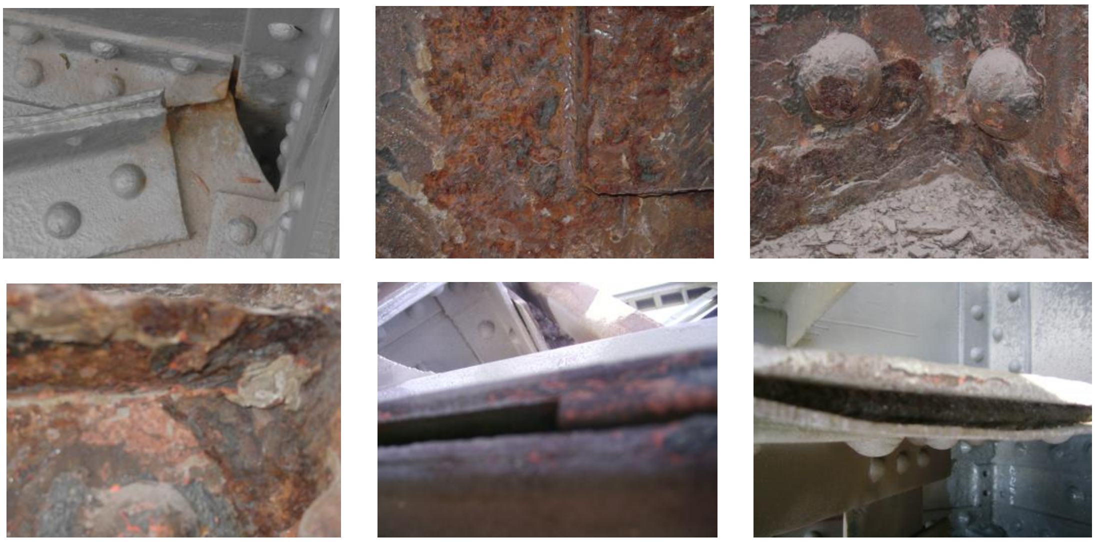
The structure made of closed profiles was surrounded by a metal sheet. The contractor of the structure did not clean it by abrasive blasting of tangent places. The method was used - application of the first layer of paint, silicone called SIKAFLEKS and then application of subsequent layers of paint.

*The main problems are the **joints of the concrete slab with the steel structure of the span**, hard-to-reach places such as **pockets**, **steel angles welded with intermittent weld**, very **deep pits** and many others.*

Below one can see fragments of a riveted bridge ruined by corrosion.



Therefore, there is a need for a preparation that would enable the painting of steel surfaces of various degrees of preparedness (e.g. with flash rust), without decreasing the adhesion of coatings to the substrate just after painting and after seasoning/exposure under atmospheric conditions.

The purpose of this article is to present the results of tests checking the properties of the ***ikorol®*** *shield, given in the technical data sheet, used for the preparation for painting of surfaces with various degrees of preparedness before applying typical coating systems.*

Characteristics of the ikorol® shield (extract from the Technical Data Sheet 2020)

ikorol® is a surface shield used for the preparation of steel, zinc-coated surfaces, heavily corroded weathering steel (known as “corten steel”), and surfaces coated with old but well-adhered paint. **ikorol®** shield is applied prior to any anticorrosive coating systems.

ikorol® shield contains organic solvents and derivatives of benzaldoxime that can form complexes and react with rust. The active components of **ikorol®** shield form stable complexes with iron, zinc and aluminium, that are insoluble in water, which inhibit corrosion of metals and make their surface hydrophobic. The product improves the adhesion of the applied coating system and stabilizes the corrosion products remaining on the metal surface. **ikorol®** shield also acts as a surface activator in relation to paint. **ikorol®** shield is not an oil inhibitor.

Due to outstanding penetrating properties **ikorol®** shield penetrates deep into cracks and scratches to form an effective primer-tack coat for coating systems and filling compounds (putties).

