DRAFT INTERNATIONAL STANDARD ISO/DIS 16842

ISO/TC **164**/SC **2** Secretariat: **JISC**

Voting begins on **2013-01-10** Voting terminates on **2013-04-10**

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Metallic materials — Sheet and strip — Biaxial tensile testing method using cruciform specimen

Matériaux métalliques — Tôles et bandes — Méthode d'essai de traction biaxiale sur échantillon cruciforme

ICS 77.040.10

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

THIS DOCUMENT IS A DRAFT CIRCULATED FOR COMMENT AND APPROVAL. IT IS THEREFORE SUBJECT TO CHANGE AND MAY NOT BE REFERRED TO AS AN INTERNATIONAL STANDARD UNTIL PUBLISHED AS SUCH.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

RECIPIENTS OF THIS DRAFT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.

Contents

Page

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 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee 2, *Ductility testing*.

Introduction

This standard specifies the testing method for measuring the biaxial stress-strain curves of sheet metals subject to biaxial tension at an arbitrary stress ratio using a cruciform specimen made of flat sheet metals. The standard applies to the shape and strain measurement position of the cruciform specimen. The biaxial tensile testing machine will be described in Annex C, only in terms of the typical example of the machine and the requirements that the machine must comply.

The cruciform specimen recommended in this standard has the following features:

a) The gauge area of the specimen ensure superior homogeneity of stress; enabling measurement of biaxial stress with satisfactory accuracy;

b) Capability of measuring the elasto-plastic deformation behavior of sheet metals at arbitrary stress or strain ratios;

c) Free from the out-of-plane deformation as is encountered in the hydrostatic bulge testing method;

d) Easy to fabricate from a flat metal sheet by laser cutting, water jet cutting or other alternative manufacturing methods.

Metallic materials – Sheet and strip – Biaxial tensile testing method using cruciform specimen

1 Scope

This standard specifies the method for measuring the stress-strain curves of sheet metals subject to biaxial tension using a cruciform specimen with even thickness as fabricated from one sheet metal. The applicable thickness of the sheet shall be 0.1 mm or more and 0.08 times or less of the arm width *B* of the cruciform specimen. The test temperature shall range from 10 to 35 °C. The amount of plastic strain applicable to the gauge area of the cruciform specimen depends on the stress ratio, slit width of arm, work hardening exponent (*n*-value), and anisotropy of the test materials (see **Annex B**).

2 Normative references

The following referenced documents are indispensable for the applications of this document. The latest edition of the referenced document (including any amendments) applies.

ISO 6892-1, Metallic materials — Tensile testing — Part 1: Method of test at room temperature

ISO 80000-1, Quantities and units — Part 1: General

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

3.1
cruciform specimen
specimen which is recommended in the biaxial tensile test and whose geometry is specified in this standard (see Figure 1)

3.2
gauge area
square area which is located in the middle of the cruciform specimen and is enclosed by the four arms of the cruciform specimen (see Figure 1)

3.3
arm
generic name for all areas other than the gauge area in the cruciform specimen. The arm plays a role of transmitting tensile loads in two orthogonal directions to the gauge area of the cruciform specimen.

3.4
biaxial tensile testing machine
testing machine for applying biaxial tensile forces to a cruciform specimen in the orthogonal directions parallel to the arms of the specimen (see **Annex C**)

3.5
yield function
function used to generate the conditional equation (yield criterion) which the stress components must comply with when the material subject to the stress is in the plastic deformation state

3.6
contour of plastic work
graphic figure derived by subjecting the material to plastic deformation along various linear stress paths and plotting the stress points in stress space at the instant when the plastic work consumed per unit volume along each stress path becomes identical and the plotted stress points are approximated into either a smooth curve or curved surface (see **Annex A**).

