Korrosionsinstitutet
Swedish Corrosion Institute

Excerpts from The Swedish Corrosion Institute report

KI Rapport 2002:4

Overcoating of structures painted with lead-based paint _
an alternative strategy in corrosion protection maintenance

Final report
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Translation of the Swedish text.

Summary *

An estimated area of about 4 million square meters of steel that has been coated with lead-based paints exists in Sweden today. The removal of lead-based paint prior to repainting, through *e g* blast cleaning, creates big waste problems, since both the paint residues and the blasting agent will have a high content of lead and must be stored at special waste disposal sites, leading to high costs. A possible alternative to removing the old lead-based paint would be to overcoat it with an alternative coating system (environmentally acceptable paint system) with a good adhesion to the lead-based paint, allowing as much as possible of the old paint to remain on the objects.

In January 2001 the Swedish Corrosion Institute started an R & D project, "Overcoating of lead-based paint as an alternative strategy in corrosion protection maintenance". The Swedish National Rail Administration, Elforsk and the Swedish National Road Administration initiated the project.

The final report presented here contains result from

_ Inspections of older lead-painted steel structures that have been overcoated at least 10 years ago with alternative coating systems.

_ Laboratory investigations of methods for the determination of the penetrating power of alternative corrosion protective paints into rusty crevices.

The purpose of the first part of the investigation was to collect and compile experiences on the subject of overpainting lead painted structures with alternative corrosion protective paints through contacting paint producers, painters, inspectors and contractors and through inspections of different overpainted structures.

The purpose of the second part was to develop a test method for the determination of the penetration depth of corrosion protective paints in rusty crevices.

From the collection of experiences and the inspections of the lead paint coated steel structures that have been overcoated with alternative corrosion protective paints systems the following conclusions may be drawn:

_ Where the old lead-based paint adheres well (≥ 2MPa) to the structure it is not necessary to remove it before painting.

_ When choosing the paint system for overcoating, it is important that it is compatible with the existing lead-based paint, and that it will have a good adhesion to the old lead-based paint and the topcoat.

_ All loose lead-based paint, old topcoat and rust must be removed before overcoating.

_ Rusty surfaces should first be painted with a suitable primer before the whole structure is coated with a suitable paint and topcoat.

_ When corrosion damage occurs on a repainted, previously lead painted steel structure the damage is often localized to crevices in *e g* riveted joints.

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* the English version from the original report

From the investigations of the penetrating power of different alternative primers into crevices the following conclusions may be drawn:

- The recommended test method for investigation of the penetration power of corrosion protective paints is well reproducible and simple to use. For pigment-free paints it should however be supplemented with an accelerated corrosion test so that it is possible to decide with greater certainty that not only the solvent has penetrated into the narrow crevice.

- Plomb Mönja O, Rust-Oleum 769 and Power-Coat "3 in 1" have about equal penetrating power in rusty crevices.

- Isotrol Grundfärg and Isotrol HV have about 4 times better penetrating power than Plomb Mönja O, Rust-Oleum 769 and Power-Coat "3 in 1".

2 Background

In Sweden there are today at a rough estimate about 4 million square meters of steel painted with lead-based paint. Removal of lead paint at repainting by means of *e g* sandblasting creates great waste problems since both the paint residues and the blasting agent will have a high content of lead and have to be stored at special waste deposit sites at high costs. An alternative to blasting away old lead paint could be to overpaint the lead paint with an environmentally acceptable paint system with good adhesion to the lead-based paint. Experiences from U.S.A. of such a procedure have shown that the lifetime of the corrosion protection could be prolonged with up to 15_20 years. If the overpainting can be repeated this could be a long-term maintenance strategy. How well an overpainting will prove to be a success is dependant of several factors as for instance choice of pre-treatment and paint system as well as what compability the paint system has to the existing paint system.

Some people are of the opinion that one of the good properties of lead paint from a corrosion point of view is its excellent penetration capability into *e g* rusty crevices. When choosing future environmentally adapted paint systems for overpainting of older steel constructions it is important that these paints have a good penetrating capability into rusty crevices.

3 Goal

The goal of the investigations is to produce guiding principles for how an overpaint work should be performed. This concerns the whole chain from the initial inspection, sample collection, choice of paint system to the actual work with pre-treatment and overpainting.

4 Objective

The objective of the investigations is to try to minimize and optimize the costs of future maintenance painting of steel constructions painted with lead paint.

5 Technical arrangement and performance

5.4 Railway bridges over Kukkasjoki and Keräsjoki, Haparanda track

Information about the bridges (girder bridges) such as permission before overpainting, pre-treatment, paint system, point of time of latest overpainting etc. has been received in writing from Anders Kronborg, the Swedish Rail Administration, Lars Kjellberg, Introteknik AB and Leif Johansson, Renator AB.

