

Note: The obligations arising from the Directive 98/34/EC of the European Parliament and the Council, dated 22 June 1998, regarding a procedure for the provision of information in the field of standards and technical specifications (OJ No. L 204, p. 37), most recently amended by the Directive 98/48/EC of the European Parliament and the Council, dated 20 July 1998 (OJ No. L 217, p. 18) have been taken in account.

Notification No: 99/482/D

**Guidelines  
for the  
testing of coating systems  
for the corrosion protection  
of hydraulic steel structures**

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# Waterways Engineering and Research Institute (BAW) RPB

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I = Initial testing      Q = Qualification testing      P = Prolongation testing

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**Enclosures**

- Enclosure 1 Indication of material components
- Enclosure 2 Documentation of the coating system to be applied
- Enclosure 3 Dimensions of test panels (abrasion test and for cathodic corrosion protection - CCP)
- Enclosure 4 Dimensions of test panels (long term trials in nature)
- Enclosure 5 Positions of drillings for attachment and decoding

**Preliminary remarks**

Products from other Member States of the European Communities and goods originating from the Member States of the European Trade Area that do not correspond to these technical specifications will be treated as being equivalent, likewise tests that have been carried out in the country of manufacture, if the required protection level - safety, health and suitability for use - will be achieved equally and permanently. As far as the Directive 73/23/EC will be applied, the safety level of the products corresponding to it will be considered as likewise complying with the standards.

The testing in each case has to be in accordance with DIN EN ISO 12944-6, Laboratory performance test methods.

**1 General notes on the testing of coating materials**

For the passive corrosion protection DIN EN ISO 12944 is valid. Coating systems for the corrosion protection in steel hydraulic engineering are listed in Part 5, Table A.8, of this standard. Further required systems are given, for completion, in the "Zusätzlichen Technischen Vertragsbedingungen – Wasserbau (ZTV-W) für den Korrosionsschutz im Stahlwasserbau (Leistungsbereich 218)" (Additional technical contract conditions – Hydraulic engineering (ZTV-W) for the corrosion protection in steel hydraulic engineering (Service area 218). The field of validity is likewise specified in that document.

The duration of laboratory testing period is about seven months. The period of validity of the approval of a coating system is five years, starting from the end of the initial testing. After the expiry of the approval a prolongation test can be requested, provided that the formulation has not been changed (see clause 9, page 18). Qualification tests are to be carried out in the case of special requirements. In this case, the testing period amounts to up to 15 months (see clause 7).

The prolongation testing can be given only once. In the area of the Wasser- und Schifffahrtsverwaltung (water and shipping administration) only such systems shall be used for corrosion protection which have been subjected to the subsequent test methods and which comply with the specified requirements.

**2 Testing of the composition****2.1 Indication of the components**

The manufacturer has to inform the Bundesanstalt für Wasserbau (Federal Waterways Engineering and Research Institute, BAW) on the following components, in parts by mass, of the coating material to be tested (see enclosure 1):

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- Binders (in the case of reactive materials the components separately)
- Amounts of alternatives to tar and hydrocarbon resins, when in combination with the binder, are to be indicated separately.
- Pigments and extenders
- Solvents

This information will be used for purposes of control and will be treated confidentially by the BAW. Changes of the formulation require a repetition of the initial testing or, respectively, a premature prolongation testing.

EC Safety Data Sheets as well as application guidelines or technical data sheets with definite information on the application conditions have to be attached.

### **2.2 Examination of wet samples**

About 250 ml of representative sample material, separate for the components, are to be submitted to the BAW.

For testing the composition, in terms of quantity, of the coating material, it is proceeded as follows:

- The amount of pigments and extenders is determined by weighing after separation by centrifugation.
- The amount of volatile components is obtained by determining the loss of mass by drying at 70 °C (DIN 53216). Two-component systems will be previously weighed, mixed and cured in accordance with the specified formulation.
- The binder content is obtained indirectly by subtraction.

The composition of the individual components is determined as follows:

- Solvent composition by Gas Chromatography (GC).
- Binder composition by Infrared Spectroscopy (IR).
- Pigments and extenders by infrared spectroscopy or X-ray diffraction and, in particular cases, by chemical analysis.

In addition, the curing behaviour will be checked.

### **3 Preparation of test specimens**

The test panels, consisting of unalloyed structural steel (DIN EN 10025), are prepared by blast-cleaning to the surface preparation grade Sa 2½ (DIN ISO 8501-1).

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The average peak-to-valley height is at least 12,5 µm (DIN 4768, see also DIN ISO 8503-1).

The application of the coats takes place at the manufacturer of the coating material. The information on the application is to be included in a form corresponding to enclosure 2. Alternatively, the application of the coats can take place at licensed testing institutes.

The systems will be allocated on the basis of the proposed coats, in accordance with STLK 218. The measured film thicknesses may exceed the nominal film thicknesses by the factor 1,25, at maximum.

With the exception of certain coating materials to be applied by hot spraying, the coatings shall not be heated above room temperature. In no case, the glass transition temperature shall be achieved. The application conditions are to be recorded and signed by the applicator.

After seven days storage at the BAW at standard atmosphere 23/50 (DIN EN 23270) the examinations will start, at the earliest.