4 Principle

Measurement is made at room temperature, on the yield stress and the stress-strain curves of sheet metals under biaxial tensile stresses by measuring simultaneously and continuously the biaxial tensile forces and strain components applied to the gauge area of a cruciform specimen while applying biaxial tensile forces in the orthogonal directions parallel to the arms of the specimen. The specimen is made of a flat sheet metal and has a uniform thickness. The measured biaxial stress-strain curves are used to measure contours of plastic work of the sheet samples (see **Annex A**). According to the finite element analyses of the cruciform specimen as recommended in Clause 5 and the strain measurement position as specified in Clause 6.2.4, the stress calculation error is estimated to be less than 2.0 % [1][2].

5 Specimen

5.1 Shape and dimensions

Figure 1 shows the shape and dimensions of the cruciform specimen recommended in this standard. The specimen shall be as described below.

a) The arm width *B* should be 30 mm or more with an accuracy of ± 0,1 mm, except that *B* may be determined according to the agreement between parties involved in transaction.

b) In principle, the thickness of a specimen shall be the same as that of the original sample, without any work done in the thickness direction. When the material thickness a exceeds 8% of the arm width B, either the arm width B shall be increased in such a manner that satisfies a≤ 0,08B or the specimen thickness shall be reduced.

c) Seven slits per one arm shall be worked. Specifically, one slit shall be worked on the centerline (*x*- or *y*-axis) of the specimen with an accuracy of ± 0,1 mm and three slits shall be worked at an interval of *B*/8 with an accuracy of ± 0,1 mm on each side of the centerline. The opposing slit ends shall be worked at an equal distance from the centerline. The distances B_{Sx} and B_{Sy} between the slit ends shall be made equal with an accuracy of *B* ± 0,1 mm. All slits shall have the same length *L* ± 0,1 mm, and the relationship of $B \leq L \leq 2B$ must be established. The slit width w_S should be worked as small as possible (see Figure B.2), preferably less than 0,3 mm.

d) The grip length *C* is considered to be enough if it can secure the specimen to the chuck of the biaxial tensile testing machine and can transmit the necessary tensile force to the specimen. The standard length would be *C=B/2* to *B*, but may be determined arbitrarily according to the agreement between parties involved in transaction.

e) The arm width *B* and the slit length *L* shall be measured accurately to 0,05 mm and the result shall be rounded to the digit of 0,1 mm according to ISO 80000-1.

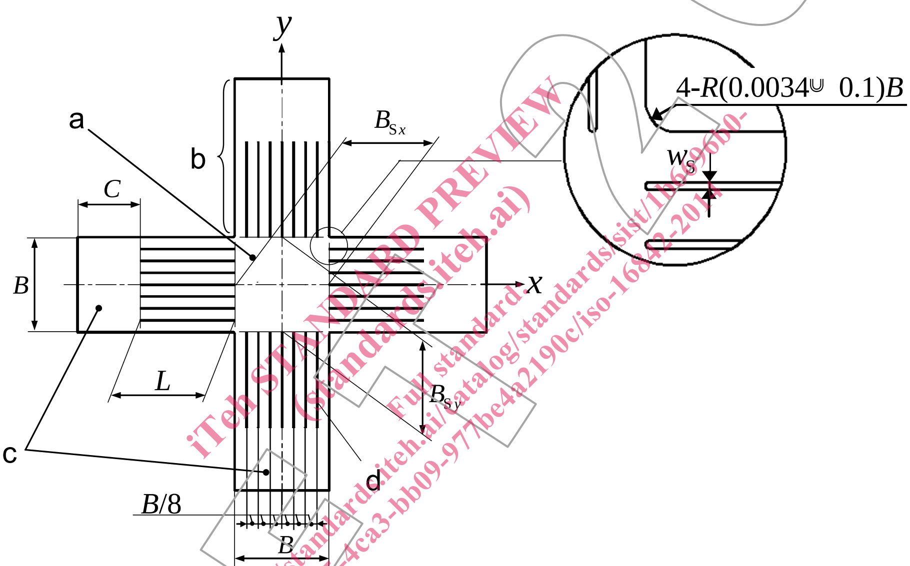
5.2 Preparation of specimens

a) The specimen shall be fabricated from a flat sheet metal sample.

b) The standard sampling direction of the specimen shall be such that the directions of arms are parallel to the material rolling and transverse directions, respectively, except that the specimen sampling direction may be determined according to the agreement between parties involved in transaction.

c) For the fabrication of the specimen (including cutting of slits), any method, e.g., laser cutting, water jet cutting or other alternative manufacturing methods, demonstrated to work satisfactorily may be used if agreed upon by the parties.

d) Unless otherwise specified and except for the sampling work, unnecessary deformation or heating to the specimen shall be avoided.



