Guideline for the manufacturing of hot-dip galvanised screws

Version July 2009

Jointly issued by:

DEUTSCHER SCHRAUBENVERBAND E.V.

Informations-**C**entrum-**S**chrauben (Screw Information Centre)

GEMEINSCHAFTSAUSSCHUSS VERZINKEN E.V.

1. Area of application and purpose

This guideline is applicable for the manufacturing of hot-dip galvanised screws of strength classes 4.6, 5.6, 8.8 ad 10.9 in accordance with DIN EN ISO 898-1 for use in steel construction listed in the German Building Regulation List. They implement the findings gained in the research projects of the joint research in GAV and DSV for avoiding cracks as a result of liquid metal induced crack formation and from brittle fractures on high-strength screws as a result of hydrogen embrittlement for use in manufacturing practice.

They serve the goal of ruling out cracks from liquid metal induced crack formation and brittle fractures, and ensure product safety. It describes particular measures in individual stages of the production processes.

2. Manufacturer qualification and company production control

The screw manufacturer and the hot-dip galvanising company commissioned by them must dispose over a certified quality management system. The processing instructions, characteristics to be checked, times and scopes of checking of the company production control must be defined by the respective person responsible for the process.

Mechanical properties of each production batch must be verified. The results of the company production control must be filed for 10 years and be available if required.

Hot-dip galvanised screw - nut combinations and pre-tensioned fittings made from screw, nut and washer must be used in hot-dip galvanised version by one manufacturer.

3. Special measures in the manufacturing process

In the following table, the special measures that go beyond the requirements of the product standards and technical delivery conditions with the manufacturing of galvanized steel construction screws are listed where their attention is
recommended in this guideline.

	Strength classes 4.6 and 5.6	Strength class 8.8	Strength class 10.9
3.1 Use	Hot-dip galvanised fittings, comprising screw and nut, packed together	Hot-dip galvanised fittings comprising screw, nut and washer with marking of the same manufacturer, packaged separately and combined as desired	Hot-dip galvanised fittings comprising screw, nut and washer with marking of the same manufacturer, packaged separately and combined as desired.
3.2 Material		Limitation of the P and S content to maximum 0.02 %, sum of P and S maximum 0.03 %, verification by means of ladle analysis Material purity: Total sum characteristic value according to DIN 50 6021) K3 < 20	Limitation of the P and S content to maximum 0.02 %, sum of P and S maximum 0.03 %, verification by means of ladle analysis Material purity: Total sum characteristic value according to DIN 50 6021) K3 < 20
3.3 Design	Thread tolerance before hot-dip galvanising in accordance with DIN ISO 965-4 according to DIN EN ISO l0684: 2003-02 with dimension on the screw	Thread tolerance before hot-dip galvanising in accordance with DIN ISO 965-4 according to DIN EN ISO l0684:2003-02 with dimension on the screw	Individual marking of the screws for each production batch by separate head marking Production according to the specifications in DIN EN 14399-4 and DIN EN 14399-8, thus, increased radius under the head compared to normal hexagonal screws Thread tolerance before hot-dip galvanising 6g rolled thread with carefully rounded thread run-out Limitation of permissible surface errors in accordance with DIN EN 26157-3 for special requirements