The thin layer of **ikorol®** shield coating provides an adhesion for typical paint coatings. It can be applied to corroded steel surfaces (once loose rust has been removed) and to coatings that exhibit chalking after mechanic cleaning with steel brush. On average it increases the adhesion of the coating system by 3–4 MPa. The use of **ikorol®** eliminates the unfriendly process of the thoroughly cleaning of the steel surfaces from rust, i.e. sandblasting, grinding or chemical etching, that is required when applying most paints. **ikorol®** shield prevents blistering and improves the elasticity of the entire coating to prevent cracking, peeling and falling off. It extends the service life of coating systems by increasing the adhesion and corrosion resistance. It works especially well wherever it is not possible to clean the surface with any method, i.e. in hard-to-reach places or in potentially explosive atmospheres – it received the technical recommendation of the Road and Bridge Research Institute in Warsaw No. RT/2011-02-0086 and the hygienic certificate of the National Institute of Hygiene No. HK/B/0982/2011.

Industrial case studies on the **ikorol®** shield have been successfully completed for painting systems applied on high voltage poles, on bridges, on telecommunication masts, in petrochemical plants and for renovation painting of steel constructions: i.e. car bodies, entrance gates or fences as well as in the conservation of monuments.

ikorol® can be used together with different types of solvent-based paints, varnishes and putties (including epoxide, polyurethane, epoxy-ester, chlorinated rubber paints, acrylic paints, modified alkyd paints and paints based on mixed synthetic resins). The minimum recommended thickness of the varnish coating is 60 μm, as such thickness of coating prevents discoloration (change of color) in light-colored and one-component paints (single-layer coating). **ikorol®** shield itself, without additional painting can be used for temporary protection up to 12 months.

Due to skin irritating properties of **ikorol®** shield, protective gloves and protective clothing must be used. If the product gets into the eye, it will cause risk of serious eye damage, therefore wearing goggles or glasses is required. If used in confined space, ensure good ventilation.

When using larger amounts of **ikorol®** shield in closed rooms, due to the high flammability (flash point: 12°C, auto-ignition temperature: 400°C) and the risk of explosion from vapors, it is recommended to follow ATEX regulations, and in particular to use electrical devices in explosion-proof version, i.e. marked with the Ex symbol, group IIA, temperature class T2. It is forbidden to smoke and use open fire.

FIELD RESEARCH

Standards and instruments used in corrosion tests

The tests were conducted based on the requirements of:

- ISO 9001, PN-EN ISO 12 944 standards in full along with the referenced standards, ISO 4624 (*pull off*), ISO 16276-1 (cross cutting), and PSK-01: 2005 procedures,
- tests of adhesion of coatings with the peel method, "pull off", carried out with the use of the HYDRAULIC ELCOMETER JPC 89 No. 1323631,
- the surfaces were cleaned with the abrasive blast method, using broken steel grit, granulation 0.9–1.0 AM and 1.0–1.2 AM (plates 1–6) and copper slag (samples 7–9) PN-90 / M-81090,
- stamps were glued with cyanoacrylate glue ELCOMETER M 2000, No. 11135,
- for the evaluation of the results, the required detachment force – min. 3 MPa,
- climatic conditions were checked with the ELCOMETER – 219 DEW CHECK MD 5766 device in accordance with the EN ISO 12944-8, IDT ISO 3270, PN EN 23270 and EN ISO 554 standards,
- dry coating (film) thickness testing was performed with the ELCOMETER 456 AM0182, F-l 16251, measurements were made in accordance with EN ISO 12944-8 and EN ISO 2378, prior to the measurements, the device was calibrated in accordance with BS EN ISO 19840 standard,
- the adhesion was checked with the QALICHECK MASTERPAINTPLATE device, the test were performed in accordance with EN ISO 2409 2-3, PN-EN ISO 4618, PN-EN ISO 12944, ISO 16276-1, ANEX A and the PSK-01: 2005 procedure.

Determination of adhesion

The adhesion of paint coats (films) was determined on the basis of two tests:

1. "Cross-cutting" test – the degree of adhesion was determined on a grading scale of 0–5 (Fig. 1).
2. "Pull off" test – the breaking strength was determined. Adhesion is good when force is ≥ 3.0 MPa.