Key

a gauge area
b arm
c grip
d slit

B_{Sx}, B_{Sy} distance between opposing slit ends
B arm width
C grip length
L slit length
w_S slit width

Figure 1 — Standard shape and dimensions of the recommended cruciform specimen [1][2]

6 Testing method

6.1 Testing machine

The specifications required for the biaxial tensile testing machine (hereinafter referred to as testing machine) are as follows (for examples of typical testing machines, see Annex C).

a) It shall have sufficient functions and durability to hold four grips of a cruciform specimen (hereinafter referred to as specimen) in one single plane with a tolerance of ± 0.01 mm during testing.

b) Two opposing chucks shall move along a single straight line (hereinafter referred to as *x*-axis and *y*-axis), and the *x*- and *y*-axes shall intersect at an angle of 90 ± 0.1° (The plane that contains the *x*- and *y*-axes is referred to as the reference plane while the intersection of *x*- and *y*-axes as the center of testing machine)

c) It shall have a function for adjusting the two opposing chucks to the positions at an equal distance from the center of the testing machine before the installation of the specimen to the chuck

d) It shall have a function for enabling the installation of the specimen to the chucks while aligning the center of specimen to the center of the testing machine.

e) It shall have a function for enabling equal displacement of two opposing chucks or the maintenace of the center of the specimen always on the center of the testing machine with a tolerance of ± 0.1 mm during biaxial tensile test (for example, the testing machines shown in Figs. C.1 and C.2 use a link mechanism to ensure equivalent displacement of two opposing chucks)

f) It shall have a capability of the servo controlled biaxial tensile testing to perform the test with the constant nominal stress ratio (constant load ratio) and/or the test with the constant true stress ratio, and/or the test with constant strain rate ratio, according to the purpose of the test (see **Annex C.2**). For the link type biaxial tensile testing machine it shall ensure equal displacement of two opposing chucks (see **Annex C.3**)

g) Modern control electronics allow independent and combined control of each actuator – it is called Modal Control [3]-[6]. (see **Annex C.4**)

h) It shall have a function for measuring and storing the values of the tensile force (two channels for the x- and y-axes) and strain components (two channels for the x- and y-axes) during biaxial tensile test with the specified accuracy and time interval agreed by the parties concerned.

6.2 Measurement method of tensile force and strain

6.2.1 General

This subclause specifies the method for measuring the tensile forces (F_X, F_y) and nominal strain components (e_x, e_y) applied to the *x* and *y* directions of a cruciform specimen.

6.2.2 Measurement method of tensile force

For measurement of (F_X, F_y) load cells shall be used in the *x*- and *y*-directions. The force-measuring system of the testing machine shall be calibrated in accordance with ISO 7500-1, class 1, or better.

6.2.3 Measurement method of strain

For measurement of (e_x, e_y), strain gauges or other methods, e.g., optical measurement systems, shall be used. Measure e_x and e_y to an accuracy of ±1 %.

6.2.4 Strain measurement position

Figure 2 shows the positions of strain gauges for measuring (e_x, e_y). (e_x, e_y) shall be measured at a position, with a distance of (0,6 to 0,8)× *(B/2)* from the center of specimen, on the centerline parallel to the maximum tensile force (F_x in Figure 2). The strain gauge shall be adhered in such a manner that the sensor portion of the strain gauge falls fully into a range of (0,6 to 0,8) × *(B/2)*. According to the finite element analyses of the

