

TECHNICAL REPORT

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

*Directives 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

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 7705, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 17, *Steel*.

This second edition cancels and replaces the first edition (ISO/TR 7705:1983), which has been technically revised.

The Charpy V-notch impact test is widely used as a means of evaluating the toughness and the susceptibility to brittle fracture of steel products. It is also considered to be suitable for checking the soundness of a material.

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Therefore, the Charpy V-notch impact test is included in many ISO standards developed by sub-committees of ISO/TC 17 responsible for standardization of steel products.

ISO/TR 7705 was published in 1983 with a view to giving recommendations for specifying impact strength requirements in ISO standards for steel products, when those requirements were still being considered.

At the time of the three-yearly review in 1986 it was decided by a majority of TC 17 P-members that ISO/TR 7705 be revised and remain as a Technical Report, taking into account the comments received.

Annex A forms an integral part of this Technical Report.

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

1 Scope

This Technical Report gives recommendations for specifying Charpy impact V-notch prescriptions in steel specifications.

Extracts from ISO 148, ISO 404, ISO/R 442 and ISO 3785 listed in clause 2 are given in annex A.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 148:1983, *Steel — Charpy impact test (V-notch)*.

ISO 404:1981, *Steel and steel products — General technical delivery requirements*.

ISO/R 442:1965, *Verification of pendulum impact testing machines for testing steels*.

ISO 630:1980, *Structural steels*.

ISO 683-1:1987, *Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Direct-hardening unalloyed and low-alloyed wrought steel in form of different black products*.

ISO 2604-4:1975, *Steel products for pressure purposes — Quality requirements — Part 4: Plates*.

ISO 3785:1976, *Steel — Designation of test piece axes*.

ISO 4950-2:1981, *High yield strength flat steel products — Part 2: Products supplied in the normalized or controlled rolled condition*.

ISO 4950-3:1981, *High yield strength flat steel products — Part 3: Products supplied in the heat-treated (quenched + tempered) condition*.

3 General feature of Charpy V-notch impact test

3.1 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 cheapness these methods are highly suitable for use as delivery tests for steel consignments.

Fracture toughness tests such as the CTOD test 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 the material in a structure 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.

3.2 Historical background to the Charpy V-notch impact test

When welded structures, especially heavy ones such as bridges and ships, were 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 specially evident during the second world war when the USA began to produce welded ships of the Liberty and Victory type, where a lot 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. What was started in the USA was then continued by IIW (International Institute of Welding) with their recommendations and 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 × 10 mm V-notch impact test piece which was later increased to 20 ft·lb. The IIW recommendation 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/cm² corresponding to 20 ft·lb. Later the units were transformed into SI units and the reference to the area was retained. This gave the value of 27 J (20 ft·lb).

Today 27 J is generally used for mild carbon and carbon-manganese steels and 40 J (30 ft·lb) for steels with higher tensile properties.

3.3 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 1950's interest was concentrated on the risk of brittle fracture in welded structures and the V-notch test bar was introduced because 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, Izod, Schnadt etc.) have also been used.

The drop weight test is a material test which is intended to measure the highest temperature at which a steel exhibits brittle fracture. Some offshore material standards allow the acceptance of plate material for offshore applications on the basis of drop

weight testing but normally this test is used for information purposes only. This test may be an alternative to the Charpy V-notch impact test.

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 an 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 of course could not be used as a delivery 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.

3.4 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.

In addition, the Charpy V-notch test result is influenced by the following:

- orientation of test piece;
- orientation of notch;
- sharpness of notch;
- specimen position in the product;
- steel type;
- type of impact machine striker.

For these and other reasons (e.g. different safety potentials) the impact energies or transition temperatures determined under the well-defined conditions of an impact test cannot without any further considerations be regarded as determinant with re-