BAW
Bundesanstalt für Wasserbau

Kompetenz für die Wasserstraßen

BAWGuideline

Testing of Coating Systems for the Corrosion Protection of Hydraulic Steel Structures (RPB)

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BAW Codes of Practice, Recommendations and Guidelines

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1 Scope of application

This Guideline applies to the testing of coating systems for the corrosion protection of hydraulic steel structures. The coating systems shall be subjected to the test procedures described in Chapter 6.

In accordance with DIN EN ISO 12944-2, coating systems may be approved for the following environmental conditions:

- Freshwater (Im1)
- Saltwater (Im2) and Soil (Im3)

The coating systems fulfil the protection period termed “very high” according to DIN EN ISO 12944-1 (≥ 25 years). The protection period is to be understood as a planning parameter when drawing up a maintenance program. The protection period is not a “warranty period”.

In the scope of the Federal Waterways and Shipping Administration (WSV), the requirements of ZTV-W LB 218, Chapter 2 [1] apply. Accordingly, only coating systems that are listed on the “Lists of Approved Systems” [2] of the Federal Waterways Engineering and Research Institute (BAW) may be used for passive corrosion protection. These are regularly updated and can be accessed at www.baw.de.

The coating systems are tested by the BAW or by a recognized testing body (“P-Stelle” as per TL/TP-ING [3], conformity assessment body accredited according to ZTV-ING [4], or a testing laboratory accredited according to ISO/IEC 17025).

2 Testing and approval of coating systems at the BAW

2.1 Approval testing procedures

Coating systems for hydraulic steel structures can be tested and approved for various corrosivity categories according to DIN EN ISO 12944-2 (Table 1). The category Im1 corresponds to a permanent freshwater exposure load and the category Im2/Im3 corresponds to a permanent saltwater exposure load or soil environment. The individual tests are carried out according to DIN EN ISO standards or BAW's own procedures (RPB). Long-term exposure (LTE) in nature is carried out in parallel to the laboratory tests to verify the laboratory results. After completion of the test procedures, a test report is prepared.

Table 1: Test procedures in the course of an approval test for the various corrosivity categories and their exposure load duration

Test procedures	**Guideline/standard**	**Im1**	**Im2/Im3**
Condensation water changing exposure	RPB	4 cycles	-
Resistance to humidity	DIN EN ISO 6270-1	2,160 h	-
Resistance to liquids	DIN EN ISO 2812-2	4,000 h	4,000 h
Resistance to neutral salt spray	DIN EN ISO 9227	-	2,160 h
Determination of abrasion resistance	RPB	6 months + 10 days	
Long-term exposure (LTE) in nature	RPB	5 years	5 years

A certificate of approval is first issued after the laboratory tests have been completed and successfully passed (Chapter 7).

Table 2 provides an overview of the approval testing procedure for coating systems at the BAW and the corresponding sections in this guideline.

Table 2: Flow chart of the approval test procedure for coating systems at the BAW

Heading	Description	Chapter
Commissioning	Commissioning by the client for an approval test of a hydraulic steel structure coating system according to RPB	3
Delivery	Production and delivery of the test panels for the respective immersion categories by the client	3.1
	Delivery of wet samples of the individual components	3.2
	Provision of documentation (Annex 1 and 2) and product and safety data sheets	3.2
On-receipt inspection	Coating thickness measurement	4.1
	Categorization according to “Categories of coating systems for hydraulic steel structures”	4.2
	Comparison of the composition to wet samples	4.3
Sample preparation	Conditioning	5.1
	Application of an artificial defect	5.2
Performance of the tests	Exposure load of samples in the laboratory and in nature	6
	Evaluation of samples after exposure load	6
	Issuance of the respective test reports	6
Approval	Issuance of the test certificate	7
	Inclusion in the corresponding “List of approved systems”	7

If an approval is requested, all required test panels must be submitted at the same time. The costs of the tests are laid down in the remuneration regulations for services provided by the Federal Waterways Engineering and Research Institute to third parties (VL-BAW-Dritte) [5].

NB: *All test procedures required for approval (Table 1) may also be ordered individually. Individually commissioned test procedures cannot be recognized for approval.*

2.2 Optional test procedures

Further special requirements may be placed on coating systems for special operating conditions. The suitability for these requirements is demonstrated by the following optional test procedures.

Optional test procedures:

- Determination of resistance to cathodic delamination
- Cyclic ageing test
- Resistance to sudden deformation
- Determination of abrasion resistance without water exposure

A test report is issued after the respective test procedure has been carried out. In the case of determination of resistance to cathodic delamination, the positive result is listed in the “Lists of approved systems”.

NB: *The optional tests are no substitute for the approval tests, but they can supplement them.*

3 Commissioning by the client

The commissioning for approval of a hydraulic steel structure coating system according to RPB for inclusion on the lists of approved systems is made in text form.

In the course of the commissioning, the client assigns the coating system to be tested to a category in accordance with the "Categories of coating systems for hydraulic steel structures" [6] of the BAW. The BAW reserves the right to adjust the system assignment as part of the on-receipt inspection (Chapter 4).

3.1 Requirements for coated test panels

For the approval and optional test procedures at the BAW, coated test panels made of unalloyed structural steel S235 or S355 according to DIN EN 10025-2 must be provided in the quantity and panel geometry in accordance with Table 3.

The steel surface is prepared by blasting to a surface preparation level of Sa 2½ (DIN EN ISO 8501-1). The produced roughness depth (R_{y5}) must be medium (G) according to DIN EN ISO 8503-1.

The coating system is applied by the coating material manufacturer in accordance with the product data sheet. The application of the individual coatings must be done in contrasting colour changes. The coating system and the application conditions must be documented (see Annex 1). All test panels must be manufactured with identical coating system and coating thickness on both sides. The application of the individual coatings of all samples for the approval test procedures is carried out on the same coating batch. The use of diluents in the preparation of test panels must be specified. In addition, a sample of the diluent must be submitted together with the wet samples.