	Strength classes 4.6 and 5.6	Strength class 8.8	Strength class 10.9
3.4 Tempering		Prevention of surface carburation	Prevention of surface carburation, Prevention of δ ferrite on the screw surface
3.5 Mechanical material properties			maximum tensile strength of 1170 N/mm2 maximum surface hardness 375 HV 0.3
3.6 Pre-treatment for hot-dip galvanising		Activation of the surface with suitably inhabited hydrochloric acid of concentration 15 – 8 %. Subsequent refinement of acids is not permitted. Treatment time ≤ 30 min at room temperature. The regulations for strength class 10.9 can be applied	Activation of the surface with suitably inhabited hydrochloric acid of concentration 15 – 8 %. Subsequent refinement of acids is not permitted. Inhibitors must be used that have been verified for the suitability and effectiveness by the inhibitor manufacturer by means of tests in accordance with specifications of DSV and GAV. The current list of inhibitors can be requested from GAV. Pickling period ≤ 15 min at room temperature. To reduce the treatment time, a degreasing or mechanical cleaning process (e.g. blasting) may be necessary. When exceeding this time, in individual cases, annealing according to DIN 50969 must be carried out up to maximum 30 minutes. Remark: Temperature treatment over 6 hours at minimum 200°C or over 11 hours at minimum 180°C have been proven. In the scope of the company production control (wPk), an additional "WSR bracing test" can be carried out to check the effectiveness of the inhibited pickling according to the work instruction in Annex A1. When checking the pickling process by the WSR bracing test with regard to the limitation of the hydrogen risk potential, the prohibition of subsequent refinement of the acid is omitted. Acids and inhibitor concentrations may also be determined individually deviating from the inhibitor manufacturer specifications.
3.7 Hot-dip galvanising	According to DIN EN ISO l0684 Normal-temperature galvanising (zinc bath temperature 445 – 470° C) permissible for all screws, mandatory for all screws with dimension ≥ M 33 High-temperature galvanising (zinc bath temperature 530 – 560° C), permissible only for screws with dimension ≤ M 30 Remark: Requirements for the composition of the molten zinc according to DAST guideline 022	According to DIN EN ISO l0684 Normal temperature galvanising (zinc bath temperature 445 – 470° C) permissible for all screws, mandatory for all screws with dimension ≥ M 27 High-temperature galvanising (zinc bath temperature 530 – 560° C) permissible only for screws with dimension ≤ M 24 Remark: Requirements for the composition of the molten zinc according to DAST guideline 022	According to DIN EN ISO l0684 Normal temperature galvanising (zinc bath temperature 445 – 470° C) permissible for all screws, mandatory for all screws with dimension ≥ M 27 High-temperature galvanising (zinc bath temperature 530 – 560° C) permissible only for screws with dimension ≤ M 24 Remark: Requirements for the composition of the molten zinc according to DAST guideline 022
3.8 Axial load bearing capacity	Generally, unlimited load bearing capacity under axial load can only be represented for dimensions > M10		

1) **respective limit values for DIN EN 10247:2007-07 are currently not available.**

Annex A1:

Work instruction for the tension test for monitoring the effectiveness of inhibitors for the reduction of the hydrogen risk potential of inhibited hydrochloric acid pickling

1. Purpose

This work instruction (AA) represents the test specification for the tensioning test on hydrogen loaded shaft circlips with the tensioning devices. During the test, it specifies the procedure to be observed with regard to the implementation of the test and documentation and describes the possible errors to be observed during the test.

2. Description

2.1 General

For assessing the hydrochloric acid pickling with regard to its risk potential for favouring a hydrogen induced brittle fracture formation on components made from tempered steels, shaft circlips (WSR - DIN 471) of different hardnesses pickled in a pickling bath samples are taken from the running production process and then tensioned in the tensioning fixture max. 5 minutes after the pickling process and in doing so are subject to a defined flexural stress.

2.2 Test equipment

A bracing fixture provides ten individual test stands on two sides. This allows two tests series of 10 WSRs each to be tested in one bracing fixture independent from each other.

