



**NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA**

GB/T 40393-2021

**Corrosion of metals and alloys - Accelerated corrosion test for
intergranular corrosion susceptibility of austenitic stainless
steels**

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1 Scope

This document specifies an accelerated test method for determining the susceptibility to intergranular corrosion of austenitic stainless steel.

This document applies to the testing of a variety of metal products, including double rolled metal, welded joints, deposited metal, and weld metal.

Note 1: The results obtained by this method are the same as those obtained by the methods in the ISO 3651-1 and ISO 3651-2 standards, but the accelerated corrosion test cycle is shorter.

Note 2: This document specifies two test methods:

--- Method A: Corrosion test in copper sulfate and concentrated sulfuric acid solutions in the presence of metallic copper;

--- Method B: Corrosion test in copper sulfate, sulfuric acid, and copper fluoride solutions in the presence of metallic copper.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document;

for the undated documents, only the latest version (including all the amendments) is applicable to this standard.

GB/T 10123 Corrosion of metals and alloys -- Basic terms and definitions (GB/T 10123-2001, ISO 8044:1999, IDT)

ISO 3651(all parts) Determination of resistance to intergranular corrosion of stainless steels

- a) For plate specimens, segmental specimens, cylindrical specimens with a diameter not exceeding 5 mm, and tubular specimens with a diameter not exceeding 5 mm, angle bending should be $(90 \pm 3)^\circ$;
- b) Annular and tubular specimens with a diameter exceeding 5 mm should be flattened and formed into cones;
- c) Examine the curved surfaces in cross-sectional regions with sufficient thickness to identify intergranular cracks.

4.4 Machining the blank to prepare the specimen of the required thickness:

- a) The metal plate should be sampled from one side only; if one of the sides is treated, then take samples from the treated side;
- b) The rolled metal (rolled sections and profiles), forgings, castings, and tubular samples should be sampled from a suitable surface;
- c) The hot-deformed or cold-deformed pipe should be sampled from the outside;
- d) The hot-rolled pipe should be sampled from the inner or outer surface;
- e) The pipe that has been exposed to the service environment should be sampled from the side that is in contact with the service environment.

4.5 The following kinds and types of specimens should be prepared from welded joints (see Table 2):

- Prepare Type I or Type II plate specimens from welded joints of plate metal, rolled sections, castings or forgings;
- Prepare Type II annular, tubular, or segmental specimens from electric welded pipes;
- Prepare Type I segmental, annular, or tubular specimens from girth welded joints of pipe sections;
- Prepare Type I or II plate specimens, or Type I segmental, annular, or tubular specimens from welded joints of double-wall tubes.

4.6 For welded specimens (Table 2, Type I and Type II), the weld reinforcement should be removed with a depth not exceeding 1 mm.

The required thickness of the specimen should be achieved by machining, and the metal

should be removed from the side that is not in contact with the corrosive medium. If it is not sure which side is in contact with the corrosive medium, the machining should be processed on the side where the weld metal is least heated during the welding process.

If it is necessary to reduce the wall thickness of the specimen, sampling should be carried out in accordance with 4.4.

4.7 The inspection of electrodes, filler wires, and strips shall be carried out through the fabricated surfacing or weld metal.

The surfacing metal shall be tested with plate specimens (see Table 2). The specimen shall be cut from the multi-layer surfacing metal made of the inspected welding material (the surfacing metal substrate is not used for specimen preparation, and can be prepared from materials with similar chemical compositions). When the chemical composition of the metal substrate is similar to that of the surfacing metal, the number of surfacing metal substrates not used for specimen preparation can be reduced to 3 layers.

The weld metal is tested with plate specimens cut from the upper layer of the multi-layer welded seam of the welded joint. The welded seam thickness of the cut specimen area should not be less than 15 mm. The chemical composition of the plate used for the welded joint should be similar to the chemical composition of the weld metal.

Welded backing plates can be used when using thin plates to obtain the welded seam of desired thickness. The chemical composition of the steel for welded backing plate is similar to the thin plate. When welding the edge of the thin plate specimen initially, the entire surface of the welded backing plate should be similarly treated.

Weld metal testing should be carried out on plate welded specimens (see Types I and II in Table 2) prepared from specially-made welded joints. The welded joints are made of intergranular-corrosion-resistant steel and welding consumables to be evaluated.

4.8 The recommended size of the specimen is shown in Appendix B, and different specimen sizes can also be used.

4.9 When testing plates, pipes, metal profiles, wires, and strips, at least two specimens should be prepared for each group.

For all types of steels and alloys, at least 4 specimens (two of which are used for comparison) should be prepared for each forging, casting, and weldment.

The control specimen should be bent $90^{\circ} \pm 3^{\circ}$ and not be exposed to the boiling test solution. If the specimen needs to be inspected from both sides, then the specimen should be bent into a "Z" shape.

4.10 The sensitization treatment of unstabilized steel is as follows: on the premise of no special requirements in the technical documents, if the unstabilized steel does not contain titanium or niobium, the maximum carbon content is greater than 0.03% and it is used

under the delivery conditions, then the sensitization treatment test should be carried out on the specimen of the delivery conditions.

? (11 $\pm$ 1)mL HNO₃ (ρ_{20} =1.35 g/mL);

? (955 $\pm$ 3)mL H₂O;

? Temperature: 40 °C~50 °C;

? Current density 0.5 $\times$ 10⁴ A - m⁻²~0.6 $\times$ 10⁴ A - m⁻².

The oxide coating on the specimen should be thoroughly removed, and the specimen should be carefully rinsed with water after etching.

It can be removed by other etching solutions or methods that can ensure the complete removal of the oxide coating. For intergranular corrosion-resistant steels, it is necessary to prevent preferential erosion or pitting along the grain boundaries.

When there are any differences in the test results, only the above solutions should be used for etching.

4.12 During the polishing or grinding process of the specimen, the surface should be prevented from overheating, and the surface roughness of the processed specimen should not exceed 0.8 μ m.

Unless otherwise stated in the technical documents, specimens made of cold-deformed and heat-deformed tube or cold-drawn metal products, or made of metal products with special surface treatment, should not be polished or ground.

4.13 Mark the specimen before testing. At one or both ends of the specimen, the position with a distance of 5 mm~10 mm from the edge shall be marked by means of steel stamping or electrical discharge machining.

4.14 Degrease the specimen with a suitable organic solvent (reagent grade) before testing. The degreasing step may be omitted if the specimen is placed directly in the test vessel after the etching or rinsing step.

5 Test methods

5.1 Method A

5.1.1 Method principle The steel specimen shall be placed together with the metallic copper in a solution made up of H₂SO₄ and CuSO₄ · 5H₂O, and the concentration of which shall be higher than the concentration of the solution extracted by the method specified in ISO 3651-2.

This method is an accelerated test method and can be used for the verification of steel grading specified in ISO 3651-2.

5.1.2 Test solution Use analytical reagents to prepare the test solution: add (50 $\pm$ 0.1) g of