Table 3: Dimensions of the test panels for approval and optional test procedures

Dimensions of the steel panels [mm]	**Approval testing procedures**		**Optional test procedures**			
	Im1	**Im2/ Im3**	**KKS**	**Cyclic ageing**	**Impact test**	**Abrasion resistance without water exposure**
150 x 100 x 4	x	x		x	x	
300 x 200 x 4 [1]	x					x
400 x 400 x 4	x	x				
250 x 150 x 4	x	x				
150 x 150 x 4 [2]			x			

[1] Test panels including coating may not exceed the specified dimensions in length, width and depth by more than 1 mm. If this is not possible due to the thickness of the coating, the steel panel size may be reduced accordingly (e.g. 298 x 198 x 4 mm).

[2] A welding wire 5 mm thick and at least 100 mm long must be attached to the test panels (Annex 3). When coating the test panels, care must be taken to ensure that the welding wire is coated to a maximum of 30 mm.

Before coating, holes must be drilled into the test panels for long-term exposure in accordance with Annex 3.

3.2 Documentation and wet samples to be submitted

Wet samples of 50-200 ml for each component from the same batch used for the test panels must be submitted with the test panels. In addition, an acceptance test certificate 3.1 according to DIN EN 10204 must be supplied, indicating viscosity and density as well as, in accordance with component and binder type, epoxy equivalent, amine number and isocyanate number.

Additional documentation to be submitted:

- Information on the client and the application according to Annex 1,
- Information on the composition of the coating according to Annex 2,
- Safety data sheets for each component,
- Technical data sheet,
- Processing specifications, including the maximum permissible thickness of a single coat.

4 On-receipt inspection

Coating thicknesses are determined during the on-receipt inspection and used for the final categorization of the coating system.

4.1 Coating thickness measurement

The total coating thickness of the submitted test panels is determined using a magnetic induction method according to ISO 19840 and the test side is determined. For this purpose, the coating thickness is measured at 3 points per side on the vertical centre line of the test panel. On the test panels for the long-term exposure and abrasion tests, the coating thickness measurement is carried out in a manner distributed evenly over the surface.

4.2 Classification of the coating system based on the “Categories of coating systems for hydraulic steel structures”

The system assignment made during the submission is compared with the coating thickness measurement (Chapter 4.1). When classifying according to the “Categories of coating systems for hydraulic steel structures” [1], a total coating thickness factor of 1.2 is permissible for the average total coating thickness. If the average total coating thickness is higher, the system is assigned to the next higher coating thickness category.

4.3 Verification of the manufacturer's specifications on wet samples and characterization on the cured coating material

Control tests at the BAW are carried out on wet samples. The information in Annex 2 “Composition of the coatings” regarding the contents of binders, fillers, pigments, additives and solvents is compared with the laboratory results. In addition, further characterizations of the coating components are carried out if required.

In addition to the tests on the wet samples, a characterization for identification is carried out on the cured coating material and on one of the coated test panels submitted by the manufacturer. This is done by infrared spectroscopy, thermogravimetry and gas chromatography.

5 Preparation of the test panels

5.1 Conditioning

The test panels delivered to the BAW are conditioned for at least 7 days under normal climate (23 °C / 50 % relative humidity; DIN EN 23270). The test procedures shall begin at the earliest 4 weeks after application of the coating, in accordance with the application protocol.

5.2 Artificial defects

In addition to the evaluation of possible surface changes on the test panels, artificial defects according to DIN EN ISO 17872 are required to assess the corrosion protection performance. These defects are caused by mechanical removal of the coating down to the steel substrate.

5.2.1 Test panels for approval testing procedures

For the test procedures of condensation water changing exposure, resistance to neutral salt spray mist, and long-term exposure, an artificial defect 2 mm wide and at least 50 mm long is made in the middle and parallel to the long side of the panel. Application of the artificial defect is carried out at the BAW.

5.2.2 Test panels for optional test procedures

For the test procedures for determining the resistance to cathodic delamination, an annular defect and an extensive circular defect are made in the middle of the test panel. The annular defect has a diameter of 30 mm and a width of 1 mm. The extensive circular defect has a diameter of 5 mm (Annex 3).

For the cyclic ageing test procedures, an artificial defect 2 mm wide and 50 mm long is made on the test panel parallel to the short side of the panel. A distance of 25 mm to the edge of the short side of the panel and 12.5 mm to the edge of the long side of the panel is maintained. Application of the artificial defect is carried out at the BAW.

5.3 Adhesion strength test

At the earliest after the 7-day conditioning (Chapter 5.1) a determination of adhesion strength according to DIN EN ISO 4624 Method B is carried out on an unexposed test panel by means of triplicate determination. The averaged adhesion strength value is used in the test procedures (Chapter 6) as a comparison value (zero value).

After each exposure load, a triplicate determination is carried out on each test panel. The resulting average adhesion strength value must not be less than half (< 50 %) of the zero value. If the loss of adhesion strength is higher, an adhesion strength of at least 5 MPa must be achieved after exposure load.

6 Implementation of test procedures and their requirements

The implementation and requirements of all approval test procedures as well as the optional test procedures are presented below. After the test procedures have been carried out, a test report is prepared that shows whether the coating system fulfils the respective requirements.

6.1 Testing of resistance to condensation water changing exposure

The test to determine the resistance to condensation water changing exposure is carried out on three test panels (150 x 100 x 4 mm) according to the BAW method based on DIN EN ISO 6270-2 for corrosivity category Im1. Two out of three test panels must meet all requirements.

The test procedure consists of

- 5 times (exposure load phase)
  - 2 h exposure in distilled water at room temperature (23 ± 2 °C)
  - 22 h exposure in a condensation water constant climate at 40 ± 3 °C and 100 % relative humidity
- 1 time (rest phase)
  - 48 h in a closed climate chamber in an almost saturated atmosphere at room temperature (23 ± 2 °C)

The test procedure is repeated a total of 4 times (672 h).