The test panels for the different initial tests are to be prepared uniformly, i.e. at the same time with identical coats and method of application. Face and reverse side generally are to be coated with the same coats. Test panels for qualification tests and for long-term exposure can be submitted at a later date (together with a reference test panel).

As a survey in table 1 the type of test panels, their dimensions as well as the required number which is necessary for the individual tests are given (see also enclosure 3).

**Table 1:** Tests and required test panels

Test method	Clause/ Subclause	Dimensions [mm]	Number [n]	Type of test	Immersion class <sup>2</sup>
Water condensation changing test (BAW/Bahn AG)	4.1.1	300x200x2,5 <sup>1</sup>	4	I, P	Im1, Im 2/Im 3
Resistance to liquids (EN ISO 2812-2)	4.1.2	150x100x2,5 <sup>1</sup> 150x100x2,5 <sup>1</sup>	4	I	Im1, Im 2/Im 3
			4	I	
Resistance to neutral salt spray (ISO 7253)	4.1.3	150x100x2,5 <sup>1</sup>	4	I	Im 2/Im 3
Resistance to humidity (ISO 6270)	4.1.4	150x100x2,5 <sup>1</sup>	4	I	Im 1
Natural long-term exposure (BAW)	4.2	400x400x3,5 <sup>1</sup>	12	I	Im 1/Im 2/ Im 3
Determination of ab- rasion resistance (BAW)	5.1	300x200x2,5 <sup>1</sup>	5	I, P	Im 1/Im 2/ Im 3
Determination of impact strength (ISO 6272)	5.2	300x200x2,5 <sup>1</sup>	1	Q	
Determination of resistance to chemicals (EN ISO 2812-1)	6	150x100x2,5 <sup>1</sup>	4	Q	Acid, alkali, oil
Compatibility with Cathodic corrosion Protection (BAW)	7	150x150x2,5 <sup>1</sup>	8	Q	Im 1/Im 2

<sup>1</sup> Tolerance:  $\pm 0,5$  mm    <sup>2</sup> Im 1: Fresh water; Im 2: Sea or brackish water; Im 3: Soil

I = Initial testing    Q = Qualification testing    P = Prolongation testing

## 4 Testing of resistance to corrosion

### 4.1 Laboratory test methods

As a matter of principle, the tests regarding the corrosion protection for hydraulic steel structures aiming at "high durability" (more than 15 years in accordance with DIN EN ISO 12944-1). Visual assessments are to be carried out immediately after the end of the test procedures. Tests that are destructive are to be carried out after 24 h conditioning at standard atmosphere. The cross cuts - with a distance of 5 mm - will be performed using a machine particularly developed for this purpose or by hand. Additionally, testing using the St. Andrew's cross (manually) is possible.

The local damage (scratch/scribe) may be applied manually or mechanically (good reproducibility). For the assessment the area 1 cm left and right of the local damage will be used – beginning at a distance of 1 cm from the test panel edge.

For all laboratory test methods requirements before the exposure are to complied with:

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- Cross cut value in accordance with EN ISO 2409 \*  $\leq$  Gt 1
- alternatively/supplementary  
St. Andrew's cross value following BAW  $\leq$  Kt 1
- Pull-off test value in accordance with DIN EN ISO 4624  $\geq$  1,5 N/mm<sup>2</sup>
- In the case of adhesion failure A/B (area affected > 50 %)  $\geq$  5 N/mm<sup>2</sup>

Two of three test panels shall comply with the test criteria. A further test panel will always be used as zero specimen or, respectively, held back. Apart from that the procedures laid down in DIN EN ISO 12944-6 apply.

### 4.1.1 Resistance to alternating exposure to condensation water

The test panels of dimensions 150 mm x 100 mm (see table 1) will be cut from the test panels provided and a defined local damage (mechanically, of width 2 mm) down to the metallic substrate will be applied. This treatment of the test panels takes place at the BAW. Three test panels will be exposed while the test cycle will be repeated 20 times.

#### Test conditions for Im 2/Im 3:

Over a period of 20 days

- 2 h in saturated sodium chloride solution at -15 °C and
- 22 h in condensation-water constant climate at 40 °C (DIN 50017)

are intended.

#### Test conditions for Im 1:

Three test panels will be tested in distilled water (at 20 °C) and afterwards likewise for 22 h in the condensation-water constant climate.

#### Test criteria for Im 1, Im 2/Im 3 (after the exposure):

##### *Area/surface:*

- Degree of blistering in accordance with ISO 4628-2 m0/g0
- Degree of rusting in accordance with ISO 4628-3 Ri 0
- Degree of cracking in accordance with ISO 4628-4 0
- Degree of flaking in accordance with ISO 4628-5 0
- Pull-off value in accordance with DIN EN ISO 4624  $\geq$  1,5 N/mm<sup>2</sup>
- In the case of adhesion failure A/B (area affected > 50 %)  $\geq$  5 N/mm<sup>2</sup>

\* Pattern: 5 mm distance in the case of film thicknesses  $\geq$  350  $\mu$ m

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alternatively:

- Cross-cut value in accordance with EN ISO 2409 \*  $\leq$  Gt 1

*Local damage:*

- Degree of blistering in accordance with ISO 4628-2 m1/g2
- Average underrusting (one-sided)  $\leq$  1 mm
- Mean creeping (one-sided)  $\leq$  1,5 mm

### 4.1.2 Resistance to liquids – Water immersion method (EN ISO 2812-2)

In total six test panels of dimensions 150 mm x 100 mm are required (see table 1). In accordance with EN ISO 2812-1 the immersion method (method 1) is to be applied. The panels are to be placed in the vessel with  $\frac{3}{4}$  of their length, at an inclination of 20° and in a distance of 30 mm. The temperature of the test liquid is held at 40 °C during whole the test period (3000 h). Every three days, at the latest, the position of the test panels is to be changed. Aeration of the immersion medium is to be provided.