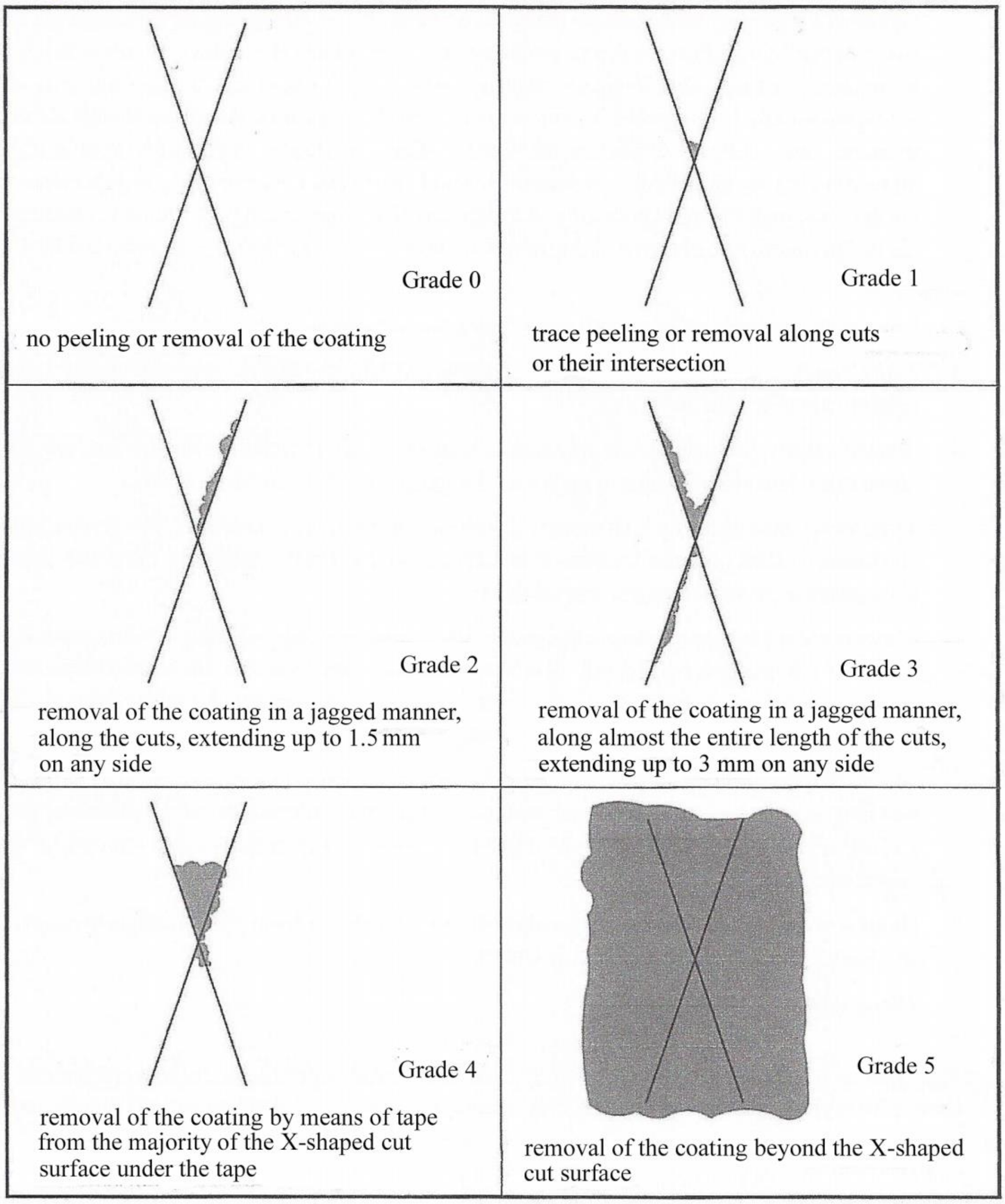


Figure 1. Grading scale in accordance with the Polish standard PN-EN ISO 16276-2, from 0 to 5. Adhesion of the coating is determined according to the appearance of the incision.

Types of samples

First, 6 test panels measuring 300 x 300 mm were made, to which 150 x 80 mm channel sections (C profiles) were welded with an interrupted weld (Fig. 2). The plates and channels were slightly corroded (B condition according to PN-EN ISO 8501-1). Samples 1 and 2 were not cleaned (condition B). The remaining four samples (3–6) were blast cleaned with broken GH 18 steel grit without hawking (BSt2.5 condition).