When assessing and documenting the condition of the surface immediately after the end of the exposure load (after 672 hours), the following requirements apply:

- Degree of blistering (DIN EN ISO 4628-2) 0(S0)
- Degree of rusting (DIN EN ISO 4628-3) Ri 0
- Degree of cracking (DIN EN ISO 4628-4) 0(S0)
- Degree of flaking (DIN EN ISO 4628-5) 0(S0)

The assessment and documentation of corrosion on the artificial defect are carried out in accordance with DIN EN ISO 12944-6. The delamination is determined after the exposure load has been removed and the coating around the artificial defect has been removed. The evaluation is also carried out using optical image processing according to DIN EN ISO 21227-3. The following requirements apply:

- Degree of corrosion (DIN EN ISO 4628-8) ≤ 1.0 mm
- Degree of delamination (DIN EN ISO 4628-8) ≤ 5.0 mm
- Degree of delamination Informative

The following requirements apply when assessing and documenting the adhesion strength seven days after the end of the exposure load:

- Adhesion strength (DIN EN ISO 4624 Method B) ≥ 2.5 MPa
  ≥ 5 MPa (for A/B fraction)

6.2 Resistance to humidity – Continuous condensation

The resistance to humidity is tested on three test panels (150 x 100 x 4 mm) according to DIN EN ISO 6270-1 (one-sided exposure load due to continuous condensation) for corrosivity category Im1. The exposure load duration is 2,160 hours. Two out of three test panels must meet all requirements.

The following requirements apply when assessing and documenting the surface immediately after the end of the exposure load:

- Degree of blistering (DIN EN ISO 4628-2) 0(S0)
- Degree of rusting (DIN EN ISO 4628-3) Ri 0
- Degree of cracking (DIN EN ISO 4628-4) 0(S0)
- Degree of flaking (DIN EN ISO 4628-5) 0(S0)

The following requirements apply when assessing and documenting the adhesion strength seven days after the end of the exposure load:

- Adhesion strength (DIN EN ISO 4624 Method B) ≥ 2.5 MPa
  ≥ 5 MPa (for A/B fraction)

6.3 Resistance to liquids

The resistance to liquids is tested according to DIN EN ISO 2812-2 for the corrosivity categories Im1 and Im2/Im3. For this purpose, three test panels (150 x 100 x 4 mm) are immersed in the respective medium up to three-quarters of their length. The exposure load duration is 4,000 hours. Two out of three test panels must meet all requirements.

Test procedure for Im1:

Immersion in aerated, purified demineralized water (conductivity ≤ 20 µS/cm) at 40 ± 2 °C

Test procedure for Im2/Im3:

Immersion in a 5% aerated aqueous sodium chloride solution at 40 ± 2 °C

The following requirements apply when assessing and documenting the surface immediately after the end of the exposure load:

- Degree of blistering (DIN EN ISO 4628-2) 0(S0)
- Degree of rusting (DIN EN ISO 4628-3) Ri 0
- Degree of cracking (DIN EN ISO 4628-4) 0(S0)
- Degree of flaking (DIN EN ISO 4628-5) 0(S0)

The following requirements apply when assessing and documenting the adhesion strength seven days after the end of the exposure load:

- X-cut testing (DIN EN ISO 16276-2) Informative
- Adhesion strength (DIN EN ISO 4624 Method B) ≥ 2.5 MPa
  ≥ 5 MPa (for A/B fraction)

6.4 Resistance to neutral salt spray

Resistance to neutral salt spray is tested on three test panels (150 x 100 x 4 mm) according to DIN EN ISO 9227 for corrosivity category Im2/Im3. The exposure load duration is 2,160 hours. The test panels are positioned in the test device so that the artificial defect is aligned vertically. Two out of three test panels must meet all requirements.

The following requirements apply when assessing and documenting the surface immediately after the end of the exposure load:

- Degree of blistering (DIN EN ISO 4628-2) 0(S0)
- Degree of rusting (DIN EN ISO 4628-3) Ri 0
- Degree of cracking (DIN EN ISO 4628-4) 0(S0)
- Degree of flaking (DIN EN ISO 4628-5) 0(S0)

The assessment and documentation of corrosion on the artificial defect are carried out in accordance with DIN EN ISO 12944-6. The delamination is determined after the exposure load has been removed and the coating around the artificial defect has been removed. The evaluation is also carried out using optical image processing according to DIN EN ISO 21227-3. The following requirements apply:

- Degree of corrosion (DIN EN ISO 4628-8) $\leq$ 1.5 mm
- Degree of delamination (DIN EN ISO 4628-8) $\leq$ 5.0 mm
- Degree of delamination Informative

The following requirements apply when assessing and documenting the adhesion strength seven days after the end of the exposure load:

- Adhesion strength (DIN EN ISO 4624 Method B) $\geq$ 2.5 MPa
  $\geq$ 5 MPa (for A/B fraction)

6.5 Determination of abrasion resistance with water exposure

To determine the abrasion resistance with water exposure, two test panels (300 x 200 x 4 mm) are exposed according to DIN EN ISO 22182.

These test panels are exposed in freshwater for 6 months before being subjected to abrasion. The mechanical abrasion is generated in a testing machine with an octagonal, horizontally mounted drum. The drum is filled with a mixture of crushed basalt chippings and water with the following composition: 2 kg of grain size 8-2 mm, 1 kg of grain size 5-8 mm, 1 kg of grain size 3-5 mm and 8 litres of tap water.

One cycle of abrasion exposure load consists of 40,000 drum revolutions (16 revolutions per minute), with the direction of rotation changing after every 5,000 revolutions. To determine the abrasion value (a_v), the coating thickness is measured at eight specific points before the exposure load and after each cycle. If the coating thickness is at least 50 µm at all measuring points, the abrasion exposure load is continued for a maximum of five cycles.

