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PROHESION TEST OF METAL ROOFING SCREWS				

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1 Foreword

Painted carbon steel mounting screws are used in installation of painted metal sheet metal products of building shell structures (roofs and walls). Kingi metal roofing screw is intended for the installation of prepainted zinc coated metal sheet products. The screw has 12 μm zinc coating which is silane pretreated and has been painted with an epoxy-polyester primer (60 μm) and polyester top coat (60 μm).

Kingi metal roofing screws are intended for the installation of prepainted sheet metals used both outdoor and indoors in ventilated frame structures and which can have an atmospheric corrosivity category as high as C4 (high) in accordance with standard EN ISO 12944-2 and durability range of high (H) over 15 years.

The durability of Kingi screws and commonly used screws of other producers was studied by using prohesion corrosion test.

2 Corrosion test

Prohesion test was performed according to standard *ASTM G85 – 09 Standard practice for modified salt spray (fog) testing, Annex 5. Dilute electrolyte cyclic fog/dry test*. The samples were sprayed for one hour by solution which contains 0.05 wt% sodium chloride (NaCl) and 0.35 wt% ammonium sulfate ((NH₄)₂SO₄). After that the samples were dried one hour by air flow at 35 °C. The spray and drying steps were repeated during the test. The pH of the solution is 5.0 ... 5.4. The test was carried out in Q-FOG CCT 1100 corrosion test chamber (figure 1).

The total test time was 1000 h but part of the samples were removed earlier due to their bad condition. 1000 hours test time is often used for testing of roof materials which will be installed in demanding conditions. The samples were inspected in about 200 hour intervals. The sample was inspected visually and the samples with significant changes were photographed. At the end of the test the samples were photographed first with salt deposition and after that they were washed and photographed second time. Finally the delaminated paint layer of the screws was removed by washing with a dish brush and photographed once again. The photographs in which the delaminated paint was removed are presented in this report. At the end the screws were removed from the rack and inspected visually.



Figure 1. Samples in the testing chamber at the end of the test (together with samples from other test series).

3 Samples

Five different Kingi metal roofing screws (size 4.8 x 25 mm) were tested. Information of the screws is given in table 1. The tested screws were taken randomly from the production and from the stock of Kingi Ltd (figure 2) by the staff of Sheet Metal Centre. In addition eight different commonly used metal roofing screws, bought from hardware shop, were tested. Also one Kingi screw sample painted only with a top coat was tested (table 2).

Table 1. Kingi screws tested.

Code	Colour	Production code	Production date
1	RR32 Dark Brown	A7B2C7A9B5	16.2.2016 9:47
2	RR20 White	A2A2A7A4A8	12.8.2015 14:55
3	RR29 Red	A3A2B1A4A5	30.9.2015 22:37
4	RR23 Dark Grey	A8A5C3A9B6	12.1.2016 13:11
5	RR33 Black	A3A2B3A4B1	14.10.2015 17:39

Table 2. Tested screws of the other manufacturers.

Code	Producer	Code	Producer	Code	Producer
A	Würth 1	D	Essve	G	KRANIT
B	PROF	E	Berner	H	Kingi, top coat only
C	Ruukki, producer Red Horse	F	IKH	I	Würth 2



Figure 2. The Kingi screws were taken from normal production by random sampling.

Three or five similar screws were taken from each screw type. The screws were mounted in a thin sheet and wooden rib imitating the normal mounting procedure (figure 3). The samples were tested simulating the surface structure of steel in the lowest pitched roof (1:5) that is allowed for tile sheet roof. The mounting was staggered to avoid possible messing by the rust run-off.



Figure 3. Screws mounted on the sample racks before the test. Left rack contains the screws of other manufacturers and the Kingi screw with top coat only. The right rack contains the Kingi screws randomly taken from the manufacturing and from the stock.

4 Results

The worst screws were rusty in the first intermediate inspection after 187 hours, but the test was continued in order to follow the further corrosion. In the next inspection after 425 hours most of the screws made by the other manufacturers were totally deteriorated (figure 4). After 618 hours the test rack with other manufacturers' screws was removed from test because they had reached the point after which they could not have been maintained for further use (EN 12944-1).



Figure 4. Screws A (Würth) ja E (Berner) after 425 hours test time.

When comparing corrosion resistance of Kingi screws and the Pural coating (which was used on the sample racks) both the screws and the painted sheet were in a good condition. Corrosion and delamination of coating was found only on the cutting edges (figures 5 and 6). 1000 hour prohesion test is a harsh test method and it accelerates corrosion phenomenon. It is unusual that the products in reality end up to such a harsh conditions.