The bridges were built during the years 1910_1911, **see figures 4** and **5.** The bridges have up to 2002 been overpainted three times (Kukkasjoki 1939, 1957 and 1989 and Keräsjoki 1933, 1961 and 1989). At the two first overcoatings red lead was used as primer. Prior to the latest overpainting, the paint on approximately 30 % of the earlier painted areas had loosened from the bedding. The steel surfaces laid bare were covered with loosely attached surface rust.

Before overpainting the bridges were cleaned with hot water using high-pressure washing appliance (max. 100 bar). Thereafter a sweep blasting of earlier painted areas where the paint had loosened from the bedding was performed (old lead paint with good adhesion was left remaining) as well as on lightly corroded steel surfaces. After the sweep blasting a cleaning blasting of heavily corroded steel surfaces was performed.

The paint systems were applied by spray painting. According to statement the following paints were used at the latest overpainting:

Primer: Isotrol Primer. Non-pigmented paint based on linseed oil alkyd, 2 coats of paint (ca 15 m per layer), a total of 25_30 m dry coat (Introteknik AB)

Intermediate coat: Isoguard. Oil modified alkyd with zinc chromate, 30 m dry coat (Introteknik AB)

Top coat: Isotrol Finish. Pigmented alkyd paint, total 50 m dry coat (Introteknik AB).

5.5 Road bridge over the river Fjällsjöälven, road 331 ca 10 km north of Ramsele

Information about the road bridge (girder bridge) such as permission before overpainting, pre-treatment, paint system, point of time of latest overpainting etc. has been received in writing from both Lage Rosén, Swedish National Road Administration and Lars Kjellberg, Introteknik AB.

The bridge was built during 1963, **see figure 6**. At the latest and only repaint 1988 the existing paint coat had come loose on ca 50 % of the surface of the bridge. The steel surfaces laid bare were covered with rust. On the remaining lead painted surfaces (ca 50 %) the red lead coat had a very good adhesion to the bedding.

Before overpainting the bridges were cleaned with cold water using high-pressure washing appliance (max. 100 bar). Thereafter a mechanical wire brushing was performed to St 2 according to 8501-2:1988. Existing red lead paint (ca 50 % of the surface of the bridge) with good adhesion was left remaining. The paint systems were applied by brush painting. According to statement the following paints were used at the latest overpainting:

Primer: Isotrol Primer. Non-pigmented paint based on linseed oil alkyd, 2 coats of paint (ca 15 m per layer), a total of 25_30 m dry coat (Introteknik AB)

Intermediate coat: Isoguard. Oil modified alkyd with zinc chromate, 30 m dry coat (Introteknik AB)

Top coat: Isotrol Finish. Pigmented alkyd paint, total 50 m dry coat (Introteknik AB).

5.8 Laboratory investigation of the penetrating ability into rusty crevices

This part is concerned with the penetration power of some alternative rust protective paints. The aim has been to compare the penetrating power of alternative and environmentally accepted paint systems with that of red lead.

As testing material hot-rolled carbon steel plates, size 200×75×3 mm, were used. All the test plates had, prior to the penetration tests, been pre-corroded to rust grade C and then wire brushed to St 2. The crevice between two test plates was obtained by placing a shim of thickness 0,5 mm at one edge of the plates and then compressing the plates with help of tape. The width of the crevice between the taped plates varied from 0 to 0,5 mm along the length of the plates.

The taped plates were vertically immersed 1 cm down in the paint for about 15 minutes. Then the plates were placed to drip-dry for seven days. The specimens were then evaluated by breaking the plates apart. The depth of penetration was determined by measuring the maximal penetration of paint in the crevice. A total of six test bodies per paint system were used for evaluation of the penetration power. From **table 6** it appears which primers were used in the investigations.

Table 6. Primers used for investigation of the penetrating power

Primer	**Paint supplier**
Plomb Mönja O (Oil based lead paint)	Alcro Beckers AB
Rust Oleum 769 (Fish oil containing alkyd)	INDUF AB
Isotrol Primer (Non-pigmented alkyd paint with vegetable oils)	Introteknik AB
Power Coat “3 in 1” (One component, modified polyester paint)	INDUF AB
Isotrol HV (Non-pigmented alkyd paint with vegetable oils, high viscosity)	Introteknik AB

6 Results from inspections of red lead painted objects overpainted with alternative rust protective paint

6.4 Railway bridges Kukkasjoki and Keräsjoki, Haparanda track

The corrosivity class for carbon steel at the site of the bridges was estimated to C3.

At the ocular inspection of the two bridges it was noticed that there was no difference between the two bridges with respect to corrosion attack. From the inspections, it was clear that ca 1_2 % of the rivet joints were subjected to crevice corrosion, **see figure 11**. Plane surfaces, edges and rivets were nearly totally undamaged, **see figure 12**. No blistering, flaking, nor cracking could be detected.