Test conditions for Im 1:

- Immersion in aerated purified water (conductivity  $\leq$  20  $\mu$ S/cm) at 40 °C
- Test duration 3000 h

Test conditions for Im 2/Im 3:

- Immersion in aerated aqueous sodium chloride solution, 5 %, at 40 °C
- Test duration 3000 h

Test criteria for Im 1/Im 2/Im 3 (after exposure):

*Area/surface:*

- Degree of blistering in accordance with ISO 4628-2 m0/g0
- Degree of rusting in accordance with ISO 4628-3 Ri 0
- Degree of cracking in accordance with ISO 4628-4 0
- Degree of flaking in accordance with ISO 4628-5 0
- Pull-off value in accordance with DIN EN ISO 4624  $\geq$  1,5 N/mm<sup>2</sup>  
In the case of adhesion failure A/B  
(area affected > 50 %)  $\geq$  5 N/mm<sup>2</sup>

alternatively:

- Cross-cut value in accordance with EN ISO 2409 \*  $\leq$  Gt 1

\* Pattern: 5 mm distance in the case of film thicknesses  $\geq$  350  $\mu$ m

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The visual observation comprises all the further visual characteristics of changes (colour change, rust spots, embrittlement etc.).

### 4.1.3 Resistance to neutral salt spray (DIN ISO 7253)

The test is carried out exclusively for the immersion media Im 2 and Im 3. Three test panels of dimensions 150 mm x 100 mm are required. In parallel to the longer side in a distance of at least 30 mm to the edge an artificial damage of about 0,05 mm width is applied mechanically or manually in accordance with Clemens. The storage in the testing apparatus is carried out at an angle of 20° ( $\pm 5^\circ$ ) to the vertical. The test liquid consists of an aqueous sodium chloride solution, 5 % (pH 6,5 to 7,2) which is held constant during the testing at (55  $\pm$  2) °C. The test duration is 1440 h. A pure visual checking of the test panels takes place about every 500 h.

After the end of the exposure the test panels will be conditioned for at least 24 h at standard atmosphere. Non-destructive tests are to be carried out immediately afterwards. All signs of degradation (flaking, cracking) are to be recorded.

#### Test criteria for Im 2/Im 3 (after exposure):

##### *Area/surface:*

- |  |                           |
|--|---------------------------|
| ● Degree of blistering in accordance with ISO 4628-2                           | m0/g0                     |
| ● Degree of rusting in accordance with ISO 4628-3                              | Ri 0                      |
| ● Degree of cracking in accordance with ISO 4628-4                             | 0                         |
| ● Degree of flaking in accordance with ISO 4628-5                              | 0                         |
| ● Pull-off value in accordance with DIN EN ISO 4624                            | $\geq 1,5 \text{ N/mm}^2$ |
| In the case of adhesion failure A/B<br>(area affected > 50 %)<br>alternatively | $\geq 5 \text{ N/mm}^2$   |
| ● Cross-cut value in accordance with EN ISO 2409 *                             | $\leq \text{Gt } 1$       |

##### *Local damage:*

- |  |                     |
|--|---------------------|
| ● Degree of blistering in accordance with ISO 4628-2 | m1/g2               |
| ● Underrusting (one side only)                       | $\leq 1 \text{ mm}$ |
| ● Creep below the coating (one side only)            | $\leq 5 \text{ mm}$ |

### 4.1.4 Resistance to humidity – Continuous condensation (ISO 6270)

For the test three test panels of dimensions 150 mm x 100 mm are required (see table 1). The testing apparatus consists of a water bath (40  $\pm$  2) °C. The test panels form a roof the sides of which are in an angle of (15  $\pm$  5)° to the horizontal. The temperature at the test panels should be held constant to  $\pm 2$  °C and should not be lower than 35 °C. The test duration is 1440 h.

After the end of the exposure the test panels will be conditioned for at least 24 h at standard atmosphere. Immediately afterwards all signs of degradation (flaking, cracking, colour change etc.) are to be recorded.

\* Pattern: 5 mm distance in the case of film thicknesses  $\geq 350 \mu\text{m}$

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### Test criteria for Im 1 (after exposure):

#### *Area/surface:*

- |   |                         |
|---|-------------------------|
| ● Degree of blistering in accordance with ISO 4628-2          | m0/g0                   |
| ● Degree of rusting in accordance with ISO 4628-3             | Ri 0                    |
| ● Degree of cracking in accordance with ISO 4628-4            | 0                       |
| ● Degree of flaking in accordance with ISO 4628-5             | 0                       |
| ● Pull-off value in accordance with DIN EN ISO 4624           | ≥ 1,5 N/mm <sup>2</sup> |
| In the case of adhesion failure A/B<br>(area affected > 50 %) | ≥ 5 N/mm <sup>2</sup>   |
| alternatively   |                         |
| ● Cross-cut value in accordance with EN ISO 2409 *            | ≤ Gt 1                  |

### **4.2 Resistance to natural influences during long-term exposure (BAW)**

Finally, the performance during natural exposure is decisive for the suitability of a corrosion protection system (DIN EN ISO 12944-6, subclause 4.1).