Figure 2. Panels No. 1 (left) and no. 2 (right) (condition B) – painted with **ikorol** shield

Then, three test elements were prepared from a highly corroded 200 x 200 mm angle (condition C according to PN-EN ISO 8501-1), to which a corroded 80 mm wide flat bar was spot welded. The samples thus obtained were purified as follows:

- sample 7, without any cleaning (**C** condition),
- sample 8, cleaned manually with a wire brush (**CSt1** condition),
- sample 9, blasted with a copper slag (**CSt2.5** condition).

Examples of test samples are shown in Fig. 3.

Figure 3. Appearance of heavily corroded samples – No. 7 (left) (condition **C**) without any cleaning, No. 8 (middle) (condition **CSt1**) after manual cleaning with a wire brush, No. 9 (right) (condition **CSt2.5**) after blasting with copper slag

Coating systems and testing

At first samples were covered with one layer of the **ikorol®** shield and after 1 hour the painting systems were applied. After application, the coatings were cured for 21 days in a laboratory atmosphere at 18–20°C and then exposed (seasoned) for 14 months at the field station in the downtown of Katowice. After hardening and after seasoning in field conditions, the adhesion of the coatings was assessed using the peel off method according to PN-EN ISO 4624 and the X cut according to PN-EN ISO 16276-2. After completion of the field exposure, the welded elements were cut off and the condition of the metal and the presence of the **ikorol®** preparation in the crack were assessed. The paint systems used and the results of the coating adhesion tests, pull-off and through the X-cut, are shown in selected photos (Figs. 4–16) and in Tab. 1.

Results on slightly corroded samples (B condition)

Figure 4. Panel No. 2 (condition B) – pull off results, with **ikorol®**: 7.5 and 8.0 MPa, without **ikorol®**: 7 and 9 MPa

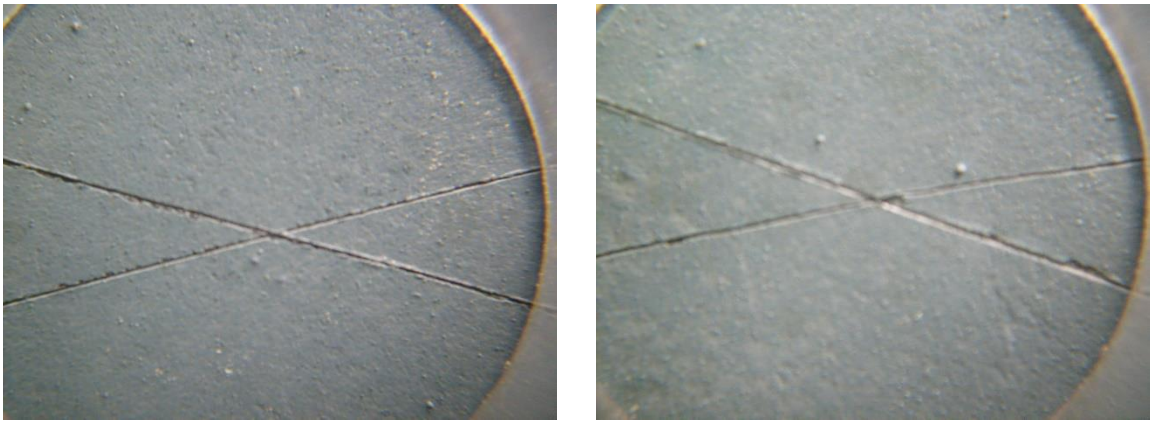


Figure 5. Panel No. 2 (condition **B**) – appearance of cross cuts – with **ikorol®**, grade 0 (left), without **ikorol®**, grade 1 (right)