From the results of measuring the layer thickness it was evident that the thickness of the overpainted layers varied between 110 and 140 m and that the overpainted layer together with the old red lead layer varied between 550 and 610 m on the bridge over Kukkasjoki and between 500 and 575 m on the bridge over Kersäjoki.

At Kukkasjoki bridge the adhesion between the overpainted layer and the steel brushed steel surface was measured to 9,8 MPa. The breakage (adhesive breakage in bedding 95 % A/B and 5 % B) was established between the steel bedding and the first layer in the overpainted paint. The adhesion between the overpainted layer and the old red lead was measured to 10,0 MPa. The breakage (adhesive breakage in bedding 80 % B/C and 20 % C) was established between the old red lead and the first layer of the overpainted paint.

At Kersäjoki bridge the adhesion between the overpainted layer and the steel brushed steel surface was measured to 9,2 MPa. The breakage (adhesive breakage in bedding 90 % A/B and 10 % B) was established between the steel bedding and the first layer in the overpainted paint. The adhesion between the overpainted layer and the old red lead was measured to 9,5 MPa. The breakage (adhesive breakage in bedding 85 % B/C and 15 % C) was established between the old red lead and the first layer of the overpainted paint.

Summarized assessment

To sum up, the two bridges were judged to be in a very good shape. The rust grade of the whole construction was estimated to Ri1. The adhesion between the overpainted layer and the steel surface as well as the old paint system and the overpainted layer was estimated to be very good.

However, it should already here be pointed out that the intermediate paint (Isoguard) which was used for the overpainting 1988 contained zinc chromate. Today the zinc chromate has, due to environmental reasons, been replaced by zinc phosphate and micaceous iron oxide. How that will affect the corrosion protection properties of today's Isoguard is for the present not known.

6.5 Road bridge over the river Fjällsjöälven, road 331 ca 10 km north of Ramsele

The corrosivity class for carbon steel at the site of the bridge was estimated to C3.

From the ocular inspections it was clear that the steel bows at the outside were totally undamaged by rust. At some spots the topcoat on the bow was too thin, **see figure 13**. The insides of the bows, which were painted with only primer and intermediate were also entirely undamaged, **see figure 14**. At the underside of the bridge, edges, welds and plane surfaces were almost entirely undamaged, **see figure 15**. No blistering, flaking, nor cracking could be detected on any part of the bridge.

From the results of measuring the layer thickness it was evident that the thickness of the overpainted layers varied between 90 and 110 m. The overpainted layer together with the old red lead layer varied between 390 and 460 m.

The adhesion between the overpainted layer and the steel brushed steel surface was measured to 6,2 MPa. The breakage (adhesive breakage in bedding 80 % A/B and 20 % B) was established between the steel bedding and the first layer in the overpainted paint. The adhesion between the overpainted layer and the old red lead was measured to 5,4 MPa. The breakage (adhesive breakage in bedding 75 % B/C and 25 % C) was established between the old red lead and the first layer of the overpainted paint.

Summarized assessment

To sum up, the two bridge was judged to be in a very good shape. The rust grade of the whole construction was estimated to Ri1. The adhesion between the overpainted layer and the steel surface as well as the old paint system and the overpainted layer was estimated to be very good.

However, it should here already be pointed out that the intermediate paint (Isoguard) which was used at the overpainting 1988 contained zinc chromate. Today the zinc chromate has, due to environmental reasons, been replaced by zinc phosphate and micaceous iron oxide. How that will affect the corrosion protection properties of today's Isoguard is for the present not known.

6.7 Results from the laboratory investigation of the penetrating ability into rusty crevices

The results from the immersion experiments are given in **table 7**. Both maximal and minimal penetration of paint into rusty crevices is given in the table.

Figures 17_21 show the penetration of paint in rusty crevices after 15 minutes of immersion in rust protective paint and air-drying for ca 7 days.

As is clear by the results in **table 7** and from **figures 17_21**, Isotrol Primer and Isotrol HV exhibit the highest penetration power into the crevice. The penetration of Isotrol is largest where the crevice width is smallest. The penetration powers of the other systems are considerably less and diminish with diminishing crevice width.

