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Guidelines for specifying Charpy V-notch impact prescriptions in steel specifications

Lignes directrices pour la spécification des prescriptions d'énergie de rupture sur éprouvette Charpy à entaille en V dans les normes d'acier

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Foreword

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This document was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 20, *General technical delivery conditions, sampling and mechanical testing methods*.

This first edition of ISO/TS 7705 cancels and replaces ISO/TR 7705:1991, which has been technically revised.

Guidelines for specifying Charpy V-notch impact prescriptions in steel specifications

1 Scope

This document gives guidelines for specifying Charpy V-notch impact prescriptions in steel specifications.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

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

4 General features of Charpy V-notch impact test

4.1 Toughness testing methods in design codes and in steel specifications

Tests for evaluating the toughness of steel can be divided into two categories: notch toughness tests and fracture toughness tests based on fracture mechanics.

Notch toughness tests are used to measure the ability of a material to absorb energy and deform plastically in the presence of a mechanical notch. The Charpy V-notch impact test and the drop weight test are typical examples of small scale tests which are used for evaluations of notch toughness. They are often used to determine the ductile to brittle transition temperature of a material and to give a qualitative estimate of the material's toughness. Due to relatively good reproducibility and low cost these methods are highly suitable for use as delivery tests for steel consignments.

Fracture toughness tests such as the crack-tip opening displacement (CTOD) test (see ISO 12135) are fracture mechanics tests which are generally concerned with the determination of critical crack sizes which can appear without causing fracture in a material loaded to a specific stress level. Fracture mechanics tests are very complicated and expensive to carry out. They are primarily used to examine the behaviour of pressurized or structural components with respect to safety rules, etc. Therefore, fracture mechanics testing is primarily connected with design codes and not with steel specifications.

For these reasons, only notch toughness tests are dealt with in these guidelines for steel specifications.

4.2 Historical background to the Charpy V-notch impact test

When welded structures, especially heavy ones such as bridges and ships, were first developed on an industrial scale, and especially when the fabrication methods called for joining heavy segments by welding, problems with brittle fractures became more common. This was especially evident during the Second World War when the USA began to produce welded ships of the Liberty and Victory type, where a large number of failures occurred due to brittle fractures.

An empirical relationship based on many tests was found between the Charpy V-notch impact energy and service fractures. The work initiated by the USA was continued by the International Institute of Welding (IIW) who provide recommendations and a classification system for steels according to their susceptibility to brittle fracture after welding.

Originally the USA required an impact energy value of 15 footpounds (ft lb) for a standard 10 mm x 10 mm V-notch impact test piece. This was later increased to 20 ft lb. The IIW converted these figures into metric units and referred the impact energy value to the cross-section under the notch, which gave a figure of 3,5 kg m/cm^2 corresponding to 20 ft lb. Later the units were transformed into SI units. This gave the value of 27 J (20 ft lb).

In 1953 Pellini compared the Charpy V-notch impact test with an explosion crack starter test intended to simulate the service performance of higher quality steels. Pellini recommended impact energy of 20 ft lb (27 J) instead of the earlier used 15 ft lb.

Wells also simulated service conditions at the starting point of a brittle fracture crack by using a wide plate test. The intention of this test, which could not be used as an acceptance test for a steel consignment, was to include in a big plate specimen the stresses existing in a weld, the influence of plate thickness, the type of defect, etc. The results of wide plate tests were also compared with Charpy V-notch impact values.

Today 27 J is generally used for unalloyed steels. In some cases, for instance for fine grain steels or quenched and tempered steel grades, this level can be 27 J or alternatively fixed to a higher level (40 J) according to the requirements for specific steels and intended applications. Impact test requirements are included in the product standard.

4.3 The Charpy V-notch impact test in relation to other tests

Originally the Charpy impact test was performed with a “keyhole” or U-notch test bar. Its purpose was to check that the material was sound as to cleanliness, rolling and heat treatment. In the 1950s interest was concentrated on the risk of brittle fracture in welded structures and the V-notch test bar was introduced as the V-notch test indicates transition behaviour more clearly than the U-notch test.

In addition to the Charpy impact test other impact test methods (e.g. Mesnager, lzod, Schnadt) have also been used.

The drop weight test is a material test which is intended to measure the highest temperature at which steel exhibits brittle fracture. This test can be an alternative or can be required in addition to the Charpy V-notch impact test.

4.4 Factors influencing impact properties

The behaviour of a steel structure subject to impact is not only dependent on the material. It is also dependent on the following:

— material thickness;

— stress state;

— temperature;

— steel type;

— loading rate;

— surface conditions;

— residual stresses;

— yield strength.

