



JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS Z 2283 : 1998

Method of low cycle fatigue
testing for metallic materials
in liquid helium

ICS 77.040.20

Descriptors : metals, metal sections, liquids, helium, fatigue testing

Reference number : JIS Z 2283 : 1998 (E)

Z 2283 : 1998

Foreword

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

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

Date of Establishment: 1998-03-20

Date of Public Notice in Official Gazette: 1998-03-20

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

JIS Z 2283:1998, First English edition published in 2000-04

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

In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

© JSA 2000

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Printed in Japan

Method of low cycle fatigue testing for metallic materials in liquid helium

Introduction This Japanese Industrial Standard was developed referring to the Method of high temperature low cycle fatigue testing for metallic materials (**JIS Z 2279**) and the Tensile testing method for metallic materials in liquid helium (**JIS Z 2277**) and, in particular, taking into account the plastic deformation work which is likely to raise greatly the temperature of materials in a very low temperature such as the liquid helium hard to deal with and more expensive, in addition, than liquid hydrogen used relatively well for coolant.

1 Scope This Japanese Industrial Standard specifies the uniaxial tensile—compressive fatigue testing method under the alternating constant strain range control for the purpose of acquiring the low cycle fatigue life of metallic materials in liquid helium under the atmospheric pressure.

2 Normative references The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. Of these normative references, the most recent editions apply.

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

JIS R 6252 *Abrasive papers*

JIS Z 2277 *Tensile testing method for metallic materials in liquid helium*

JIS Z 2279 *Method of high temperature low cycle fatigue testing for metallic materials*

3 Definitions For the purpose of this Standard, the definitions given in **JIS G 0202**, **JIS Z 2277** and **JIS Z 2279** and the following definitions apply.

- a) **stress** (σ) The value obtained by dividing the axial direction test force P of the test piece by the initial cross section A_0 of the test piece (nominal stress). P shall be positive in tension and negative in compression.
- b) **total strain** (ε_t) When the initial gauge length of the test piece is l_0 and the gauge length after deformation is l , the total strain is expressed by the following formula. Unit of m/m (dimensionless) or % is used.

$$\varepsilon_t = \frac{l - l_0}{l_0} \dots\dots\dots (1)$$

Remarks : The initial gauge length of the test piece shall be the gauge length after mounting an extensometer on the test piece and cooling down to the test temperature, but if it is impossible to measure correctly, the value at room temperature may be used.

- c) **elastic strain** (ε_e) The elastic component out of the total strain and the value obtained by dividing the stress σ by the Young's modulus E .

$$\varepsilon_e = \frac{\sigma}{E} \dots\dots\dots (2)$$

- d) **plastic strain (ε_p)** The value obtained by subtracting the elastic strain from the total strain.

$$\varepsilon_p = \varepsilon_t - \varepsilon_e \quad \dots\dots\dots (3)$$

- e) **maximum value and minimum value of strain** The maximum value and the minimum value of each strain are expressed with $\varepsilon_{t \max}$, $\varepsilon_{t \min}$, $\varepsilon_{e \max}$, $\varepsilon_{e \min}$, $\varepsilon_{p \max}$ and $\varepsilon_{p \min}$ respectively.

- f) **tensile peak stress ($\sigma_{\max}$)** The maximum value of stress.

- g) **compressive peak stress ($\sigma_{\min}$)** The minimum value of stress.

- h) **stress range ($\Delta\sigma$)** The value obtained by subtracting the compressive peak stress from the tensile peak stress.

$$\Delta\sigma = \sigma_{\max} - \sigma_{\min} \quad \dots\dots\dots (4)$$

Remarks : $\frac{1}{2}$ of stress range is called stress amplitude.

- i) **hysteresis loop** A loop showing the relation between stress and strain in fatigue testing.

- j) **total strain range ($\Delta\varepsilon_t$)** The value obtained by subtracting the minimum value of the total strain from the maximum value.

$$\Delta\varepsilon_t = \varepsilon_{t \max} - \varepsilon_{t \min} \quad \dots\dots\dots (5)$$

The value of the total strain range which is representative of the test is the total strain range at $\frac{1}{2}$ of number of cycles of failure (N_f) or at the number of cycles in its vicinity.

