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Corrosion of metals and alloys — Measurement of critical crevice temperature for cylindrical crevice geometries in ferric chloride solution

Corrosion des métaux et alliages — Mesure de la température critique de corrosion caverneuse de crevasses de géométries cylindriques dans une solution de chlorure ferrique

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*.

Introduction

Various dimensions of pipes and tubes are used in industries such as nuclear power plants, thermal power plants, desalination plants, oil refining facilities and chemical plants, etc. Materials evaluation for these pipes, tubes and fittings makes all the difference to safety and life cycles in these industrial facilities.

There are numerous standards that specify test methods and corrosion resistance for pitting and crevice corrosion. Many of them address the corrosion rate or critical pitting temperature (CPT) or critical crevice temperature (CCT) of plate type specimens, but they are not concerned with other geometries and relations of corrosion resistance between geometries.

It is important that the initiation temperature of crevice corrosion be measured in cylindrical crevice geometries for high corrosion resistant alloys, including from traditional stainless steels (300 series) to super stainless steels (higher alloyed stainless steels).

This document provides the test method that measures crevice corrosion resistance in crevice geometries such as tube/tube sheet of heat exchangers and pipes/pipe supports, flange/couplings, bolts/nuts, etc. in industrial facilities. It can be used as a guideline which offers the criterion for materials selection of such components.

Most crevice corrosion tests are performed conforming to some standards, but these test methods use a flat geometry of an artificial crevice which shows different critical crevice temperatures to those of cylindrical crevice geometry. Therefore, results of these tests have created controversies in related industries. It has been found that the identical CCT between plate type and cylindrical type specimens could be achieved with an appropriate torque applied to the cylindrical specimen.

Corrosion of metals and alloys — Measurement of critical crevice temperature for cylindrical crevice geometries in ferric chloride solution

1 Scope

This document specifies a methodology for ranking the crevice corrosion resistance of stainless steels and related alloys when exposed to oxidizing chloride solution. This document allows the measurement of critical crevice temperatures of tube/rod type specimens equal to those of plate type ones made up of the same material by chemical initiation of crevice corrosion, but not by the electrochemical method of ISO 18070. The test method in this document defines the apparatus and the procedure used to measure the temperature of crevice corrosion initiated in pipes and tubes using cylindrical specimens. This method has also been proved to apply to plate type specimens.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8044, *Corrosion of metals and alloys — Basic terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8044 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
critical crevice temperature
CCT
minimum temperature required to produce a crevice attack of at least 0,025 mm corroded depth on the bold surface of a specimen beneath the *crevice former* (3.2), with the edge attack ignored

Note 1 to entry: Measured in degrees Celsius.

3.2
crevice former
component of the crevice corrosion test tool assembly, which allows crevice corrosion to be induced in a contacted test specimen by applying certain torques

4 General principles

4.1 Objective

This document describes laboratory tests for measuring CCT of stainless steels and high corrosion resistant alloys with cylindrical (including circular arc) and flat plate geometries in oxidizing chloride solutions. Cylindrical crevice geometries emulate crevices frequently coming from tube/tube sheet of heat exchangers and pipes/pipe supports, flange/couplings, bolts/nuts, etc. in industrial facilities. There have been differences of CCT between plate type and cylindrical type specimens of same materials which require measuring CCT of a part of real pipes and tubes in service or in fabrication. This document aims to rank the crevice corrosion resistance of stainless steels and related alloys, eliminating the geometric (tubular or rod or plate) and size (radius of curvature) effect, when exposed to oxidizing chloride solution.

4.2 Immersion test

4.2.1 General

Chloride containing solutions such as ferric chloride and acidified ferric chloride solutions are useful to determine localized corrosion rate. This test method uses 6 mass % ferric chloride or 6 mass % ferric chloride solution +1 volume % HCl solution. A crevice former is essential to produce crevice corrosion and its dimension shall be modified according to various pipes and tubes. Artificial crevice formers with a specimen shall be completely immersed in the test cell. The volume of solution shall be at least 500 ml/dm^2 of specimen surface area.