The abrasion value (a_v) indicates the average coating thickness reduction per 10,000 drum revolutions. According to the determined abrasion value (a_v), a coating material is assigned to one of three abrasion resistance categories (AR) and noted in the “List of approved systems”.

Table 4: Abrasion resistance categories (AR) with corresponding abrasion values (a_v)

Abrasion resistance category (AR)	Abrasion value [µm / 10,000 U]
poor	$a_v > 60$
average	$40 < a_v \leq 60$
strong	$a_v \leq 40$

6.6 Long-term exposure (LTE) in nature

An additional 5-year long-term exposure under natural conditions is carried out in order to conclusively evaluate the corrosion protection performance of a coating system. Such exposure load is necessary because the complexity of the stresses occurring in nature cannot be adequately represented by individual laboratory procedures (DIN EN ISO 12944-6).

The exposure in nature takes place at four locations in different water types and atmospheres (Table 5). For this purpose, a test panel is placed in the atmospheric zone, in the water changing zone and in the underwater zone in such a way that the artificial defect is aligned vertically.

Table 5: Description of the exposure locations

Location	Trier	Windheim	Kiel	Büsum
Water body	Mosel	Weser	Baltic Sea	North Sea
Water body type	Freshwater	Freshwater	Saltwater	Saltwater
Corrosivity category	Im1	Im1	Im2	Im2
Conductivity [µS/cm][1]	1,200	1,500	30,200	35,100
Atmospheric Corrosivity Category for Steel[1] (DIN EN ISO 12944-2)	C2	C2	C4	C3
W_0-Value[1] (DIN 50929-3)	-1.2	-2.2	-10.4	-9.4

[1] Average 2018-2023

After removal from exposure, the test panels are examined on site for surface defects (DIN EN ISO 4628) and documented.

The following requirements apply when assessing and documenting the surface after the end of the exposure load:

- Degree of blistering (DIN EN ISO 4628-2) 0(S0) Surface
- Degree of rusting (DIN EN ISO 4628-3) Ri 0 Surface
- Degree of cracking (DIN EN ISO 4628-4) 0(S0) Surface
- Degree of flaking (DIN EN ISO 4628-5) 0(S0) Surface

The assessment and documentation of corrosion and delamination is then carried out in the laboratory according to DIN EN ISO 12944-6 the coating around the artificial defect has been removed. The evaluation is also carried out using optical image processing according to DIN EN ISO 21227-3. The following requirements apply:

- Degree of delamination (DIN EN ISO 4628-8) ≤ 30 mm
- Degree of delamination Informative

The following requirements apply when assessing and documenting the adhesion strength after the end of the exposure load:

- Adhesion strength (DIN EN ISO 4624 Method B) ≥ 2.5 MPa
  ≥ 5 MPa (for A/B fraction)

The requirements for the degree of corrosion are summarized in Table 6.

Table 6: Requirements for the degree of corrosion (DIN EN ISO 4628-8) on the artificial defect depending on location and zone

Location	Trier	Windheim	Kiel	Büsum
Atmospheric zone (AZ) [mm]	≤ 1.0	≤ 1.0	≤ 6.0	≤ 2.0
Water changing zone (WZ) [mm]	≤ 2.0	≤ 2.0	≤ 10.0	≤ 5.0
Underwater zone (UZ) [mm]	≤ 1.5	≤ 1.5	≤ 2.5	≤ 2.5

For the requirements a tolerance range is specified regarding the degree of corrosion in the assessment. This consists of the individual tolerance and an overall limit of maximum deviation. The individual tolerance is 10% for each of the six test panels per corrosivity category, i.e. the respective limit value may be exceeded by a maximum of 10%. These individual tolerances can be accumulated on one or more test panels, but the total limit must not exceed 40% on a single test panel.

6.7 Determination of resistance to cathodic delamination

The resistance to cathodic delamination is determined on ten test panels (150 x 150 x 4 mm) according to Table 7. The test involves a protective potential of -930 ± 5 mV against Ag/AgCl (KCl_{total}) for a test period of 15 months. During the exposure load phase, the power consumption is continuously documented for each test panel (1-3, 5-8, 10). Of the test panels 1-3 and 6-8, two out of three test panels must meet all requirements. Test panels 4, 5, 9 and 10 must meet the adhesion strength requirements.

Table 7: Exposure loads of the respective test panels for determining the resistance to cathodic delamination

Test panel	Preparation	Potential Ag/AgCl (KCl_{total})	Medium
1-3	3x one-sided defect	-930 ± 5 mV	Saltwater
4	one-sided defect	without	Saltwater
5	defect	-930 ± 5 mV	Saltwater
6-8	3x one-sided defect	-930 ± 5 mV	Brackish water
9	one-sided defect	without	Brackish water
10	defect	-930 ± 5 mV	Brackish water

The test solutions are prepared according to DIN 50905-4 (Table 8). During the exposure load phase, the test solutions are continuously bubbled by an air stream at room temperature (23 ± 2 °C). Possible evapo-

ration is compensated by the addition of deionized water, so that a constant test solution volume is ensured.

Table 8: Test solution for determining the resistance to cathodic delamination

Salt used	**Chemical formula**	**Saltwater** (DIN 50905-4 A.1)	**Brackish water** (DIN 50905-4 A.2)
Sodium chloride [g/L]	NaCl	28.0	5.6
Sodium bicarbonate [g/L]	$NaHCO_3$	0.2	-
Magnesium chloride hexahydrate [g/L]	$MgCl_2*6H_2O$	5.0	1.0
Magnesium sulfate heptahydrate [g/L]	$MgSO_4*7H_2O$	7.0	1.4
Calcium chloride hexahydrate [g/L]	$CaCl_2*6H_2O$	2.4	0.48
Sodium citrate dihydrate [g/L]	$C_6H_5Na_3O_7*2H_2O$	-	0.2
Thioacetamide [g/L]	CH_3CSNH_2	-	0.1
pH value	-	7 to 8	7.5

A 15 mm wide edge of the test panel and a circle with a diameter of 50 mm in the centre of the not to be assessed extensive circular area are used when assessing and documenting the surface (Annex 3). Outside of the area not to be assessed immediately after the end of the exposure load, the following requirements apply:

- Degree of blistering (DIN EN ISO 4628-2) 0(S0)
- Power requirement ≤ 50 µA

To assess and document the adhesion strength, three adhesion pull-off test dollies are positioned adjacent to the area not to be assessed and are pulled off (Annex 3).

