

JIS

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS Z 2277 : 2000

Method of tensile testing for metallic materials in liquid helium

ICS 77.040.10

Descriptors : helium, liquefied gases, metals, tensile testing, cryogenics, cryogenic liquids

Reference number : JIS Z 2277 : 2000 (E)

Z 2277 : 2000

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law.

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Date of Establishment: 1990-06-01

Date of Revision: 2000-03-20

Date of Public Notice in Official Gazette: 2000-03-21

Investigated by: Japanese Industrial Standards Committee
Divisional Council on Iron and Steel

JIS Z 2277:2000, First English edition published in 2001-04

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

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Printed in Japan

Method of tensile testing for metallic materials in liquid helium

1 Scope This Japanese Industrial Standard specifies mainly the method of tensile testing for metallic materials at cryogenic temperatures in liquid helium.

Remarks : Tests are carried out at cryogenic temperatures prepared by boiling point [about 4 K (−269 °C)] of liquid helium under atmospheric pressure, but the agreement between the parties concerned with delivery can permit the test at cryogenic temperatures obtained by other refrigerants than liquid helium.

Informative reference : For the tensile test for metallic materials at cryogenic temperatures, special consideration shall be required because of the generation of serration on stress-strain diagram due to an unstable plastic flow (discontinuous yield), because of the rise of temperature of a test piece due to heating caused by deformation of the test piece, and because of the influence on strain speed by material characteristics. This Standard specifies testing apparatus, test piece, testing method and so on with consideration about above-mentioned phenomena.

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. The most recent editions of the standards indicated below shall be applied.

JIS B 7721 *Verification of the force measuring system of the tensile testing machine*

JIS G 0202 *Glossary of terms used in iron and steel (testing)*

JIS G 0303 *General rules for inspection of steel*

JIS G 0306 *Steel forgings—General technical requirements*

JIS Z 2201 *Test pieces for tensile test for metallic materials*

JIS Z 2241 *Method of tensile test for metallic materials*

3 Definitions For the purposes of this Standard, the definitions given in JIS G 0202 and the following definitions apply.

- a) **test force** The force applied on a test piece to fulfill the purpose of test.
- b) **serration** A phenomenon in which the stress-strain diagram in plastic deformation area of a test piece shows serrated form during the process of a tensile test (see Fig. 1).
- c) **serration start stress** σ_{ss} A quotient (N/mm²) of the maximum test force (N), which was given when serration starts during the process of a tensile test, divided by the original cross section of paralleled place (see Fig. 1).
- d) **designated straining rate** A quotient of the displacement speed of the crosshead of a testing apparatus divided by the length of paralleled place of a test piece,

and this quotient is used as an index for controlling tensile speed in tensile test at cryogenic temperatures.

- e) **cryogenic apparatus** A part of a tensile testing apparatus at cryogenic temperatures, and is composed of a Dewar, grips of a test piece, a load frame, and so on which are for loading on a test piece in cryogenic atmosphere.
- f) **dewar** A cryogenic thermostatic chamber having a heat insulating layer for keeping liquid such as a liquid helium or the like around a test piece.

4 Principle of test This test is to obtain proof stress, tensile strength, elongation after fracture, reduction of area, and so on, of metallic materials owing to the procedures as follows; cool a test piece in liquid helium at cryogenic temperatures, apply lengthwise tensile test force to the test piece, and give strain to the test piece until it is fractured.