4.2.2 CCT measurements in single test cell

A critical crevice temperature, which shows the initiation of crevice corrosion, shall be measured for a specimen from a certain temperature. After 24 h of immersion, the specimen is removed for inspection of crevice corrosion. If there is no initiation of crevice corrosion, then a different specimen shall be subjected to the test with a 5 °C increase from the previous temperature. The test shall be repeated with increases of 5 °C until crevice corrosion initiates. Every specimen at each temperature shall be fabricated from the same product or from the identical heat of a raw material with the same geometry.

4.2.3 CCT measurements in multiple test cells

Tests in 4.2.2 can be performed simultaneously in multiple test cells in which each specimen is immersed in a different temperature for speed tests. Each specimen shall be fabricated from the same product or from the identical heat of a raw material with the same geometry. Applied torque condition for each specimen shall be same if the specimens have the same radius of curvature.

4.3 Criterion for CCT

The ferric chloride solution used in this document is a strong oxidizing and corrosive medium causing pitting or crevice corrosion in high corrosion resistant alloys. Even though measuring the weight of a specimen before and after test makes it possible to show the initiation of crevice corrosion, credibility of the results is not high because the strong test solution may inadvertently corrode the edges of the specimen. The criterion for CCT, as described in 3.1, is the lowest temperature for which a corroded depth of at least 0,025 mm shows on the surface of the specimen beneath the crevice former, with the edge attack ignored.

5 Apparatus

5.1 Crevice former assembly

As shown in Figure 1, the frame of the crevice test assembly is made up of titanium that has a very high corrosion resistance against pitting or crevice corrosion. Crevices shall be formed with fittings, as shown in Figures 2 to 5, to prevent galvanic corrosion when a specimen makes contact with the titanium frame.

Locate the left and right polytetrafluoroethylene (PTFE) block decks in advance, on which a cylindrical specimen is spanned and held as shown in Figure 1. Make a position of lower crevice former between them, which has a same curvature with a specimen.

The curvature of lower crevice former for a part of circular arc geometry (e.g. of big size specimen) should be convex upwards.

CCT of the plate type specimen shall be measured with a flat crevice former.

Mount a specimen on the lower crevice former, then add an upper crevice former on top of it. Install a titanium washer on the upper crevice former; this evenly distributes the stress on the surface of the specimen when a force is added with a titanium bolt contacted on top of the washer. Finally, wrench the titanium bolt up to the determined amount of torque with a torque wrench.

The requirements for materials and dimensions of critical crevice temperature test assembly are as follows:

— materials of assembly: titanium grade 2 or equivalent;