The following requirements apply:

- Adhesion strength (DIN EN ISO 4624 Method B) ≥ 2.5 MPa
  ≥ 5 MPa (for A/B fraction)
  ≥ 50% compared to sample 4 or 9 (applies to samples 1-3, 5-8 and 10)
- Visually visible changes to the steel surface in the test dolly area in the case of A/B and B fractions correspond to a delamination ≥ 10 mm and are not permitted. To assess the progress of delamination, a fourth test dolly can be placed at the boundary between the area not to be assessed and the area to be assessed.

6.8 Cyclic ageing test

The cyclic ageing test is carried out on three test panels (150 x 100 x 4 mm) according to DIN EN ISO 12944-9. The exposure load duration is 4200 h.

The assessment, documentation and requirements for the surface as well as the degree of corrosion and delamination after end of the exposure load and after removal of the coating around the artificial defect are carried out in accordance with DIN EN ISO 12944-9. The assessment and documentation of the adhesion strength are carried out according to DIN EN ISO 4624 Method B.

6.9 Determination of the resistance to sudden deformation caused by a falling weight

Classification test

The classification test to determine the resistance to sudden deformation caused by a falling weight is carried out on two test panels (150 x 100 x 4 mm) in accordance with DIN EN ISO 6272-1 and assessed according to DIN EN ISO 29601.

Yes/no test

For a yes/no test, a 1 kg test weight according to DIN EN ISO 6272-1 is dropped from a height of 0.5 m onto a non-spring-mounted test panel. The test is carried out on differently conditioned test panels (23 ± 2 °C and 0 ± 2 °C). The assessment is carried out according to DIN EN ISO 29601. The impact exposure load is repeated at five different places. The coating material has passed the test if no cracking, no detachment from the substrate and no breakthrough are detected in at least four places after high-voltage testing at both temperatures.

6.10 Determination of abrasion resistance without water exposure

To determine the abrasion resistance without water exposure, two test panels (300 x 200 x 4 mm, NB Table 3) are exposed and assessed after conditioning (Chapter 5.1) as described in Chapter 6.5.

7 Approval certificate and duration of validity

A prerequisite for an approval certificate for a coating system to be issued is the completion of the approval test procedures as described in 2.1 and the fulfilment of the requirements of the laboratory tests (Chapter 6.1 up to 6.5). The approval certificate documents the suitability for the protection period termed “very high” and the corresponding corrosivity category and, if applicable, the resistance to cathodic delamination. All coating systems that meet these requirements are included in the BAW’s “List of Approved Systems”. These are available at www.baw.de.

The approval certificate is valid for five years from the date of issuance of the last test report.

After the approval certificate expires, a coating system can be approved for a further five years. This requires a new test with a reduced scope. This includes the following test procedures:

- Control tests on wet samples or on the cured coating material (4.3)
- Determination of abrasion resistance with water exposure (6.5)
- For Im1: Resistance to condensation water changing exposure (6.1)
- For Im2/Im3: Resistance to neutral salt spray test (6.4)

After fulfilling the requirements of these reduced scope laboratory tests, an updated approval certificate with a new validity date will be issued. After expiry of this date, a coating system can be re-approved. For this purpose, an approval test according to Chapter 2.1 is required.

An additional 5-year long-term exposure under natural conditions is carried out in order to conclusively evaluate the corrosion protection performance of a coating system. The BAW reserves the right to withdraw the approval of a coating system due to the non-fulfilment of the requirements of long-term exposure (Chapter 6.6).

The proof of suitability of the optional test to determine the resistance to cathodic delamination is valid for 10 years and is recorded in the “List of approved systems”.

Changes to the formulation of a coating system must be reported to the BAW and may require a new approval test.

1 Literature

[1] Federal Ministry of Transport and Digital Infrastructure (ed.) (2009): Additional technical terms of contract - hydraulic engineering (ZTV-W) for corrosion protection in hydraulic steel structures (performance category 218).

[2] Federal Institute for Hydraulic Engineering (ed.) List of approved systems: Compilation of approved systems I (Im1) and systems II (Im2/3). Available online at https://www.baw.de/de/publikationen/qualitaetsbewertung/qualitaetsbewertung.html.

[3] Federal Ministry for Digital and Transport (ed.) (2022): Technical delivery conditions and technical test specifications for civil engineering structures (TL/TP-ING).

[4] Federal Ministry for Digital and Transport (ed.) (2023): Additional technical terms of contract and guidelines for civil engineering structures (ZTV-ING).

[5] Federal Ministry of Transport and Digital Infrastructure (ed.) Remuneration regulations for services provided by the Federal Waterways Engineering and Research Institute to third parties (VL-BAW-Dritte). Available online at: https://www.baw.de/de/publikationen/qualitaetsbewertung/qualitaetsbewertung.html.

[6] Federal Waterways Engineering and Research Institute (ed.) Categories of coating systems for hydraulic steel structures. Available online at https://www.baw.de/de/publikationen/qualitaetsbewertung/qualitaetsbewertung.html.