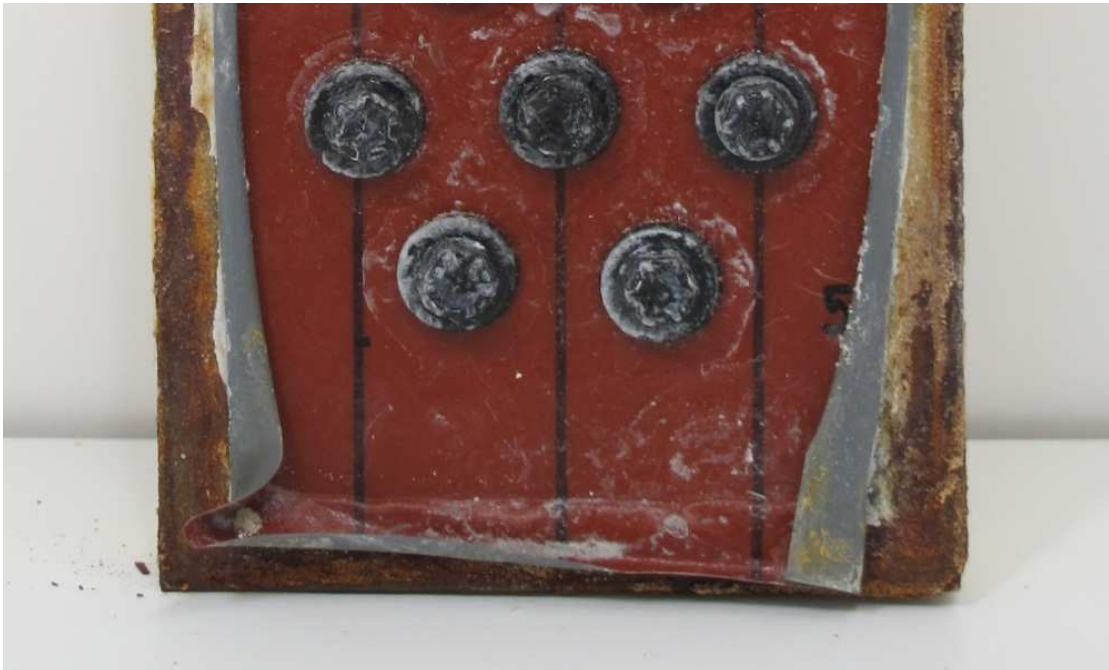


Figure 5. Kingi screws and Pural thin sheet metal after 1000 hours test.



Figure 6. Kingi screws and Pural thin sheet after test. Delaminated paint is removed.

In the following detailed photographs, the samples have been photographed after the test and removal of delaminated coating. The photos have been taken from three different directions: first from the top of the screws, second tilted downwards and third tilted upwards (figure 7). In the photo taken tilted upwards the screws are in opposite order than in the photo taken tilted downwards.