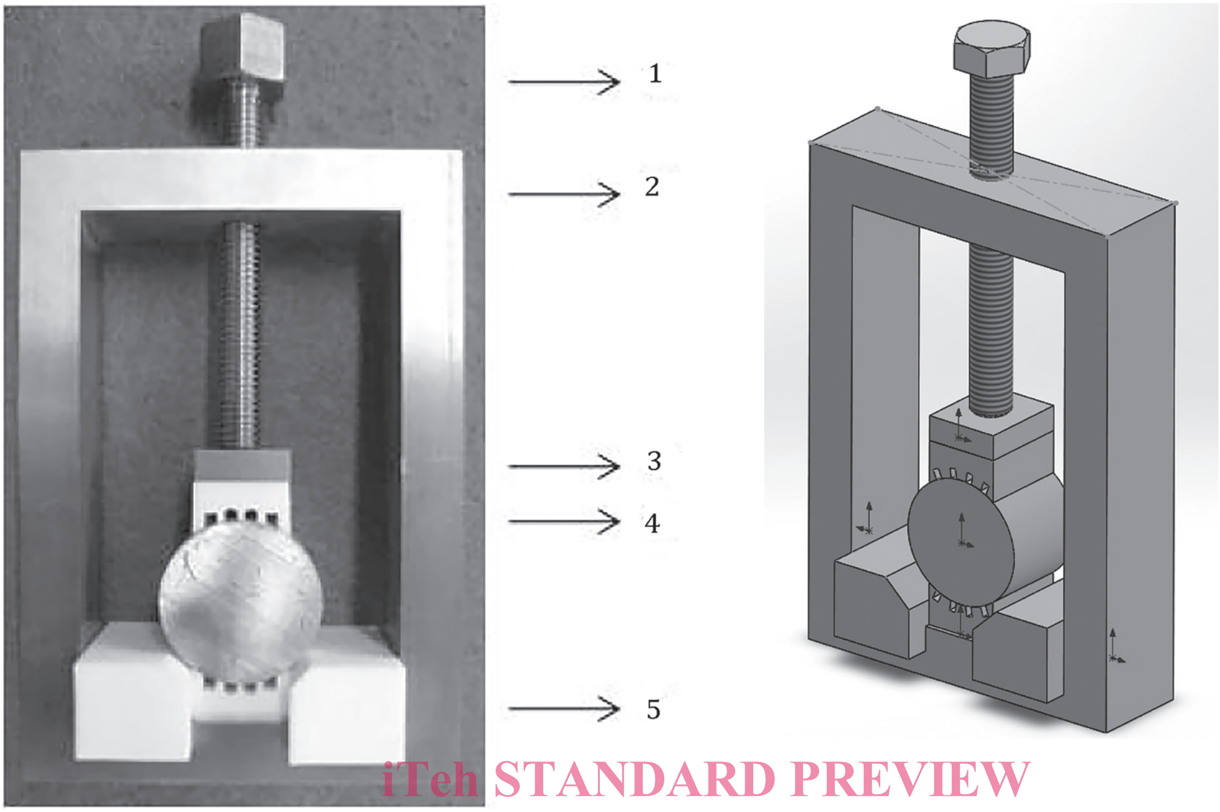
— dimension of assembly: various dimensions fit for cylindrical products;

— artificial crevice former: machined PTFE upper and lower blocks rounded surface with grooves for contacting to a specimen;

— supporting decks: right and left PTFE blocks with rounded surface for a specimen to be clamped inside the assembly;

— crevice former; PTFE crevice former should meet the mechanical requirement which the tensile strength is higher than 14,5 MPa.

— titanium bolt (see ISO 4017; thread size M8) for applying torque to the specimens.



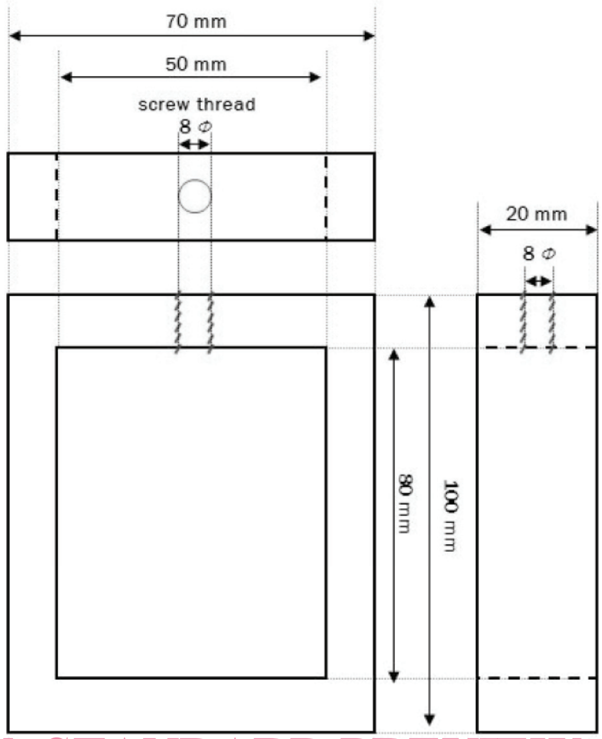
a) Front view photo   b) Side view diagram

Key

1 Ti bolt
2 Ti frame
3 Ti washer
4 crevice washer
5 deck block

Figure 1 — Assembled crevice test apparatus for cylindrical specimen

Dimensions in millimetres



NOTE: Crevice corrosion test frame dimensions, in millimetres:

Outside		Inside		Thickness
Length	Width	Length	Width	
100	70	80	50	20

Figure 2 — Ti frame of assembled crevice test apparatus for a specimen of benchmark scale