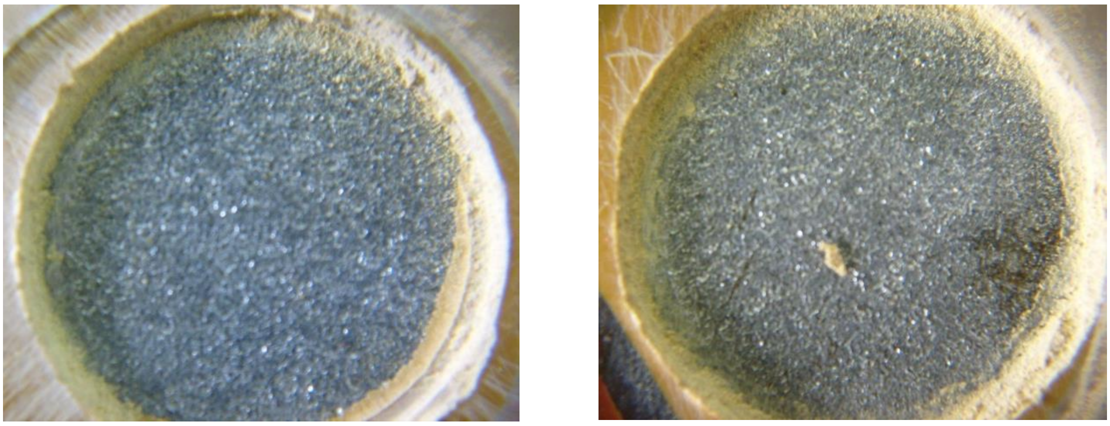


Figure 6. Panel No. 3 (condition **BSa2.5**) – appearance of areas after punches being torn off (with cuts around the punches) – the stamps were broken from the substrate over the entire surface – with **ikorol®** (left), without **ikorol®** (right). The inhibitor is visible in high roughness after breaking the punches

Figure 7. Panel No. 3 (**BSa2.5** condition) – pull off results, no cuts around the punches (black) – with **ikorol®**: 6 and 13.5 MPa, without **ikorol®** 8 and 12 MPa; with cuts around the punches (red) – with **ikorol®**: 5 and 7.5 MPa, without **ikorol®**: 8 and 9 MPa

Figure 8. Panel No. 3 (**BSa2.5** condition) – the appearance of a welded C-profile, the lack of contact of both planes is visible, despite the application of paint with an average thickness of 1302 μm

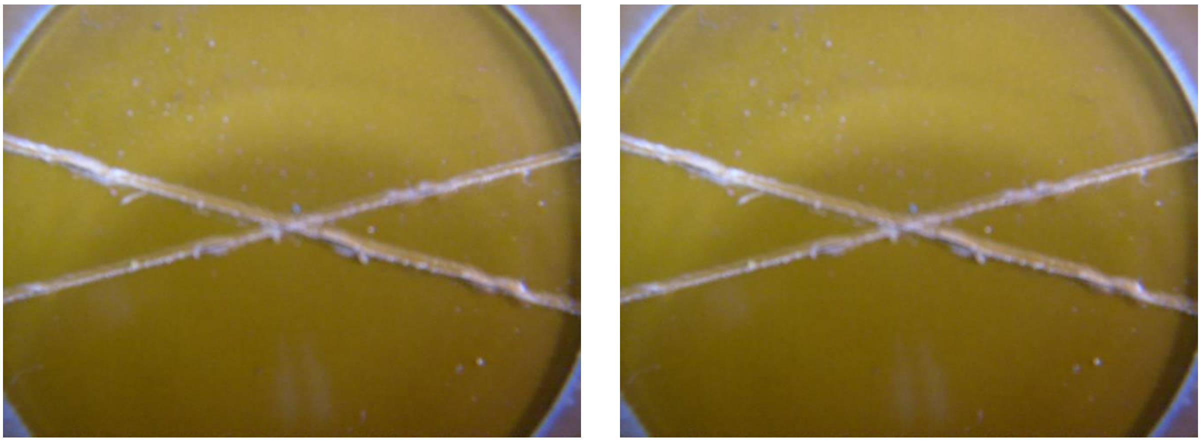


Figure 9. Panel No. 3 (**BSa2.5** condition) – appearance of cross cuts – with **ikorol®**, grade 0 (left), without **ikorol®**, grade 0 (right)

Results on highly corroded samples (condition C)

Figure 10. Panel No. 7 (untreated sample, **C** condition) – the appearance of areas after stamps being torn off, cohesive detachment on the surface of approx. 90%