Alternatively, as a replacement, the respective assessment of a five year old structure, in practical use (on-site), can be taken.

### Test conditions for Im 1, Im 2/Im 3:

For the exposure twelve coated test panels of dimensions 400 mm x 400 mm are required (see table 1). Prior to coating, holes are to be drilled by the manufacturer in accordance with the plan for the purpose of attachment and coding (see enclosure 4 and 5). After coating, a defined local damage is applied (mechanically, of width 2 mm) at the BAW, down to the steel substrate.

At each exposure site (see table 2) three test panels (atmosphere) (air), immersed to the half (fluctuating water level) and under water (underwater zone) are exposed.

The test panels are assessed for degradation such as blisters, detachment, underrusting and similar after two years (intermediate assessment) and after five years (final assessment). For the assessment of the artificial damages the areas 2 cm left and right of the crack will be taken, beginning at a distance from the edge of 2 cm.

### Test criteria for Im 1, Im 2/Im 3 (after exposure):

#### *Area/surface:*

- |  |                         |
|--|-------------------------|
| ● Degree of blistering in accordance with ISO 4628-2 | m0/g0                   |
| ● Degree of rusting in accordance with ISO 4628-3    | Ri 0                    |
| ● Degree of cracking in accordance with ISO 4628-4   | 0                       |
| ● Degree of flaking in accordance with ISO 4628-5    | 0                       |
| ● Pull-off value in accordance with DIN EN ISO 4624  | ≥ 1,5 N/mm <sup>2</sup> |

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\* Pattern: 5 mm distance in the case of film thicknesses ≥ 350 µm

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In the case of adhesion failure A/B  
(area affected > 50 %)  $\geq 5 \text{ N/mm}^2$

alternatively:

- Cross-cut value in accordance with EN ISO 2409 \*  $\leq \text{Gt } 1$

*Local damage:*

Test criteria for Im 1 (after exposure):

- Underrusting (one side only)  
Underwater  $\leq 1,5 \text{ mm}$   
Fluctuating water level  $\leq 2 \text{ mm}$   
Air  $\leq 1 \text{ mm}$

Test criteria for Im 2/sea water (after exposure):

- Underrusting (one side only)  
Underwater  $\leq 2,5 \text{ mm}$   
Fluctuating water level  $\leq 5 \text{ mm}$   
Air  $\leq 1,5 \text{ mm}$

Test criteria for Im 2/brackish water (after exposure):

- Underrusting (one side only)  
Underwater  $\leq 2,5 \text{ mm}$   
Fluctuating water level  $\leq 10 \text{ mm}$   
Air  $\leq 4 \text{ mm}$

**Table 2:** Water quality at the exposures sites (state: Summer 1994)

Immersion class	Im 1	Im 1	Im 2	Im 2
Exposure site	Trier/Moselle	Windheim/Weser	Kiel/Baltic Sea	Büsum/North Sea
Body of water	Polluted river water	Low-saline river water	Brackish water	Sea water
Conductivity [mS/cm]	1,3	3	20,2	30,7

\* Pattern: 5 mm distance in the case of film thicknesses  $\geq 350 \mu\text{m}$

## **5 Testing of the mechanical properties**

### **5.1 Determination of the abrasion resistance (BAW)**

For testing one system four coated test panels are required. Two panels will be tested after seven days storage in standard atmosphere, two further panels after six months storage in tap water. In the latter case the possible change of the film thickness caused by swelling or, respectively, degradation of the coating and shrinking. The water absorption is determined from the difference by mass of the test panel before and after storage in water.

The mechanical resistance to abrasion is determined using a testing machine consisting of a drum with horizontal axis. After coating, the coated test panels have dimensions of 200 mm x 300 mm (see table 1 or enclosure 3). The drum is filled with a mixture of water and crushed stone and moved with 16 revolutions per min.

The abrading material \*\* has the following composition:

2 kg crushed basalt of grain size 8/12 mm  
1 kg crushed basalt of grain size 5/8 mm  
1 kg crushed basalt of grain size 3/5 mm  
8 kg of water

A test cycle refers to 40.000 revolutions of the drum. After each 5.000 revolutions the direction of turning will be changed. The remaining film thickness is measured after each cycle at eight measuring areas which are fixed by a template, using the magnetic-induction method (ISO 2808) for measurement (further description of the method see publication Schröder, 1980).

It is aimed at five cycles in total, in the case of wear-resistant coatings having a film thickness above 1000 µm at ten cycles. If the coating will be abraded earlier, only that number of cycles is taken into account at which a measurable film thickness is present at all measuring areas. However, it shall be possible to carry out at least two cycles.

The abrasion  $A_w$  is determined from the loss of film thickness, in µm, related to 10.000 revolutions of the drum.

#### Example:

Total loss of film thickness: 450 µm

Total number of revolutions: 200.000

$$A_w = \frac{450 \times 10.000}{200.000} = 22,5$$

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\*\* Supplier: Baustoffvertriebsgesellschaft, D-55606 Kirn

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The abrasion values will be classified in accordance with the mechanical stress into three grades (table 3). Decisive is the mean value after the storage in water.