$\frac{1}{2}$ of total strain range is called total strain amplitude.

- k) **elastic strain range ($\Delta\varepsilon_e$)** The value obtained by subtracting the minimum value of elastic strain from the maximum value.

$$\Delta\varepsilon_e = \varepsilon_{e \max} - \varepsilon_{e \min} \quad \dots\dots\dots (6)$$

Remarks : If elastic strain cannot be obtained because the Young's modulus is unknown, it can be obtained by subtracting the plastic strain range which is obtained from the hysteresis loop given in the next sub-clause from the total strain range.

$$\Delta\varepsilon_e = \Delta\varepsilon_t - \Delta\varepsilon_p \quad \dots\dots\dots (7)$$

- l) **plastic strain range ($\Delta\varepsilon_p$)** The value obtained by subtracting the minimum value of plastic strain from the maximum value.

Remarks : If plastic strain cannot be obtained by the formula (3) because the Young's modulus is unknown, the hysteresis loop width corresponding to stress 0 can be taken as the plastic strain range.

- m) **strain range control error (ζ)** When the total strain range at an optional number of cycles is $\Delta\varepsilon_{t1}$, and the total strain range which is representative of the test is $\Delta\varepsilon_{t2}$, ζ is expressed by the following formula:

$$\zeta = \frac{\Delta\varepsilon_{t1} - \Delta\varepsilon_{t2}}{\Delta\varepsilon_{t2}} \quad \dots\dots\dots (8)$$

The maximum value of the strain range control error is expressed with $\zeta_{\max}$ and the minimum value with $\zeta_{\min}$.

- n) **strain waveform** The form of variation of the total strain which varies simply and cyclically between the specific maximum value and minimum value with respect to the time.
 - o) **strain speed** ($\dot{\epsilon}_t$) The value of the total strain range divided by the time required for $\frac{1}{2}$ cycle. The unit of s^{-1} or $\%s^{-1}$ is used.
 - p) **frequency** (f or ν) Number of cycles per unit time. The unit of Hz is used.
 - q) **number of cycles of failure** (N_f) Number of cycles until the failure of the test piece. It is also called failure life.
 - r) **number of cycles of rupture** (N_{rup}) Number of cycles until the time of complete fragmentation and rupture of the test piece. It is also called rupture life.
- Remarks : Both of number of cycles of failure and number of cycles of rupture are called **fatigue life**.
- s) **serration** A phenomenon of stress-strain curve which becomes saw-tooth form in the process of tension and compression.
 - t) **cryogenic apparatus** An apparatus consisting of dewar for storing liquid helium and the like, device for gripping test piece, load-frame, etc. It is used setting a test piece in its inside and being mounted on a fatigue testing machine.
 - u) **dewar** Very low temperature thermostat equipped with thermal insulation layer for keeping liquids such as liquid helium surrounding the test piece.

4 Principle of test This test is to obtain the number of cycles until the time of failure or rupture of the test piece by immersing the test piece in liquid helium and applying the test force repeating tensile and compressive cycles to longitudinal direction of the test piece under a specific total strain range condition.

5 Test piece

5.1 Shape and dimensions of test piece A test piece of solid round bar shall be used. Its shape and dimensions shall be as shown in Fig. 1 and Table 1.

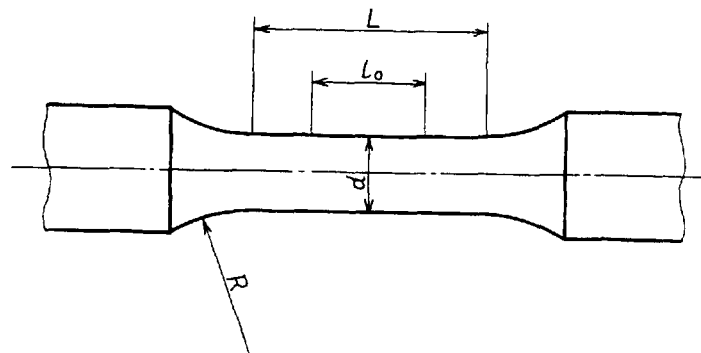


Fig. 1 Shape of test piece