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Steel — Measurement method for the evaluation of hydrogen embrittlement resistance of high strength steels

Acier — Méthode de mesure pour l'évaluation de la résistance à la fragilisation par l'hydrogène des aciers à haute résistance

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Foreword

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The committee responsible for this document is ISO/TC 17, *Steel*, Subcommittee SC 7, *Methods of testing (other than mechanical tests and chemical analysis)*.

Introduction

The mechanical properties of high strength steels, such as tensile strength, elongation and reduction of area, would be degraded by the effect of hydrogen, known as hydrogen embrittlement, and the susceptibility of hydrogen embrittlement becomes greater with increasing the strength level of steels. This International Standard suggests a standardized test method for the evaluation of hydrogen embrittlement resistance of high strength steels.

Steel — Measurement method for the evaluation of hydrogen embrittlement resistance of high strength steels

WARNING — Persons using this International Standard should be familiar with normal laboratory practice. This International Standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with any national regulatory conditions.

1 Scope

This International Standard provides a method for the evaluation of the resistance to hydrogen embrittlement (i.e. hydrogen delayed fracture) using constant loading test with hydrogen pre-charged specimens. The amount of hydrogen content absorbed in the specimens is analysed quantitatively by thermal desorption analysis such as gas chromatography, mass spectrometry and so on. In the case of hydrogen continuous charging such as hydrogen absorption in aqueous solution at free corrosion potential, hydrogen absorption in atmospheric corrosion environments and hydrogen absorption in high pressure hydrogen gas, the evaluation method is also briefly described. This method is mainly applicable to the evaluation of hydrogen embrittlement resistance of high strength steel bolts.

2 Principle

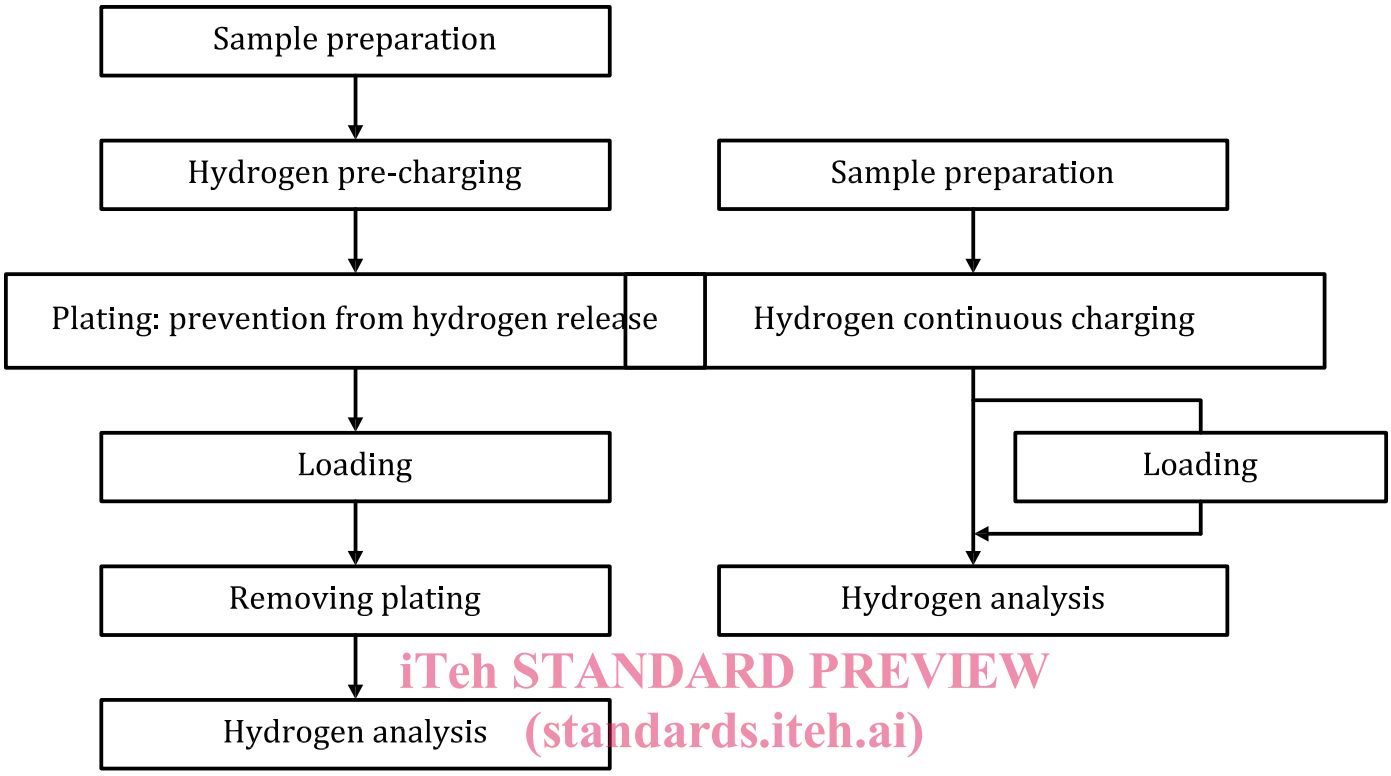
This test method is used to evaluate material resistance to hydrogen embrittlement. Figure 1 shows schematic sequences for a) hydrogen pre-charging method and b) hydrogen continuous charging method. For the hydrogen pre-charging method [see Figure 1 a)], prepare a test specimen which has a higher hydrogen level by forcibly charging hydrogen into the specimen. Apply constant load to the hydrogen charged test specimen and measure the time to failure. By testing specimens containing various contents of diffusible hydrogen, which is mainly responsible for hydrogen embrittlement, the relationship between diffusible hydrogen content and times to failure can be obtained. Diffusible hydrogen content can be measured by thermal desorption analysis using the test specimen after failure. This method can provide at least qualitative comparison of the resistance to hydrogen embrittlement among several high strength steels having different microstructures or compositions. For the hydrogen continuous charging method [see Figure 1 b)], a test specimen is loaded in one of the following three conditions:

a) in aqueous solution at free corrosion potential;

b) in atmospheric corrosion environments;

c) in high pressure hydrogen gas.

Then, hydrogen analysis is carried out after failure of the specimen. If specimens do not fail up to 100 h (up to 200 h, if necessary), qualitative comparison of the resistance to hydrogen embrittlement can be made by hydrogen analysis of unbroken specimens.

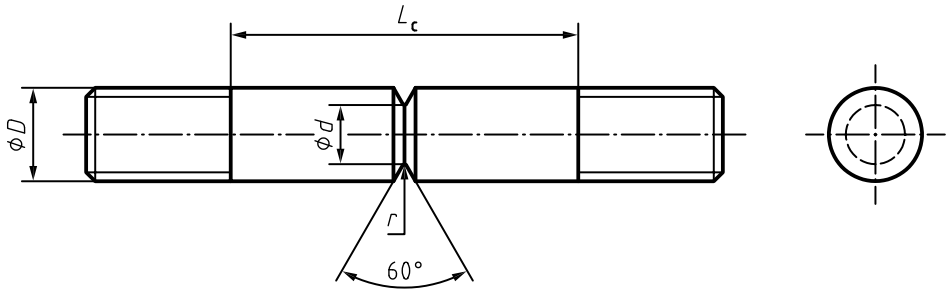


a) Hydrogen pre-charging method b) Hydrogen continuous charging method

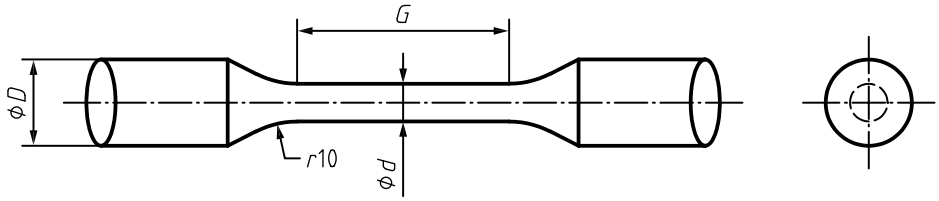
Figure 1 — Flow chart illustrating the test methods

3 Specimen preparation

The dimensions of the specimens are shown in Figure 2, and other configurations of the test specimen may be applied. It is recommended to use specimens of 10 mm in diameter as a standard size. For samples with smaller diameter (i.e. D = 5 mm), r/D = 0,02 may be applied.[1][2]



a) Notched specimen



b) Smooth specimen

d/D	0,6
r/D	0,01 or 0,02
L_c/D	7
G/D	5

Figure 2 — Dimensions and shape of specimens

4 Hydrogen charging methods

4.1 General

There are four hydrogen charging methods, such as cathodic charging, hydrogen absorption in aqueous solution at free corrosion potential, hydrogen absorption in atmospheric corrosion environments and hydrogen absorption in high pressure hydrogen gas. The examples of the condition of each method are as follows.

4.2 Cathodic charge method

4.2.1 Hydrogen charging solution

To estimate the effect of hydrogen on the mechanical properties of steels, the hydrogen is forced to diffuse into the specimens by the cathodic charging method. For hydrogen pre-charging, the charging solution should be prepared and the chemical compositions of the solutions are listed in Table 1.

Two kinds of solutions may be used for hydrogen pre-charging. Solution 1 may be used for introducing a relatively large amount of hydrogen to the specimens and Solution 2 may be used for introducing a small amount of hydrogen.