**Table 3:** Classification of the abrasion values

Requirement	Range of abrasion value
moderate load	$60 < A_w \leq 100$
medium load	$40 < A_w \leq 60$
high load	$A_w \leq 40$

Possible swelling shall not exceed the initial dry film thickness, after three days conditioning at standard atmosphere, by more than 10 % relative.

### 5.2 Determination of the impact resistance (ISO 6272)

For the simulation of stresses occurring in practice a falling weight (mass: 1 kg) with a head having the shape of a spherical sector will be allowed to fall from a height of 1 m on to a coated test panel which is supported non-springy (see ISO 6272).

After the impact it is checked in accordance with DIN ISO 4628-4 for possible cracking.

In addition a high-voltage method is used for testing for absence of pores. At the specified voltage [ $kV = (0,4 \times \text{film thickness in } \mu\text{m})/100 \mu\text{m}$ ] no electrical discharge shall occur.

In the case of doubt as to whether an impairment of the coating has occurred or not with regard to corrosion protection, the test panel may be subjected to the alternating water condensation changing test (4.1.1) for the determination of the underrusting.

## 6 Determination of the resistance to liquids (DIN EN ISO 2812-1)

The test panels of dimensions 150 mm x 100 mm x 2,5 mm (see table 1), coated at both sides, will be tested as required in accordance with

### Method 1:

Dipping method in accordance with clause 7 of DIN EN ISO 2812-1

### Method 2:

Method using an absorbent material in accordance with clause 8 of DIN EN ISO 2812-1

A fourth test panel is used as reference specimen. The test liquids as well as the test periods are to be agreed. As minimum stresses are considered 168 h for

- Acid resistance to  $\text{H}_2\text{SO}_4$ , 10 %
- Alkali resistance to  $\text{NaOH}$ , 10 %
- Oil resistance to hydraulic oil

Test criteria for chemical resistance:

*Area/surface:*

- |   |                         |
|---|-------------------------|
| ● Degree of blistering in accordance with ISO 4628-2          | m0/g0                   |
| ● Degree of rusting in accordance with ISO 4628-3             | Ri 0                    |
| ● Degree of cracking in accordance with ISO 4628-4            | 0                       |
| ● Degree of flaking in accordance with ISO 4628-5             | 0                       |
| ● Pull-off value in accordance with DIN EN ISO 4624           | ≥ 1,5 N/mm <sup>2</sup> |
| In the case of adhesion failure A/B<br>(area affected > 50 %) | ≥ 5 N/mm <sup>2</sup>   |
| alternatively   |                         |
| ● Cross-cut value in accordance with EN ISO 2409 *            | ≤ Gt 1                  |
| ● Swelling  | none                    |

**7 Testing of compatibility with cathodic corrosion protection (CCP)**

For the testing of one system in the laboratory eight test panels consisting of unalloyed carbon steel of dimensions 150 mm x 150 mm x 2,5 mm, coated on both sides, are required. Six panels shall have a welding wire connection of length 100 mm and thickness 5 mm attached by soldering (see enclosure 3) to which the cable to the potentiometer is connected (see also STG-Richtlinie No. 2220, 1<sup>st</sup> edition 1988).

The soldered area as well as the edges should be sealed additionally. The application of a defined circular local damage down to the steel substrate, using a milling machine, takes place immediately before starting the test in the laboratory.

Test procedure:

- |                     |  |
|---------------------|--|
| Panels 1 to 3 and 6 | with local damage at one side (cathodic protected)     |
| Panel 4             | with local damage at one side (not cathodic protected) |
| Panel 5             | no local damage (cathodic protected)                   |
| Panels 7 and 8      | Determination of initial data                          |

Test conditions:

Test solution: Artificial sea water in accordance with DIN 50905, Part 4.1 (Panels 1 to 5)  
Artificial sea water in accordance with DIN 50905, Part 4.2 (Panel 6)

Test potential: -930 mV Ag/AgCl/KCl<sub>sat</sub>.

Test period: Panel 1: 3 months  
Panel 2: 6 months  
Panels 3 to 6: 15 months

\* Pattern: 5 mm distance in the case of film thicknesses ≥ 350 μm

Test criteria:

- |  |  |
|--|--|
| ● Degree of blistering in accordance with ISO 4628-2   | m0/g0  |
| ● Cross-cut value in accordance with EN ISO 2409 *   | ≤ Gt 3   |
| ● Infiltration below the coating at the damage   | ≤ 10 mm  |
| ● Impact strength in accordance with ISO 6272<br>(1 kg from 1 m height)  | no crack, no<br>delamination                     |
| ● Pull-off value in accordance with DIN EN ISO 4624<br>In the case of adhesion failure A/B<br>(area affected > 50 %) | ≥ 1,5 N/mm <sup>2</sup><br>≥ 5 N/mm <sup>2</sup> |

For the evaluation the required current during the test is used.

## **8 Test criteria – Test methods**

In the following test methods of principle importance used for the determination of the test characteristics are described in more detail.