Table 7 *The penetrating power of different primers. The penetrating power is presented as the mean value of 6 crevice test bodies, expressed in maximal and minimal penetration depth. The crevice specimens have been immersed 1 cm down in the paint for 15 minutes and then air dried for 7 days.*

Primer	**Penetration depth (mm)**		**The condition of the paint after 7 days of air drying**
	Maximal	**Minimal**	
Plomb Mönja O	10,3 (1,4)	2,7 (0,5)	Moist
Rust-Oleum 769	14,0 (0,9)	6,0 (3,2)	Dry
Power Coat “3 in 1”	11,3 (0,5)	3,2 (2)	Somewhat moist
Isotrol Primer	46,0 (7,6)	6,0 (3,2)	Dry
Isotrol HV	46,7 (9,6)	15,7 (0,5)	Running

7.2 Penetrating power into rusty crevices of rust protective paints

A general opinion has been that one of the good protective properties of red lead from a corrosion point of view is that it has a very good penetrating power into narrow crevices.

From the results of the laboratory investigation of the penetrating power of different rust protective paints into rusty crevices, **see table 7**, it is evident that Plomb Mönja O (red lead paint), Rust-Oleum 769 and Power Coat "3 in 1" have about the same penetrating power into rusty crevices. Isotrol Primer and Isotrol HV have ca four times better penetrating power than Plomb Mönja O, Rust-Oleum 769 and Power Coat "3 in 1". The question that can be asked is thus whether the penetrating power of a primer is of a vital significance for how good the corrosion preventive property is in narrow crevices. This investigation shows that there could be other properties than the penetrating power that gives red lead its superior corrosion protective capability compared to other rust protective paints. Among those other properties can be mentioned a good passivating pigment and the formation of a tight layer which prevents moisture and oxygen to penetrate into the crevice.

A difficulty when judging the penetrating power of non-pigmented paints is to decide whether it is the whole content of the paint or only solvent that has penetrated the narrow crevice. From this investigation it is difficult to decide whether it is only solvent or the non-pigmented paint that has penetrated the crevice. To decide the penetrating power of the non-pigmented paint, one should perform complementary tests such as an accelerated corrosion testing. If only solvent has penetrated the crevice the ability to prevent *e g* crevice corrosion would be considerably reduced compared to if all the constituents of the paint (pigment etc) has penetrated the crevice.

To sum up, it can be said that the test method developed in the laboratory to investigate the penetrating power of rust protective paints into narrow crevices gives a good reproducibility and is simple to perform, but should be supplemented with an accelerated corrosion test when testing non-pigmented paints.

8 Recommendations and guiding principles

With considerations from this investigation the following recommendations and guiding principles can be given for overpainting of red lead painted objects:

1. Decide the corrosion state of the objects by visual inspection.

2. Measure the adhesion of the red lead/top paint by pull-off testing.

3. Overpainting can be performed if the adhesion of the existing red lead exceeds 2,0 MPa.

4. Perform pretreatment according to "Handbok i rostskyddsmålning". It is important that all loose paint, all top paint and rust are removed before overpainting.

5. Decide the corrosivity class at the site of the object.

6. Choose a paint system, considering among other things corrosivity class and desired lifetime, for the overpainting that is compatible with the existing red lead. When choosing a suitable paint system, consult BSK 99.

7. Rusty surfaces shall first be overpainted with a suitable primer and then the whole construction shall be overpainted with a suitable intermediate and topcoat.

8. As to the rest, the overpainting shall be performed according to “Handbok i rostskyddsmålning”.

9 Conclusions

The investigation leads to the following conclusions:

Inspection of overpainted steel constructions

The results from investigations of seven red lead painted steel constructions, which since at least 10 years ago have been overpainted with alternative paint systems (not red lead), showed that the overpainted layer had functioned well with six of total seven steel constructions. It is thus quite suitable to leave the old red lead remaining provided that it has a good adhesion to the bedding.

The constructions where the overpainted layer is undamaged and intact after at least 10 years outdoor exposure have in common that all loose paint and rust had been removed before the overpainting was performed.

As pre-treatment method, steel brushing and scraping were used on four objects. On one object machine grinding was also used. On two of the objects a light sweep blasting was used on both rusty steel surfaces and on old loosely adhered red lead.

For all objects overpainting has been performed on different pre-treated steel surfaces as well as on red lead painted steel surfaces where the old red lead had a good adhesion to the steel surface. The adhesion test showed that the overpainted layer had a good adhesion (≥ 2 MPa) to both steel brushed surface and old red lead.

On the rivet jointed constructions there were always occasional surfaces exposed to crevice corrosion.

Laboratory investigation of the penetrating power of rust protective paints into rusty crevices

The method developed for investigation of the penetrating power of rust protective paint has a good reproducibility and is easy to carry out. For non-pigmented paints the test should be supplemented with an accelerated corrosion test in order to ascertain with greater certainty if not only the solvent has penetrated the narrow crevice.

Plomb Mönja O, Rust-Oleum 769 and Power Coat “3 in 1” have about the same penetrating power into rusty crevices.

Isotrol Primer and Isotrol HV have about four times better penetrating power than Plomb Mönja O, Rust-Oleum 769 and Power Coat “3 in 1”.