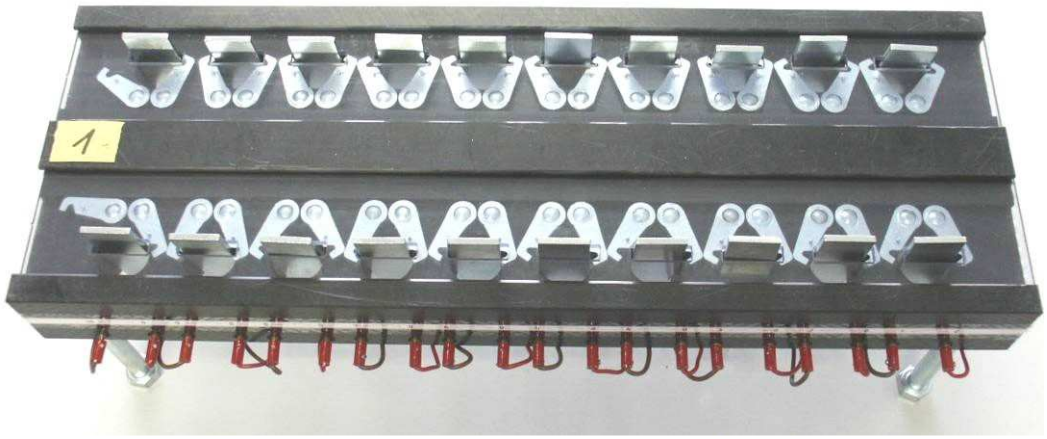

Figure 1: WSR bracing fixture

2.3 Test

Each test series to be tested must be designated in the test report. The designation of the test series results from the nominal diameter of the shaft circlips, their hardness level as well as the individual flexural stress defined for this test batch.
Example: A shaft circlip with a nominal diameter of 28 mm and a hardness in the range of the level of 600 HV should be tensioned to a tensile stress of 1500 MPa. "wsr28_hv600_sigma1500“ results as designation. For the execution of the test, only shaft circlips manufactured exclusively for this purpose with defined hardness level must be used.

During the testing of a test series, proceed as follows: Degrease
Before pickling treatment, the shaft circlips must be degreased as a layer of grease would prevent a uniform pickling attack. The shaft circlips must only be handled when wearing disposable gloves with a clean tweezers.

Pickling
Ten shaft circlips are added to a beaker (capacity, approx. 2000 ml). It must be observed that the shaft circlips are not laying on top of each other in order to ensure a uniform pickling attack. Under the extractor, now about 1000 ml of the pickling solution to be examined is filled. After five minutes, the pickling solution is poured into a prepared container via a funnel where the shaft circlips collect in the funnel. The shaft

circlips are rinsed immediately under running water. The diluted pickling solution can be returned to the company baths. Then the rings are sprayed with propanol or ethanol (spray bottle). The propanol / ethanol flowing out of the funnel is collected in a canister intended and marked for this purpose. Propanol / ethanol must not be drained to the pickling baths or in the channel system. Then the shaft circlips are spread on a paper towel to dry.

Bracing procedure

Immediately (max. 5 mins) after removing the shaft circlips from the pickling solution, these are inserted in the bracing device as follows.

Step I:
Removal of the protective cover taken off (Figure 2).

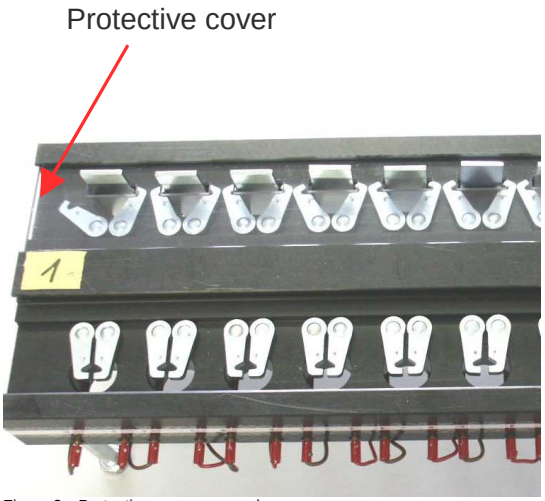

Figure 2: Protective cover removed

Step II:
The shaft circlips are inserted in the fixture (Figure 3).

Figure 3: Inserted shaft circlips

Step III:
The protective cover is reinserted and the wedges are positioned in-between the expanding tabs through the recesses of the protective cover without applying additional force. The shaft circlips must not be pre-tensioned by this wedge position (Figure 4).

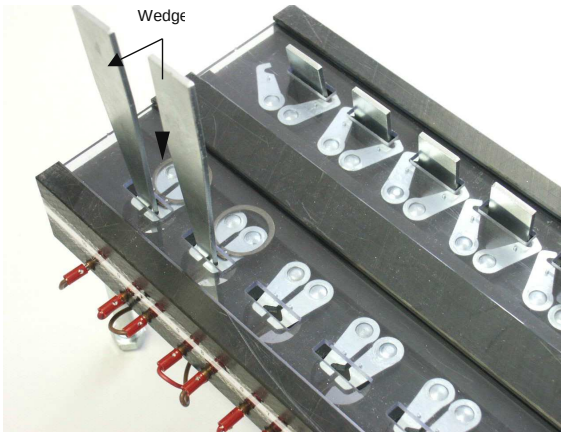

Figure 4: Wedges positioned

Step IV:
Then the key drift is positioned above the wedge and the wedge is pressed tight against the back of the U-shaped guide profile. The sliding piece is placed on the wedge head without applying force (Figure 5).