### **8.1 Determination of the pull-off strength (ISO 4624)**

For the determination of the tensile bond strength of coatings a pull-off method on the basis of DIN EN ISO 4624 is used. The test is generally carried out, at the earliest, 48 h after any stress or exposure has ceased. For this, test cylinders (∅ 20 mm) will be glued on to the coated surface to be tested. In the case of steel panels of low thickness (< 10 mm), the reverse side will be adequately reinforced if the pull-off test is carried out at one side only. The test area is to be previously degreased and will be lightly roughened. After curing, the test area will be exposed through to the substrate by using a cutting device. The tensile tester (continuous increase of the tensile stress in accordance with DIN 51221) is intended for rigid substrates and applies the stress with uniform increase of the tensile force.

Characteristics which will be determined are the pull-off strength (in N/mm<sup>2</sup>), the type of failure (adhesion failure, cohesion failure), its position (e.g. between priming coat and 1<sup>st</sup> top coat) as well as the percentage of the individual layer or, respectively, interface concerned. In case of doubt the percentage shall be below 20 %. The evaluation should preferably take place by optical imaging.

### **8.2 Determination of the cross-cut value**

In case of coating materials for hydraulic steel structures the cross-cut test cannot be carried out by customary means (see EN ISO 2409). The BAW has developed an apparatus for this purpose, which leads the cutting chisel on a revolving support. By using this, uniform and reproducible cutting will become possible. The distance of the cuts will be 5 mm in this case, unaffected by the method – mechanical or manual! Alternatively manual cutting in the form of a St. Andrew's cross is possible. The result will then be expressed in Kt units, analogously to Gt values.

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\* Pattern: 5 mm distance in the case of film thicknesses ≥ 350 µm

## **9 Test report and approval of coating systems**

The testing will be carried out by the Waterways Engineering and Research Institute or by another testing institute approved by this Bundesanstalt.

The **initial tests (I)** are to be carried out in any case. If all the criteria of the initial tests are complied with, test reports of the individual tests as well as an approval certificate will be prepared and the material will be included in the "Liste der zugelassenen Systeme" ("List of licensed systems"). In this list, it is distinguished as follows:

- Approval for fresh water (Im 1), optional with/without CCP
- Approval for sea water (Im 2), soil (Im 3), optional with/without CCP
- Approval only in combination with CCP
- Approval as material for repair

This list will be issued by the BAW regularly and is available via the Internet (<http://www.baw.de>).

The **qualification testing (Q)** carried out to give evidence of suitability in the case of special requirements does not replace the initial tests but supplements these. The results of qualification tests will be laid down in test reports.

For the **prolongation (P)** of the validity period of the test certificates an abridged testing [abrasion test after storage in water (5.1), resistance to alternating exposure to water condensation changing test (4.1.1), identification test on wet samples (2.2)] will be carried out. Thus, the validity of the test certificate can be prolonged for further five years.

After ten years all the tests are to be repeated.

If all the laboratory test methods have been passed with an affirmative result but the long-term exposure has not yet finished, a preliminary certificate of approval will be issued which likewise has the function of a (temporary) approval until the long-term exposure has been finished.

The costs for the testing are laid down in the Vergütungsordnung für Leistungen der Bundesanstalt für Wasserbau für Dritte (VL-BAW-Dritte) (Fee order of the Waterways Engineering and Research Institute for customer).

## **10 Bibliography**

DIN EN ISO 12944-1 to -8; Corrosion protection of steel structures by protective paint systems

Zusätzliche Technische Vertragsbedingungen – Wasserbau (ZTV-W) für den Korrosionsschutz im Stahlwasserbau – Leistungsbereich 218

**Waterways Engineering and Research Institute (BAW)  
RPB**

(Additional technical specifications in contracts - Hydraulic engineering (ZTV-W) for corrosion protection in steel hydraulic engineering - Work Area 218)

STLK Standardleistungskatalog für den Wasserbau (LB 218) – Korrosionsschutz im Stahlwasserbau (Standard work catalogue for hydraulic engineering (LB 218) – Corrosion protection in steel hydraulic engineering)

DIN EN ISO 3251; Bestimmung des Gehaltes an nichtflüchtigen Anteilen (Determination of non-volatile matter content)

DIN EN 10025; Hot-rolled products made from high-carbon structural steel (edition 1994)

DIN EN 23270; Temperatures and humidities for conditioning and testing

ISO 8501; Visual assessment of surface cleanliness

DIN 4768; Ermittlung der Rauheitskenngrößen mit elektrischen Tastschnittgeräten (Determination of surface roughness with electric stylus instruments)

DIN ISO 8503; Preparation of steel surfaces before coating

DIN 50014; Klimate und ihre technischen Anwendungen – Normalklimate (Climates and their technical application - Standard atmospheres)

DIN EN ISO 2812-1: Determination of resistance to liquids – Part 1: General methods

DIN EN ISO 2812-2; Determination of resistance to liquids – Water immersion methods

DIN EN ISO 7253; Determination of resistance to neutral salt spray (fog)

DIN EN ISO 6270; Paints and varnishes - Determination of resistance to humidity (continuous condensation)

DIN EN ISO 4628-2; Evaluation of degradation of paint coatings – Part 2: Designation of degree of blistering

DIN EN ISO 4628-3; Evaluation of degradation of paint coatings – Part 3: Designation of degree of rusting

DIN EN ISO 4628-4; Evaluation of degradation of paint coatings – Part 4: Designation of degree of cracking

DIN EN ISO 4628-5; Evaluation of degradation of paint coatings – Part 5: Designation of degree of flaking