2 Normative references

DIN 50929-3:2024-05	Corrosion of metals – Corrosion likelihood of metallic materials when subject to corrosion from the outside – Part 3: Buried and underwater pipelines and structural components
DIN 50905-4:2018-03	Corrosion of metals – Corrosion testing – Part 4: Performance of chemical corrosion experiments without mechanical stresses in liquids in the laboratory
DIN EN 10204:2005-01	Metallic products - Types of inspection documents
DIN EN 23270:1991-09	Paints, varnishes and their raw materials; temperatures and humidities for conditioning and testing
DIN EN ISO 2812-2:2019-03	Paints and Varnishes – Determination of resistance to liquids – Part 2: Water immersion method
DIN EN ISO 4624:2016-08	Paints and Varnishes — Pull-off test for adhesion
DIN EN ISO 4628-2:2016-07	Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 2: Assessment of degree of blistering
DIN EN ISO 4628-3:2016-07	Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 3: Assessment of degree of rusting
DIN EN ISO 4628-4:2016-07	Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 4: Assessment of degree of cracking
DIN EN ISO 4628-5:2016-07	Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 5: Assessment of the degree of flaking
DIN EN ISO 4628-8:2013-03	Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance - Part 8: Assessment of degree of delamination and corrosion around a scribe or other artificial defect
DIN EN ISO 6270-1:2018-04	Paints and Varnishes - Determination of resistance to humidity - Part 1: Condensation (single-sided exposure)
DIN EN ISO 6270-2:2018-04	Paints and Varnishes – Determination of resistance to humidity – Part 2: Condensation (in-cabinet exposure with heated water reservoir)
DIN EN ISO 6272-1:2011-11	Paints and Varnishes - Rapid-deformation (impact resistance) tests - Part 1: Falling-weight test, large-area indenter
DIN EN ISO 8501-1:2002-03	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings

DIN EN ISO 8503-1:2013-05	Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast-cleaned steel substrates – Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces
DIN EN ISO 9227:2023-03	Corrosion tests in artificial atmospheres – Salt spray tests
DIN EN ISO 12944-1:2019-01	Corrosion protection of steel structures by protective paint systems – Part 1: General Introduction
DIN EN ISO 12944-2:2018-04	Paints and Varnishes – Corrosion protection of steel structures by protective paint systems – Part 2: Classification of environments
DIN EN ISO 12944-6:2018-06	Paints and Varnishes – Corrosion protection of steel structures by protective paint systems – Part 6: Laboratory performance test methods
DIN EN ISO 12944-9:2018-06	Paints and Varnishes – Corrosion protection of steel structures by protective paint systems – Part 9: Protective paint systems and laboratory performance test methods for offshore and related structures
DIN EN ISO 17872:2007-06	Paints and Varnishes – Guidelines for the introduction of scribe marks through coatings on metallic panels for corrosion testing
DIN EN ISO 21227-3:2007-07	Paints and Varnishes – Evaluation of defects on coated surfaces using optical imaging – Part 3: Evaluation of delamination and corrosion around a scribe
DIN EN ISO 22182:2022-12	Geotextiles and geotextile-related products – Determination of index abrasion resistance characteristics under wet conditions for hydraulic applications
DIN EN ISO 29601:2011-07	Paints and Varnishes – Corrosion protection by protective paint systems – Assessment of porosity in a dry film
DIN EN 10025-2:2019-10	Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels
ISO 19840:2012-09	Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Measurement of, and acceptance criteria for, the thickness of dry films on rough surface
DIN EN ISO/IEC 17025:2018-03	General requirements for the competence of testing and calibration laboratories

Supporting documents

1. Information provided by the client

Client/address ……

……

……

Phone/e-mail ……

Contact person ……

Surface preparation

Substrate/steel grade (DIN EN 10025-2): ……

Surface preparation level (DIN EN ISO 8501-1): ……

Surface roughness (DIN EN ISO 8503-1): ……

Categorization according to
"Categories of coating systems for hydraulic steel structures" ……

Coating system and application conditions

Coat	Product name	Binder type	Batch number Colour	Application conditions				Nominal dry film thickness [µm]
				Application process[1]	Air temperature [°C]	Rel. humidity [%]	Date of application	
1								
2								
3								
4								
5								
Total coated thickness								

[1] AS: Airless sprayers
PS: Pneumatic sprayers
PTG: Painting
R: Rolling
IM: Immersion
El: Electrostatic wetting and burn-in
Other: Indication of the method used

If diluents were used in the preparation of the test panels, this must be indicated here (mass fraction, diluent, application method, coat). ……

2. Composition of the coating

Coat[1]:	☐ 1. Coat	☐ 2. Coat	☐ 3. Coat	☐ 4. Coat	☐ 5. Coat
Coating material manufacturers:					
Product name:					
Colour:					
Binder type:			Curing agent type:		
Mixing ratio for 2K systems (base component/curing agent) Mass fraction: ……..			Volume fraction: ……..		

Base component		**Curing agents**	
Binder:	..... M. %	Curing agents:	..... M. %
Pigments/fillers and additives:	..... M. %	Solvents:	..... M. %
Solvents:	..... M. %	Density:	..... kg/dm³
Density:	..... kg/dm³		

Further information on the solvents			
Solvent of the base component		**Solvent of the curing agents**	
.....	..... M. %	.....	..... M. %
.....	..... M. %	.....	..... M. %
.....	..... M. %	.....	..... M. %

Further information on the base component			
Pigments/fillers		**Additive**	
.....	..... M. %	.....	..... M. %
.....	..... M. %	.....	..... M. %
.....	..... M. %	.....	..... M. %

[1] Annex 2 is to be used for each coat of a coating system

Documents to be submitted:

- Acceptance test certificate 3.1 according to DIN EN 10204 (Chapter 3.2)
- Safety data sheets
- Technical data sheet
- Processing specifications, including maximum permissible thickness of a single coat