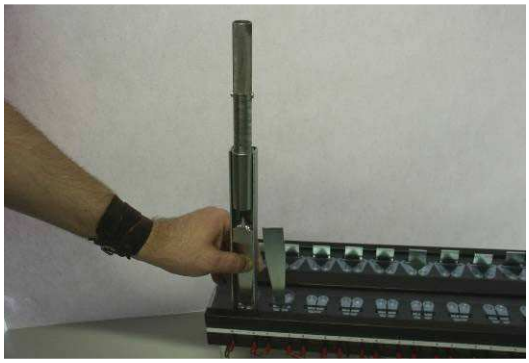

Figure 5: Wedge driver

Step V:
After putting the sliding piece on the wedge head, a random axial position is set, apparent on the position of the pilot hole relating to the edge of the guide bushing (Figure 6, arrows).

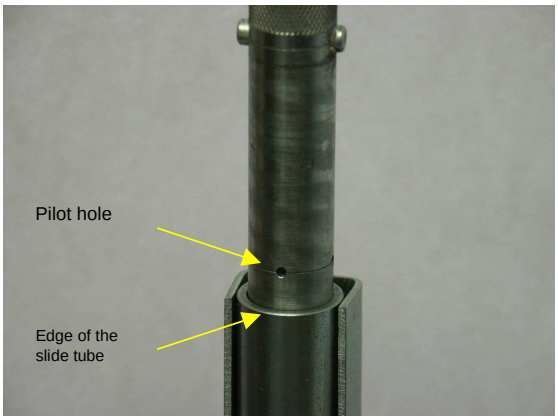

Figure 6: Pilot hole on the key drift

Step VI:
When maintaining the pressing force between the wedge and the rear wall of the U-shaped guide profile, now the middle of the pilot hole is aligned with the edge of the guide bushing by turning the handle (Figure 7).

Figure 7: Middle of the pilot hole aligned with the edge of the guide bushing

Step VII:
Then the sliding piece is pressed down until reaching the pin stop. Figure 8 shows these tensioned shaft circlips. The pre-set positions initiate a widening of the WSR by 6.2 mm and a corresponding loading on the inside of the WSR of 1500 MPa.

Figure 8: Tensioned WSR

- The testing time is determined as 24 hours.
- The number of broken shaft circlips per hardness level is recorded at the end of the test.

Cleaning the devices used
After each test, the beaker as well as the funnel used must be cleaned thoroughly under running water, and rinsed with distilled water. In order to improve drying, propanol (spray bottle) has been sprayed on the laboratory devices (handling propanol, see above).

3 Documentation in the test report

The test must be documented in a test report (Excel sheet). The following details must be present in the test report:

- Test date and time of being installed in the clamping fixture
- Designation of the test series
- Date of the pickling solution taken
- Designation (number) of the pickling bath tested
- Test bench no.
- Total number of fractures

The results must be transferred to the test report at the end of the test. Moreover, the pickling parameters such as temperature, added inhibitor, added water, etc. must be listed.

4 Possible errors

Possible errors must be ruled out by checks. Possible errors are:

- Shaft circlips with different Vickers hardnesses installed in a test series.
- Acid and inhibitor concentration set incorrectly.
- Bottles with applied pickling solution swapped.

5 Evaluation

The evaluation of the test is carried out on the failure rates of the WSR per hardness level that must always be agreed between the contractual parties.
The GAV provides a valuation standard as handling recommendation for this are on the basis of the research work achieved and field trials carried out which is available from GAV as Annex for this guideline.

Annex A2:

Literature

- Hasselmann U.

liquid metal induced crack formation with hot-dip galvanised high-strength HV screws of larger dimensions as a result of thermal tensile residual stress, dissertation in the specialist area mechanical engineering of the Technical University of Darmstadt (only in German), 124 pages., Aachen: Shaker Verlag, 1998. ISBN 3-8265-3292-9 (1997)

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