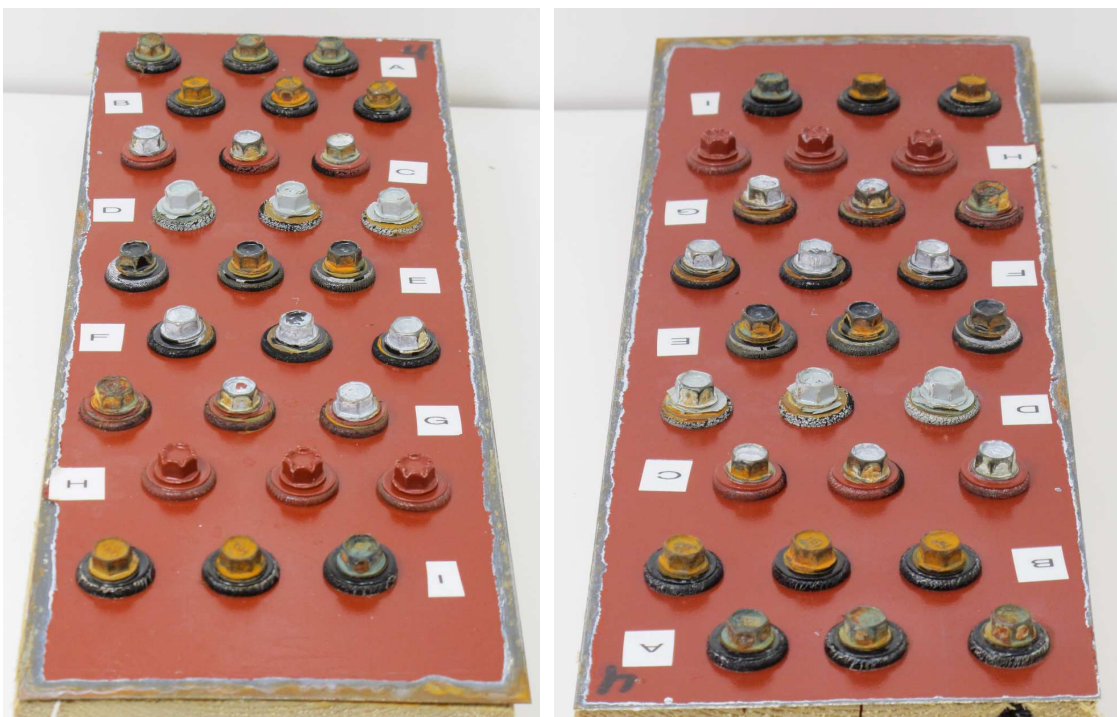


Figure 7. Samples were photographed from downwards (on left) and upwards (on right). The screws in these photographs are made by the other manufacturers and Kingi screw with the top coat only (H).

4.1 Sample 1, Kingi RR32 dark brown

One of the five screws had small amount of red rust at the end of the test. No paint was delaminated after removal of delaminated paint.



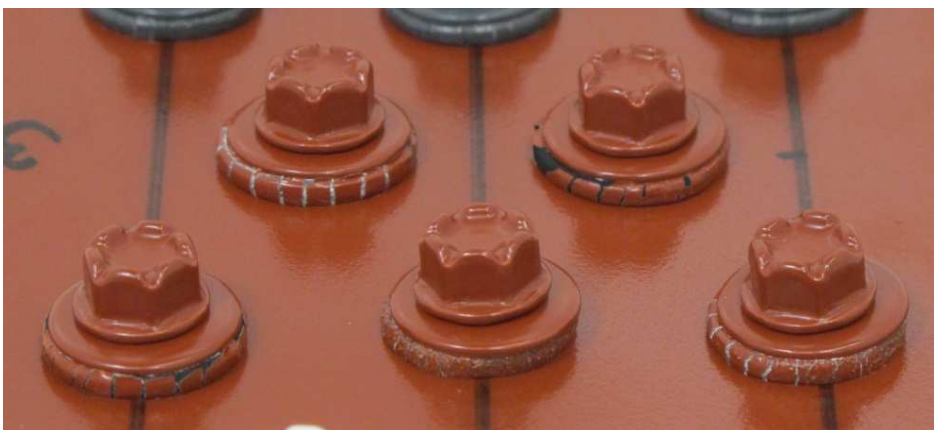
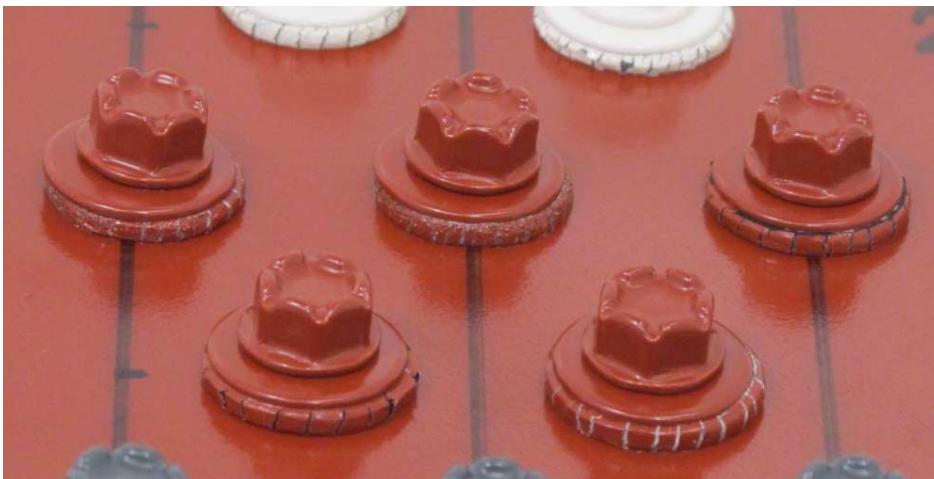
4.2 Sample 2, Kingi RR20 white

The screws survived 1000 hour test without any defects. No paint was delaminated.



