INTERNATIONAL STANDARD

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Metallic materials — Tensile testing in liquid helium

Matériaux métalliques — Essai de traction dans l'hélium liquide

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

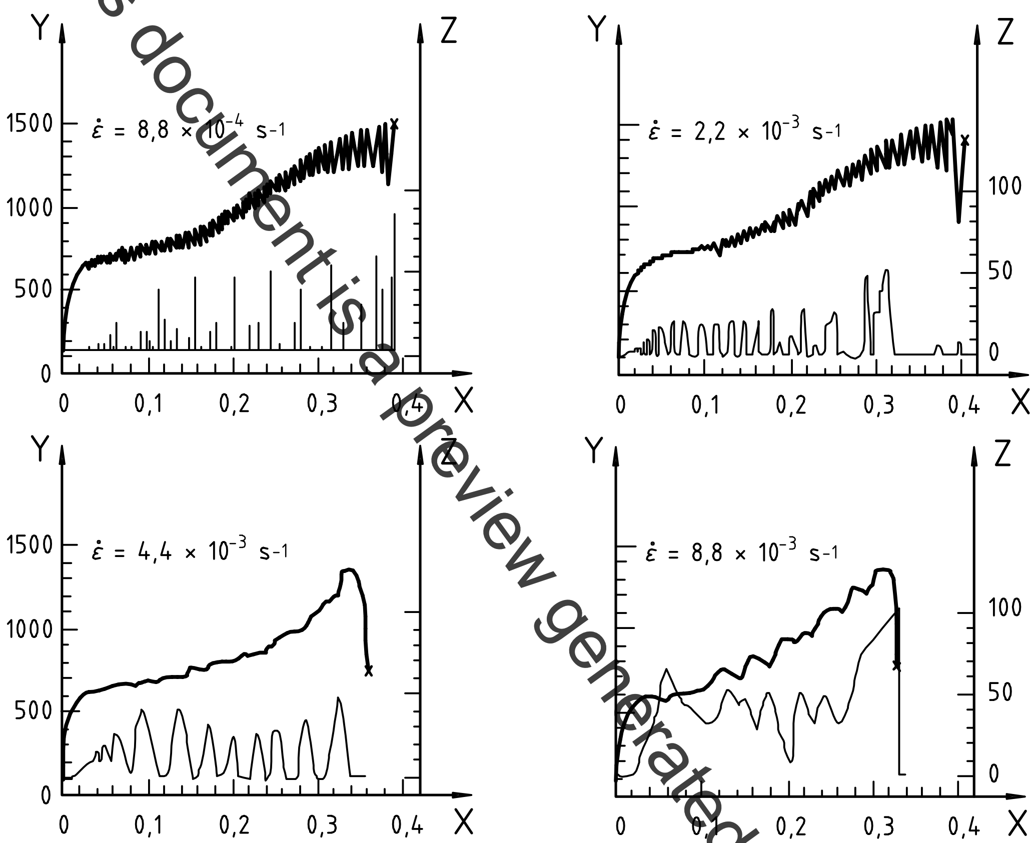
The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 19819 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 1, *Uniaxial testing*.

Introduction

The force-time and force-extension records for alloys tested in liquid helium using displacement control are serrated. Serrations are formed by repeated bursts of unstable plastic flow and arrests. The unstable plastic flow (discontinuous yielding) is a free-running process occurring in localized regions of the parallel length at higher rates than nominal strain rates with internal specimen heating. Examples of serrated stress-strain curves for a typical austenitic stainless steel with discontinuous yielding are shown in Figure 1.



Key

X strain (deformation)

Y stress (unit force), N/mm^2

Z temperature, K

Figure 1 — Example of typical stress-strain curves and specimen temperature histories at four different nominal strain rates, for AISI 304L stainless steel tested in liquid helium

A constant specimen temperature cannot be maintained at all times during testing in liquid helium. Due to adiabatic heating, the specimen temperature at local regions in the parallel length rises temporarily above 4 K during each discontinuous yielding event (see Figure 1). The number of events and the magnitude of the associated force drops are a function of the material composition and other factors such as specimen size and test speed. Altering the mechanical test variables can change the type of serration but not eliminate the discontinuous yielding, therefore, tensile property measurements of alloys in liquid helium (especially tensile strength, elongation and reduction of area) may lack the usual significance of property measurements at room temperature where deformation is nearly isothermal, and discontinuous yielding typically does not occur.

The stress-strain response of a material tested in liquid helium depends on whether force control or displacement control is used. Displacement control is specified in this International Standard since the goal is material characterization by conventional methods. The possibility of a different and less favourable material response shall be taken into account when data are used for design in actual applications subject to force-controlled conditions.

Metallic materials — Tensile testing in liquid helium

1 Scope

This International Standard specifies the method of tensile testing of metallic materials in liquid helium (boiling point at – 269 °C or 4,2 K, designated as 4 K) and defines the mechanical properties that can be determined.

This International Standard may also apply to tensile testing at cryogenic temperatures (less than – 196 °C or 77 K), which requires special apparatus, smaller specimens, and concern for serrated yielding, adiabatic heating and strain rate effects.

To conduct a tensile test at 4 K in accordance with this International Standard, the specimen installed in a cryostat is fully submerged in liquid helium (He) and tested using displacement control at a nominal strain rate of 10^{-3} s^{-1} or less. Tests using force control or higher strain rates are not considered.

2 Normative references

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

ISO 7500-1:—[1], *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 9513:1999, *Metallic materials — Calibration of extensometers used in uniaxial testing*

ISO 15579, *Metallic materials — Tensile testing at low temperature*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 15579 and the following apply.

3.1
adiabatic heating
internal heating of a specimen resulting from deformation under conditions such that the heat generated by plastic work cannot be quickly dissipated to the surrounding cryogen

3.2
axial strain
average of the longitudinal strains measured at opposite or equally-spaced surface locations on the sides of the longitudinal axis of symmetry of the specimen

NOTE The longitudinal strains are measured using two or more strain-sensing transducers located at the mid-length of the parallel length.

1) To be published. (Revision of ISO 7500-1:1999)