EN ISO 2409; Cross-cut test

**Waterways Engineering and Research Institute (BAW)  
RPB**

DIN 50017; Kondenswasser-Prüfkimate (Condensation water test atmospheres)

DIN EN ISO 2808; Paints and varnishes - Determination of film thickness

DIN 50981; Messung von Schichtdicken – Magnetische Verfahren zur Messung der Dicken (Measurement of coating thicknesses - Magnetic method for measurement of thickness)

ISO 6272; Falling-weight test

DIN EN ISO 4624; Pull-off test for adhesion

DIN 51221; Werkstoffprüfmaschinen – Zugmaschinen (Material testing machines - tensile testing machines)

STG-Richtlinie Nr 2220; Prüfung und Beurteilung der Verträglichkeit von Unterwasserbeschichtungssystemen für Schiffe und Seebauwerke mit dem kathodischen Korrosionsschutzverfahren (STG-Guideline No. 2220; Testing and evaluation of the compatibility of underwater coating systems for ships and marine structures with the cathodic corrosion protection method)

DIN 50905; Korrosion der Metalle – Korrosionsuntersuchungen, Teil 4 (Corrosion of metals - Corrosion testing, Part 4)

Zusätzliche Technische Vertragsbedingungen – Wasserbau (ZTV-W) für kathodischen Korrosionsschutz im Stahlwasserbau – Leistungsbereich 220 (Additional technical specifications in contracts for hydraulic engineering (ZTV-W) for cathodic corrosion protection in steel hydraulic engineering - Work area 220)

Schröder, H.Th.; Abriebfestigkeiten der Korrosionsschutzbeschichtungen im Stahlwasserbau (Abrasion resistances of corrosion protection coatings in steel hydraulic engineering); Werkstoffe und Korrosion 31, 866-869 (1980)

**Composition of coating materials**

The sign % means percent by mass.

Manufacturer: Test No.

Trade name: Batch No.

Material groups (Base component/curing agent):

Labelling in acc. with GefStoffV or EC safety data sheet (Base component/curing agent):

Additional notes (colour, etc.):

**Base component**

**Curing agent**

Binder:	%	Curing agent:	%
Tar alternatives/ Additives:	%	..... :	%
		..... :	%
Pigments and extenders:	%	Solvent:	%
Volatile matter*:	%	Density:	kg/dm <sup>3</sup>
Density:	kg/dm <sup>3</sup>		

**Mixing proportion Base comp./curing agent** (parts by mass)

**Individual data (Base comp./curing agent)**

Hydrocarbon resin: Chemical name:

Additives: Chemical name:

**Pigments and extenders (Base comp./curing agent)**

.....	%	.....	%
.....	%	.....	%
.....	%	.....	%
Loss on ignition at.....°C:	%	*at ..... 60 °C	

**Solvents (with indication of danger classification, DC)**

.....	% , DC .....	.....	% , DC .....
.....	% , DC .....	.....	% , DC .....
.....	% , DC .....	.....	% , DC .....

To be attached: EU Safety data sheet, Technical data sheet

....., .....

Place Date Signature



## Test panels for testing in the laboratory

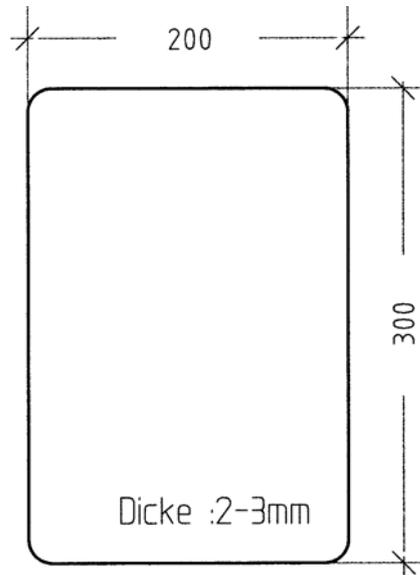


Fig. 1: Test panel for the determination of the abrasion resistance (dimensions after coating)

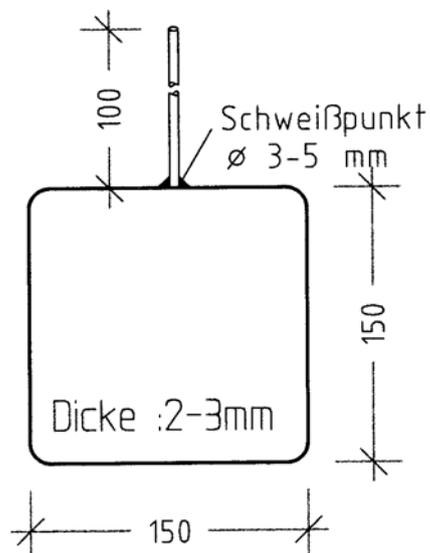


Fig. 2: Test panel for testing the suitability for cathodic corrosion protection, with soldered welding wire (soldering area sealed)