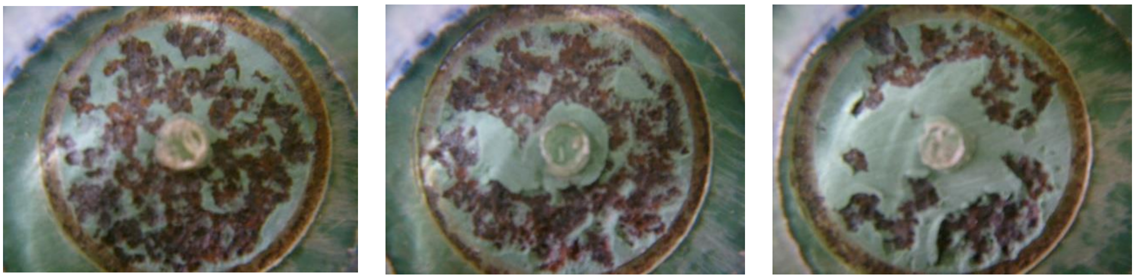


Figure 11. Panel No. 8 (sample cleaned manually with a wire brush, **CSt1** condition) – the appearance of areas after stamps being torn off, cohesive detachment on the surface of approx. **60–70%**

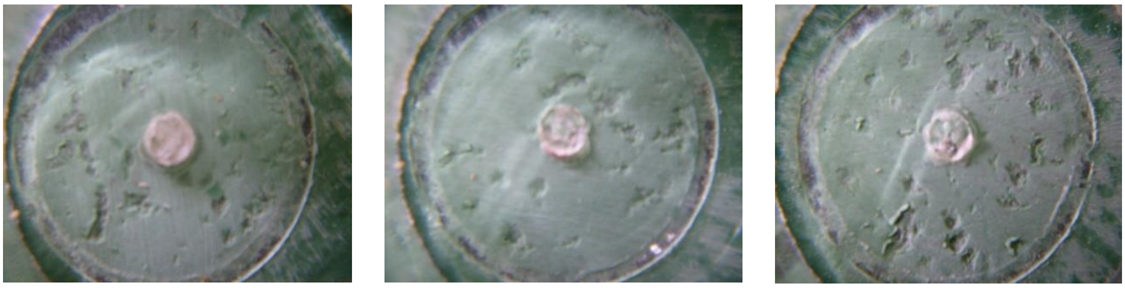


Figure 12. Panel No. 9 (sample blasted with a copper slag, **CSt2.5** condition) – the appearance of areas after stamps being torn off, cohesive detachment on the surface of approx. **5%**

Results after seasoning

After the seasoning, no undercoating corrosion occurred in any case (cross cuts and pull offs). After cutting off the welded elements (pads) after 14 months of exposure (seasoning), the presence of the **ikorol®** shield was found under them and no corrosion was found, except for signs of corrosion at the welds in the places of the widest gaps for some plates blasted to the Sa2.5 grade.

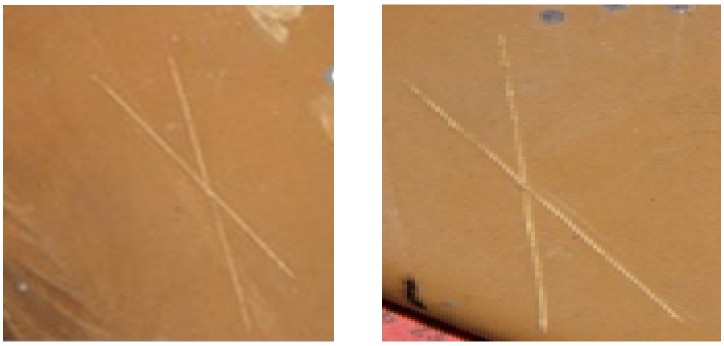


Figure 13. Panel No. 3 (**BSa2.5** condition) – appearance of cross cuts after seasoning – with **ikorol®**, grade 0 (left), without **ikorol®**, grade 0 (right)

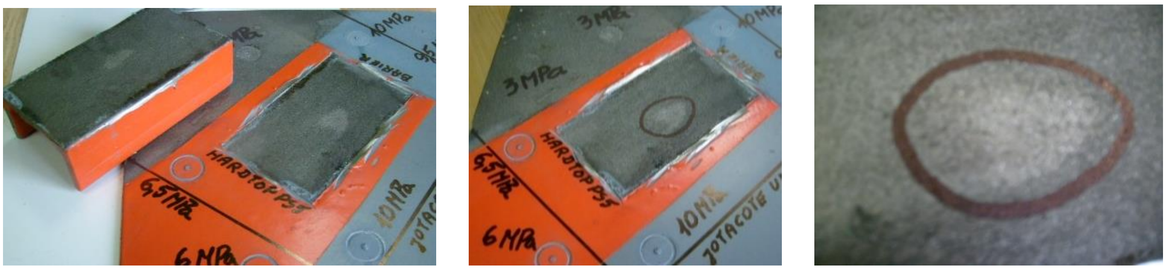


Figure 14. Panel No. 6 (**BSa2.5** condition) – appearance after the seasoning and cutting the channel section (C-profile) on welds. Under the C-profile and on the C-profile from the bottom the penetration of **ikorol®** on approx. 95% of the surface is visible. The non-penetrated fragment is marked