4.3 Sample 3, Kingi RR29 red

The screws survived 1000 hour test without any defects. No paint was delaminated.



4.4 Sample 4, Kingi RR23 dark grey

The screws survived 1000 hour test without any defects. No paint was delaminated.



4.5 Sample 5, Kingi RR33 black

The screws survived 1000 hour test without any defects. No paint was delaminated.



4.6 Sample A, Würth 1

Some incipient rusting of screws was found already in the first intermediate inspection after 187 hours of testing. In the second inspection after 425 hours, there was plenty of rust and after 572 hours the screws were in a really bad condition and they had a lot of red rust. Test was ended after 618 hours. When the delaminated paint was removed, all the paint was lost.



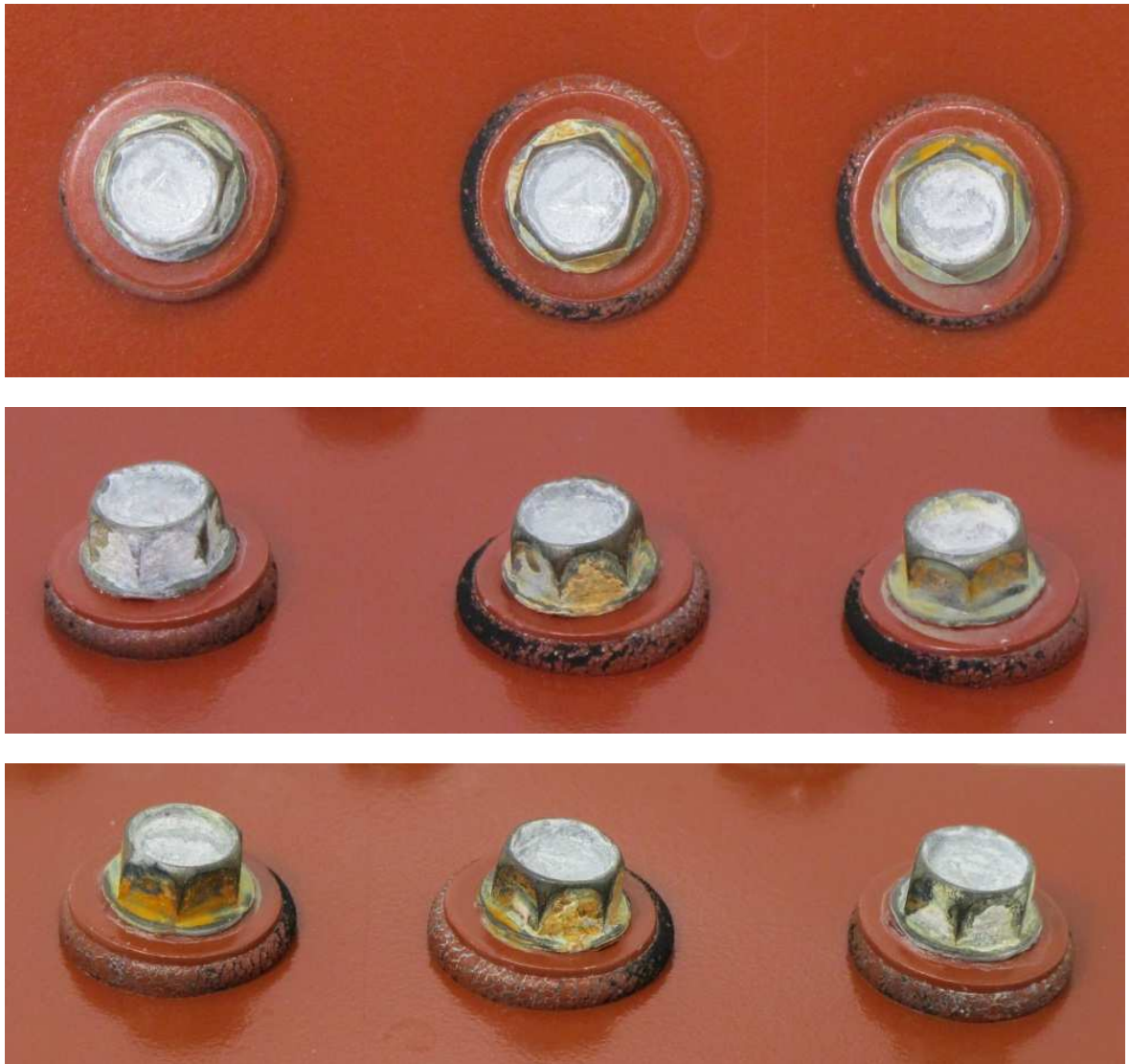
4.7 Sample B, PROF

Some incipient rusting of screws was found already in the first intermediate inspection after 187 hours of testing. In the second inspection after 425 hours, there was plenty of rust and after 572 hours the screws were in a really bad condition and they had lots of red rust. Test was ended after 618 hours. When the delaminated paint was removed, all the paint was lost.