Dicke = Thickness; Schweißpunkt = point of welding

Test panels for natural long-term exposure

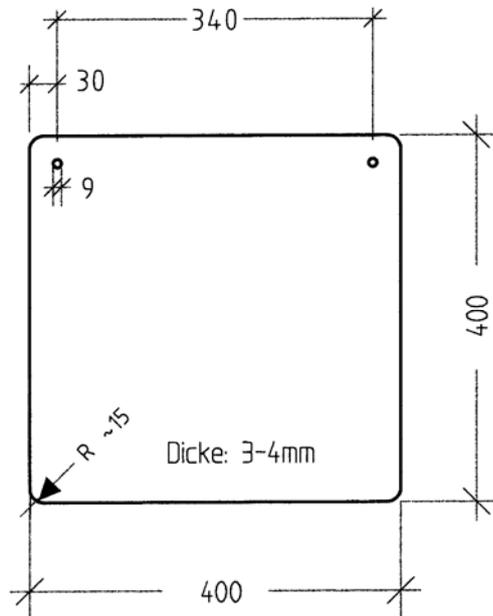


Fig. 1: Test panel for long-term exposure with drillings for attachment

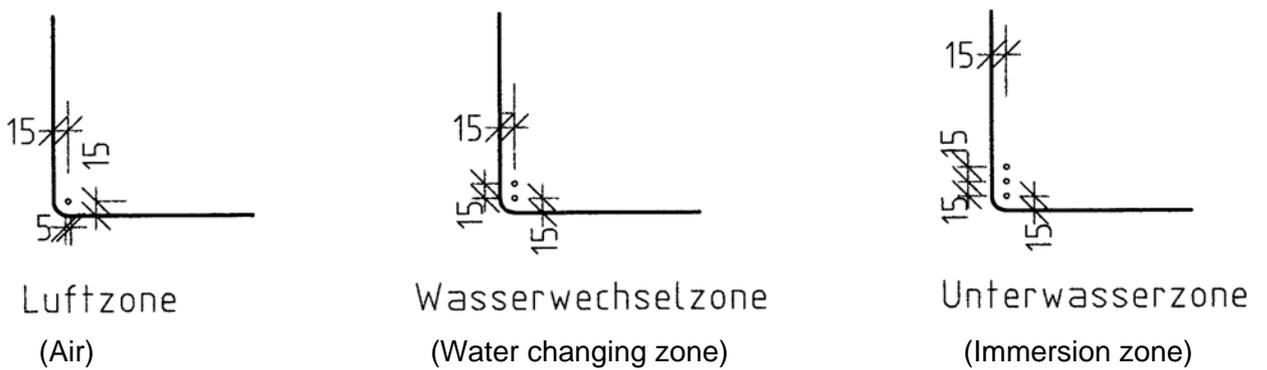


Fig. 2: Marking of the test panels by drillings regarding the position to the water level (Front side, below left)

Dicke = Thickness

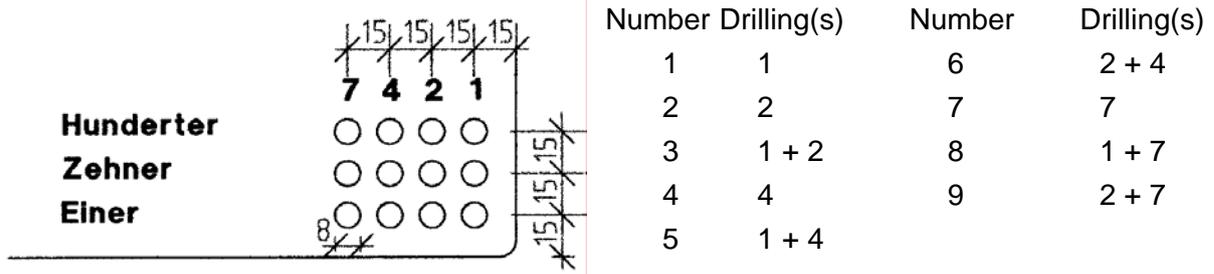


Fig. 3: System for the numbering of the test series by combination of drilling holes (front side, below right)

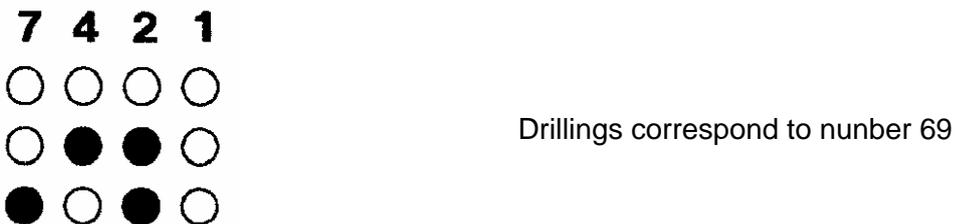
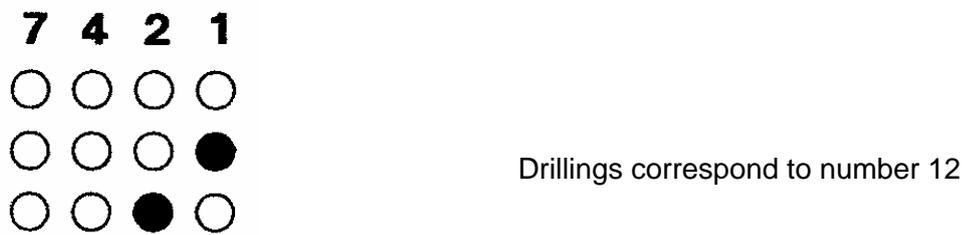


Fig. 4 a – d: Examples of combinations of numbers by arrangement of drilling holes. The numbers will be „read“ by using a template.

Translation of numbers (fig. 3): Hunderter = hundred; Zehner = ten; Einer = single