Figure 15. Panel No. 7 (**C** condition) – appearance of the angle bar after seasoning, with a flat bar cut off (left), enlargement of the bottom of the flat bar (right)

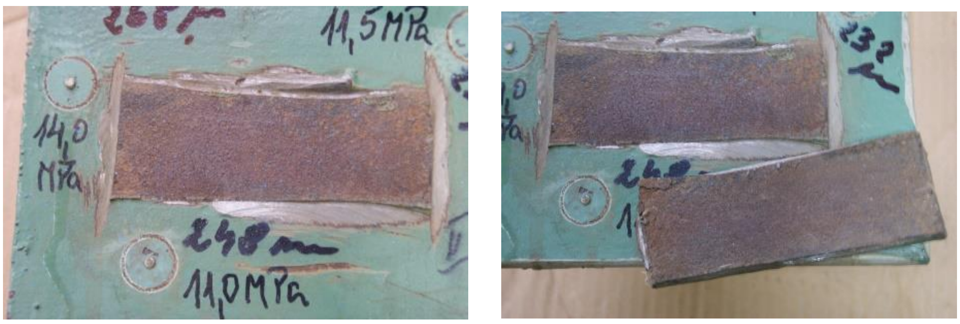


Figure 16. Panel No. 8 (**CSt1** condition) (left), Panel No. 9 (**CSa2.5** condition) (right) – appearance of the surface after the seasoning and cutting off a flat bar

Climatic conditions during the seasoning of test plates

The given temperature amplitude in Katowice during the seasoning of the test plates will be useful for the evaluation of the results. It shows that during the day the temperature jumps were from +11.00°C to +34.00°C, the average temperature was 12.03°C, while at night it varied from –24.00°C to +19.00°C, the average temperature was 3.13°C (Fig. 19) (data from the Institute of Meteorology and Water Management (IMGW)).

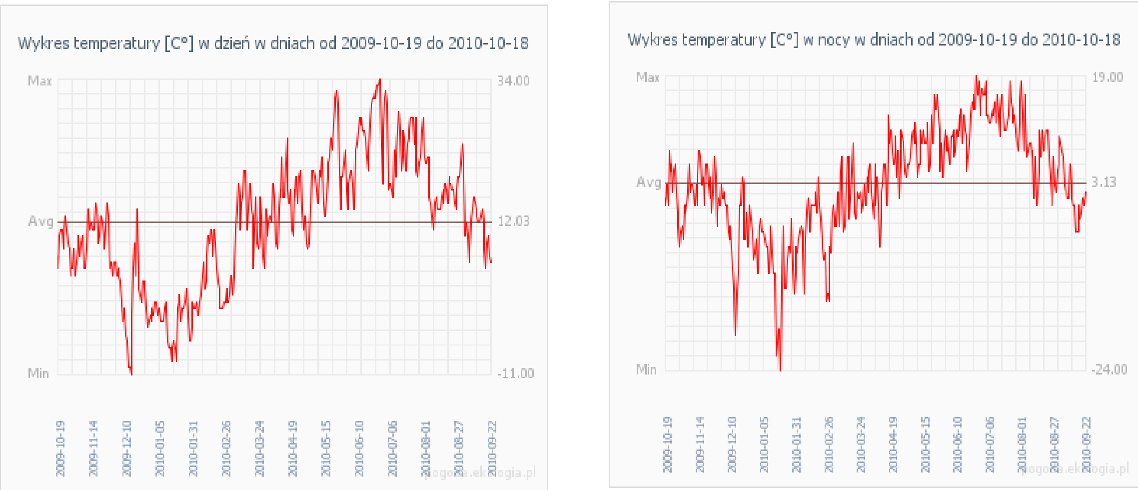


Figure 17. Temperature amplitude in Katowice during the seasoning of test plates

SUMMARY

Due to the results presented above, it was found that the **ikorol®** shield does not decrease adhesion, even when applied on abrasive blasted surfaces to the Sa2.5 degree, and when used on heavily corroded surfaces, it increases the adhesion to the substrate.