4.8 Sample C, Ruukki (manufacturer Red Horse)

Some paint came loose already during mounting before the test. There was a bit of incipient rusting during the first inspection after 187 hours. In the second inspection after 425 hours, there was a small amount of rust and after 572 hours the screws were in a bad condition with lots of red rust. Test was ended after 618 hours. When the delaminated paint was removed, all the paint was lost.



4.9 Sample D, Essve

Some of the paint lost adhesion already during mounting before the test. There was small amount of incipient rusting during the first inspection after 187 hours. In the second inspection after 425 hours, there was a small amount of rust and after 572 hours the screws were in a bad condition with lots of red rust. Test was ended after 618 hours. When the delaminated paint was removed, the paint was partly lost.



4.10 Sample E, Berner

Some of the paint lost adhesion already during mounting before the test. There was small amount of incipient rusting during the first inspection after 187 hours. In the second inspection after 425 hours, there was a small amount of rust and after 572 hours the screws were in a bad condition with lots of red rust. Test was ended after 618 hours. When the delaminated paint was removed, almost all the paint around the screw head was lost. The paint on the head remained intact.



4.11 Sample F, IKH

The screws were in a good condition during the first inspection after 187 hours. There was small amount of rust after 425 hours and 572 hours. The test was ended after 618 hours. When the de-laminated paint was removed, almost all the paint was lost.



4.12 Sample G, KRANIT

There was a bit of incipient rusting during the first inspection after 187 hours. In the second inspection after 425 hours, there was a small amount of rust and after 572 hours the screws were in a bad condition with lots of red rust. Test was ended after 618 hours. When the delaminated paint was removed, almost all the paint was lost.



4.13 Sample H, Kingi with top coat only

The screws were in a good condition during the first inspection after 187 hours. A bit of rust was found after 425 hours and small amount of rust after 572 hours. The test was ended after 618 hours because the screws were mounted on a same rack as the screws of other manufacturers, which were damaged too badly to be able to continue the test. When the delaminated paint was removed, there were some small areas in which the paint was loosened.



4.14 Sample I, Würth 2

There was a bit of incipient rusting during the first inspection after 187 hours. In the second inspection after 425 hours, there was a lot of rust and after 572 hours the screws were in a really bad condition with lots of red rust. Test was ended after 618 hours. When the delaminated paint was removed, all the paint was lost.



5 Conclusion

1000 hour prohesion test is a harsh corrosion test and it is rare that the products in reality are exposed in similar conditions. On the other hand the purpose of the test is to accelerate corrosion so that the test times would be reasonable when compared to outdoor testing. With the prohesion test it is not possible to directly estimate durability of a certain material in years in certain corrosivity category. But by exposing reference samples with known outdoor durability, comparison can be done. In this test the reference material was Ruukki's Pural roofing sheet to show the severity of the prohesion test. The edge corrosion of Pural was higher than the normal corrosion of roof eaves in 20 years in Finland. Probably the contact of the steel plate with timber accelerated corrosion.

The worst screws of the other manufacturers had rust on the screw head during the first intermediate inspection after 187 hours. The test was continued in order to follow the corrosion processes. During the next inspection after 425 hours, part of the screws of the other manufacturers were totally rusted. After 618 hours test time the sample rack of the other manufacturers was removed from the test because of the severe rusting of the screws.

Based on this study, the Kingi screws survived in this test very well. Their corrosion resistance was clearly better than the resistance of the other galvanized and paint coated commonly used screws.

According to the earlier tests (HAMK Sheet Metal Centre, report 2010-11, Asennusruuvien korroosiokokeet, in Finnish), the paint system used in the screws of Kingi, corresponds the paint systems intended for use in corrosivity category C4 (severe) and best durability range H (over 15 years) according to standard DIN 55634. It can therefore be suitable for the use in C4 conditions. According to this investigation and DIN 55634 the corrosion resistance of Kingi metal roofing screws was on the same range as the corrosion resistance of the polyurethane based coatings (eg. Pural) with the estimated durability more than 15 years (durability range H) in the corrosivity category C4 (severe).