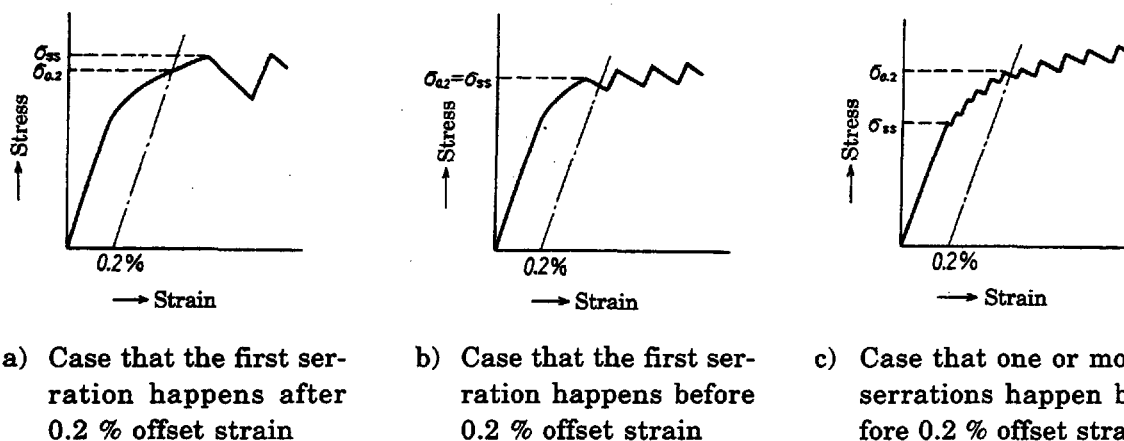


Fig. 1 Proof stress and stress for serration start

5 Testing apparatus Test shall be carried out principally with a displacement speed control-type tensile tester equipped with both a cryogenic device and an extensometer.

5.1 Tensile tester Tensile tester shall be in accordance with JIS B 7721, and have sufficient rigidity.

5.2 Cryogenic apparatus The apparatus in which a test piece is loaded at cryogenic atmosphere shall be as follows.

- a) Cryogenic apparatus shall be composed of Dewar to keep liquid helium, and grips capable of holding and loading on a test piece.
- b) Dewar shall have a heat insulating layer with enough capacity to keep the temperature of a test piece at 4 K. Furthermore, the cryogenic apparatus shall be equipped with a transfer tube with a heat insulating layer to send liquid helium into the Dewar.
- c) Grips shall have construction and strength suitable for the test piece to be tested, and be matched with the gripping device of tensile tester on service. It shall have sufficient rigidity, also.

Remarks : The materials of the grips shall have high toughness and strength so that they do not brittle at cryogenic temperatures. Generally, austenitic stainless steel or titanium alloy is used.

- d) Cryogenic apparatus shall hold a test piece on the center line of the tester while test is carried out, and any force other than tensile force shall not influence it. For this purpose, it is recommended that the cryogenic apparatus can make easily an alignment.
- e) The cryogenic apparatus shall conform to the specification by which the bending stress, to be applied to a test piece during the test, has been preliminarily checked according to Annex 1.

Remarks : The cryogenic apparatus may be so constructed that plural test pieces are simultaneously cooled and are tested one by one successively. In this case, in order to align test force applied to test piece, special care shall be taken about the structure of a grip device.

5.3 Level gauge The Dewar of a cryogenic apparatus, in order to confirm that a test piece exists thoroughly in liquid helium during test, shall be equipped with a suitable level gauge for observing the liquid surface of liquid helium.

5.4 Extensometer The extensometer shall be as follows.

- a) Principally, the extensometer shall be attached directly to a test piece in liquid helium. However, the extensometer may be attached outside the paralleled place of a test piece.
- b) The extensometer which has been preliminarily calibrated in accordance with Annex 2 prior to tensile test shall be used.

Informative reference : Extensometers to be used at cryogenic temperatures are classified into the system in which a strain gauge is directly stuck on the paralleled place of a test piece, a clip and gauge type which uses a strain gauge, and an electric capacity type extensometer.

Further, in the case where the strain gauge is used at cryogenic temperatures, care shall be taken for the selection and combination of gauge material, base materials, and adhesives. When plural extensometers are used to cancel the influences caused by bending of test piece, strain gauges are stuck facing each other at lengthwise central part of paralleled place of test piece.

6 Test piece

6.1 Reference test piece

- a) Principally, reference test piece, with circular cross section, is No. 14 A test piece specified in JIS Z 2201, and its diameter is 7 mm, but when occasion demands the test piece with other diameter can be available.
- b) Materials shaped such as sheet or wire are difficult to be sampled by a), and then other test pieces specified in JIS Z 2201 can be used.