3. Dimensions of the test panels for laboratory tests and long-term exposure

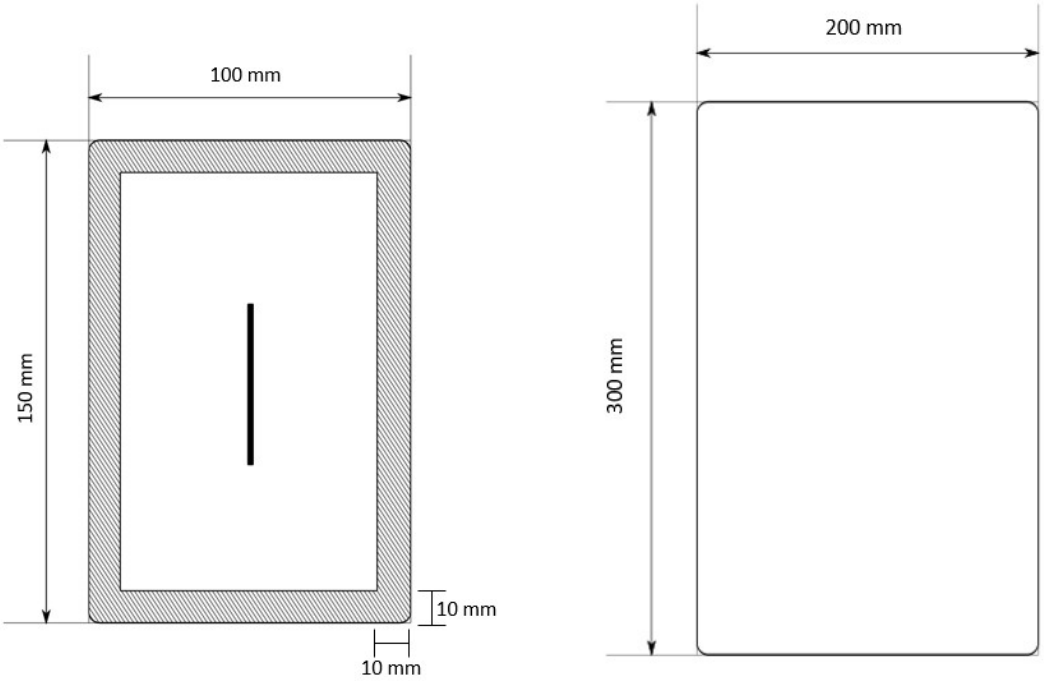
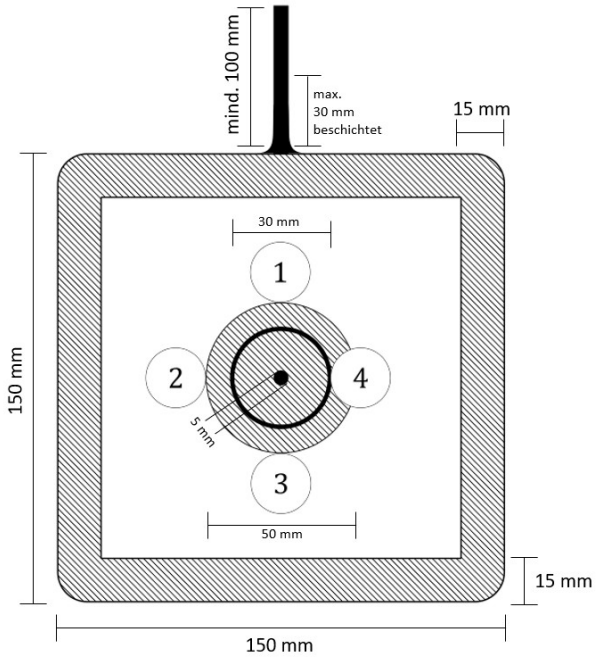


Figure 1: *(left) Dimensions of the test panels for laboratory tests with the area not to be assessed in grey and the position of the artificial defect;*
(right) Dimensions of the test panels for determining the abrasion resistance



Mind. 100 mm	At least 100 mm
Max. 30 mm beschichtet	Max. 30 mm coated

Figure 2: *Dimensions of the test panel for determining the resistance to cathodic delamination with soldered welding wire and the two artificial defects, the area not to be assessed in grey, and the position of the pull-off adhesion tests.*
When coating the test panels, care must be taken to ensure that the welding wire is coated to a maximum of 30 mm.

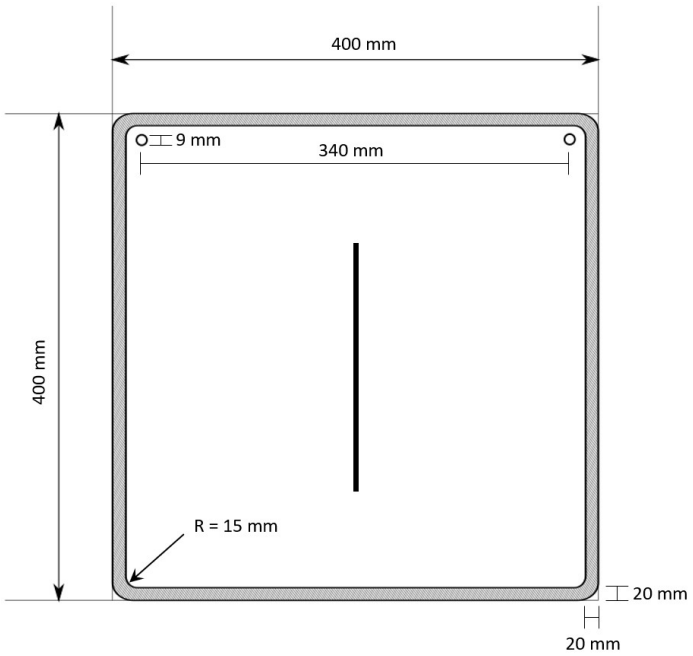


Figure 3: *Dimensions of the test panel for long-term exposure with position of the boreholes for fastening, the artificial defect and the area not to be assessed in grey*