The **"pull off"** tests on a heavily corroded surface confirm the increase of adhesion of the paint coating due to previous application of the inhibitor:

- after applying the inhibitor – min. 8.0 MPa, max. 12.0 MPa,
- without an inhibitor – min. 5.0 MPa, max. 6.0 MPa.

After the seasoning, no undercoating corrosion occurred in any case (cross cuts and pull offs).

ikorol® shield has penetrated the surface on the pads with all the particles of corrosion products, so it can be concluded that the tested inhibitor shows **exceptionally good penetrating properties**. The development of crevice corrosion under the welded rebates was not found.

Excellent adhesion to the substrate and to all the paint systems used is due to the hydrophilic and hydrophobic properties of **ikorol®** shield.

The **ikorol®** shield is a Polish product that has won several awards: **Silver medal 2009** – International Invention Show IWIS; **Product of the year 2015** – Polish Corrosion Association; **Innovative industrial product 2018** – BalticBerg Industry Officers Conference.

*Thanks to its advantages, excellent penetration, moisturizing properties, combining with corrosion products in inaccessible places, the **ikorol®** shield is irreplaceable for use during renovation.*

Table 1. Testing of various coating systems with **ikorol®** shield

Sample No.	Surface condition	Coating system	Adhesion	
			pull off (MPa)	cross cutting
1	**B + ikorol®**	–	2.5–3	
2	**B + ikorol®**	epoxide high zink level, DFT avg. 88,6 µm	Formed >7.5–8 Seasoned >4–6	Formed 0 Seasoned 1
2A	**B**		Formed >7–9 Seasoned >4–5	Formed 1 Seasoned 2
3	**BSa2.5 + ikorol®**	polyurethane no solvent, DFT avg. 1302 µm	Formed 5–7.5 Seasoned >7	Formed 0 Seasoned 1
3A	**BSa2.5**		Formed 8–9 Seasoned >6–7	Formed 0 Seasoned 1
4	**BSa2.5 + ikorol®**	ethylsilicone/epoxide, DFT avg. 374 µm	Formed >7.5–8.5 Seasoned >8.5–9	Formed 0 Seasoned 2
4A	**BSa2.5**		Formed 8–9 Seasoned >7	Formed 0 Seasoned 3
5	**BSa2.5 + ikorol®**	epoxyester, DFT avg. 176 µm	Formed >6 Seasoned 6–7	Formed 1 Seasoned 1
5A	**BSa2.5**		Formed >4–6 Seasoned 5.5–6	Formed 1 Seasoned 1
6	**BSa2.5 + ikorol®**	epoxide/polyurethane, DFT avg. 198 µm	Formed >6.5–10 Seasoned >7.5–11.5	Formed 0 Seasoned 1
6A	**BSa2.5**		Formed >6–10 Seasoned >8–10.5	Formed 0 Seasoned 1
7	**C + ikorol®**	epoxide, DFT avg. 347 µm (including rust ca. 170 µm)	Formed 8–9 Seasoned 8.5–10	–
7A	**C**		Formed >5–6 Seasoned >8.5–9	–
8	**CSt1 + ikorol®**	epoxide, DFT avg. 252 µm (including rust ca. 70 µm)	Formed 8–10 Seasoned >11–14	–
8A	**CSt1**		Formed >5–6 Seasoned >8–9	–
9	**CSa2.5 + ikorol®**	epoxide, DFT avg. 178 µm	Formed 10.5–12 Seasoned >10–10.5	–
9A	**CSa2.5**		Formed >5–6 Seasoned >10	–

B surface slightly corroded, **BSa2.5** surface abrasive blasted; **C** surface heavily corroded without any cleaning, **CSt1** surface cleaned manually with a wire brush, **CSa2.5** surface abrasive blasted

DFT = dry film thickness
Formed = coating (film) cured/hardened for 21 days at 18–20°C, laboratory conditions
Seasoned = coating (film) after 14 months of outdoor seasoning in Katowice
> = the adhesion has a higher value since the breakage occurred in the adhesive layer
– = no evaluation was carried out

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