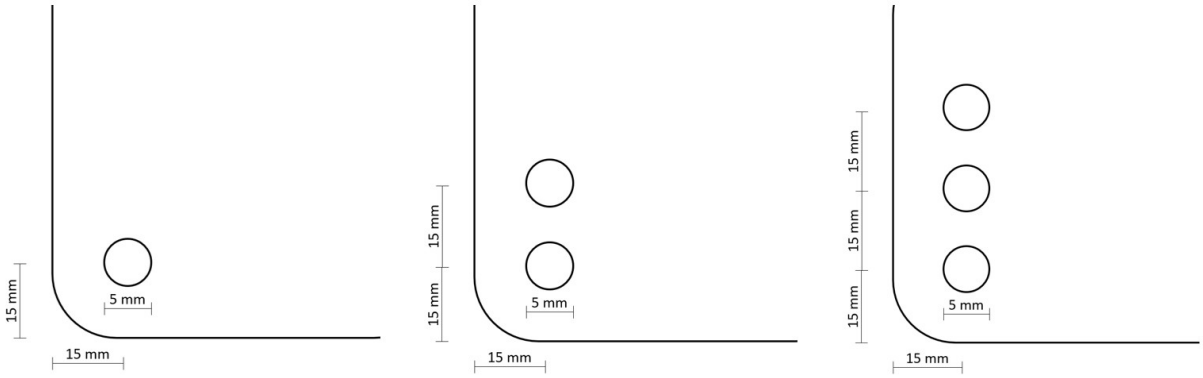
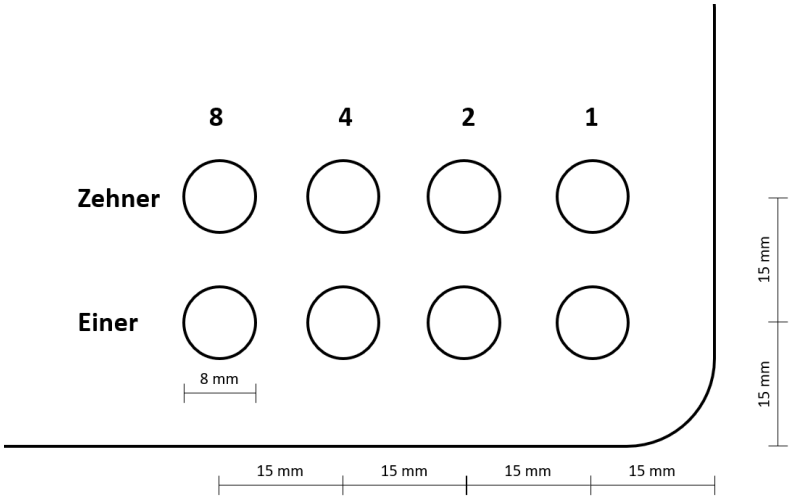


Figure 4: *Zone marking of the test panels for long-term exposure through boreholes (bottom left)*



Zehner — Tens

Einer — Ones

Number	Boreholes	
	Ones	Tens
1	1	-
2	2	-
3	1 + 2	-
4	4	-
5	1 + 4	-
6	2 + 4	-
7	1 + 2 + 4	-
8	8	-
9	1 + 8	-

Number	Boreholes	
	Ones	Tens
10	-	1
11	1	1
12	2	1
20	-	2
25	1 + 4	2
30	-	1 + 2
50	-	1 + 4
87	1 + 2 + 4	8
99	1 + 8	1 + 8

Figure 5: Coding numbers of the test panels for long-term exposure through boreholes (bottom right)

4. Summary of the requirements in the approval testing methods

	KWW, 9227	**6270-1, 2812-2, LTE**	**BAW-KKS**	**Cyclic ageing test**
Requirements (immediately after the end of the exposure load)				
Degree of blistering (DIN EN ISO 4628-2)	0(S0)		0(S0)	0(S0)
Degree of rusting (DIN EN ISO 4628-3)	Ri 0		-	Ri 0
Degree of cracking (DIN EN ISO 4628-4)	0(S0)		-	0(S0)
Degree of flaking (DIN EN ISO 4628-5)	0(S0)		-	0(S0)
Degree of corrosion (DIN EN ISO 4628-8)	≤ 1.0 mm (KWW) ≤ 1.5 mm (9227)	-	-	≤ 3 / ≤ 8 mm
Degree of delamination (DIN EN ISO 4628-8)	≤ 5.0 mm	≤ 30 mm (LTE)	≤ 10 mm	-
Degree of delamination	Informative	informative (LTE)	-	-
Power requirement	-	-	≤ 50 µA	-
Requirements (7 days after the end of the exposure load)				
Adhesion strength (DIN EN ISO 4624 method B)	≥ 2.5 MPa ≥ 5.0 MPa (for A/B fractions) ≥ 50 % rule[1]		≥ 2.5 MPa ≥ 5.0 MPa (for A/B fractions) ≥ 50 % rule[2]	≥ 50 % rule ≥ 5.0 MPa (for A/B fractions)
X-cut testing (DIN EN ISO 16276-2)	-	informative (2812-2)	-	-
Requirements for the degree of corrosion (DIN EN ISO 4628-8) (according to LTE)				
Location	**Trier**	**Windheim**	**Kiel**	**Büsum**
Atmospheric zone (AZ)	≤ 1.0 mm	≤ 1.0 mm	≤ 6.0 mm	≤ 2.0 mm
Water changing zone (WZ)	≤ 2.0 mm	≤ 2.0 mm	≤ 10.0 mm	≤ 5.0 mm
Underwater zone (UZ)	≤ 1.5 mm	≤ 1.5 mm	≤ 2.5 mm	≤ 2.5 mm
Abrasion resistance categories (AR)				
	Abrasion value [µm / 10,000 U]			
poor	$a_v > 60$			
average	$40 < a_v \leq 60$			
strong	$a_v \leq 40$			

[1] Chapter 5.3

[2] Chapter 6.7