

---

---

**Metallic materials — Sheet and strip —  
Method for springback evaluation in  
stretch bending**

*Matériaux métalliques — Tôles et bandes — Méthodes d'évaluation du  
retour élastique lors d'un cintrage sous traction*

STANDARDSISO.COM : Click to view the full PDF of ISO 24213:2008



**PDF disclaimer**

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

STANDARDSISO.COM : Click to view the full PDF of ISO 24213:2008



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2008

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 either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
Case postale 56 • CH-1211 Geneva 20  
Tel. + 41 22 749 01 11  
Fax + 41 22 749 09 47  
E-mail [copyright@iso.org](mailto:copyright@iso.org)  
Web [www.iso.org](http://www.iso.org)

Published in Switzerland

**Contents**

Page

<b>Foreword</b> .....	<b>iv</b>
<b>Introduction</b> .....	<b>v</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 Symbols and designations</b> .....	<b>3</b>
<b>5 Principle</b> .....	<b>3</b>
<b>6 Test apparatus</b> .....	<b>3</b>
<b>7 Test piece</b> .....	<b>5</b>
<b>8 Procedure</b> .....	<b>5</b>
<b>9 Test report</b> .....	<b>6</b>
<b>Annex A (normative) Method for calculating blank holding pressure</b> .....	<b>7</b>
<b>Annex B (normative) Method for calculating nominal tensile stress</b> .....	<b>9</b>
<b>Annex C (normative) Device for determining radius of curvature using a dial gauge</b> .....	<b>10</b>
<b>Bibliography</b> .....	<b>11</b>

## 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 24213 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 2, *Ductility testing*.

STANDARDSISO.COM : Click to view the full PDF of ISO 24213:2008

## Introduction

This International Standard has been established to evaluate the amount of springback occurring in metallic sheets deformed by stretch-bending. It may be used for specifying a material, directly controlling a forming operation, designing dies, or calibrating finite element programs.

In metallic sheet forming processes, the geometry of the formed parts may deviate from the design geometry after the parts are removed from the dies due to elastic recovery. This phenomenon is referred to as springback.

STANDARDSISO.COM : Click to view the full PDF of ISO 24213:2008

STANDARDSISO.COM : Click to view the full PDF of ISO 24213:2008

# Metallic materials — Sheet and strip — Method for springback evaluation in stretch bending

## 1 Scope

This International Standard specifies a method for evaluating the amount of springback of sheets of metallic materials known to exhibit large amounts of springback subjected to plane-strain stretch bending, which is a typical deformation mode generated in press-formed panels. By using this method, the amount of springback under stretch bending is evaluated accurately and quantitatively.

## 2 Normative references

The following referenced documents relate to 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 31-0, *Quantities and units — Part 0: General principles*

## 3 Terms and definitions

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

### 3.1

#### curvature

$\kappa$

reciprocal of the radius of curvature  $r$  determined at the centre of a stretch-bent specimen on the inner surface in the longitudinal direction

$$\kappa = \frac{1}{r} \quad (1)$$

### 3.2

#### amount of springback

$\eta$

relative change in curvature of a test piece under force and after removal of the force shown in Figure 1

$$\eta = \frac{|\kappa' - \kappa|}{\kappa} = \frac{r' - r}{r'} \quad (2)$$

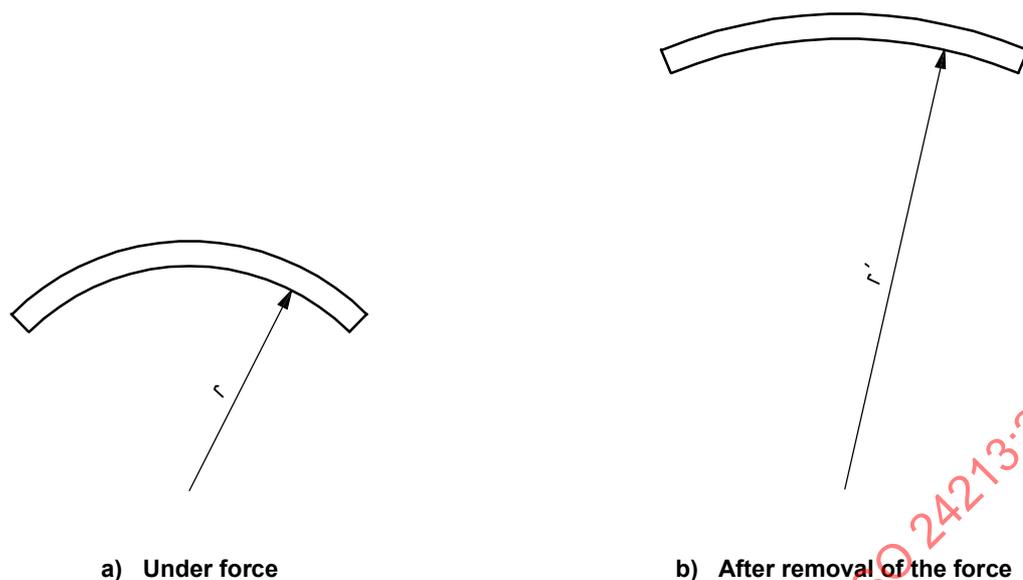


Figure 1 — Radius of curvature of test piece under force and after removal of the force

- 3.3 stretch bending**  
method of bending a test piece under tension
- 3.4 blank holding pressure**  
force applied on the test piece in the direction of its thickness, divided by the surface area of the test piece contacting the die
- NOTE The method for calculating the blank holding pressure is shown in Annex A.
- 3.5 nominal tensile stress**  
tensile force per unit cross-sectional area of the test piece
- NOTE The method for calculating the nominal tensile stress is shown in Annex B.

## 4 Symbols and designations

The symbols used in this International Standard and the corresponding designations are given in Table 1.

Table 1 — Symbols and corresponding designations

Symbol	Designation	Unit
$a$	Thickness of test piece	mm
$b$	Width of test piece	mm
$F_h$	Blank holding force	N
$h$	Amount of punch penetration	mm
$F_p$	Punch force	N
$p$	Blank holding pressure	MPa
$R_p$	Punch radius	mm
$r$	Radius of curvature of the inner surface of the test piece under force	mm
$r'$	Radius of curvature of the inner surface of the test piece after removal of the force	mm
$r_d$	Die profile radius	mm
$S$	Total surface area of test piece in contact with dies	mm <sup>2</sup>
$T$	Nominal tensile stress applied to test piece	MPa
$W$	Distance between dies	mm
$w$	Width of the base of a dial gauge for measuring the curvature of the test piece after removal of the force, see Annex C	mm
$x$	Measured value by a dial gauge for measuring the curvature of the test piece after removal of the force (length of AD in Figure C.1)	mm
$\kappa$	Curvature of the inner surface of the test piece under force ( $= r^{-1}$ )	mm <sup>-1</sup>
$\kappa'$	Curvature of the inner surface of the test piece after removal of the force [ $= (r')^{-1}$ ]	mm <sup>-1</sup>
$\eta$	Amount of springback	
$2\theta$	Spread angle of test piece around punch	rad

## 5 Principle

This test is a method for evaluating the springback of a metal sheet using a stretch-bending method. The amount of springback is determined as the change in curvatures of a test piece under force and after removal of the force (see Equations in 3.1 and 3.2). The nominal tensile stress applied to the test piece is determined using the measured value of punch penetration and punch force (see Annex B).

## 6 Test apparatus

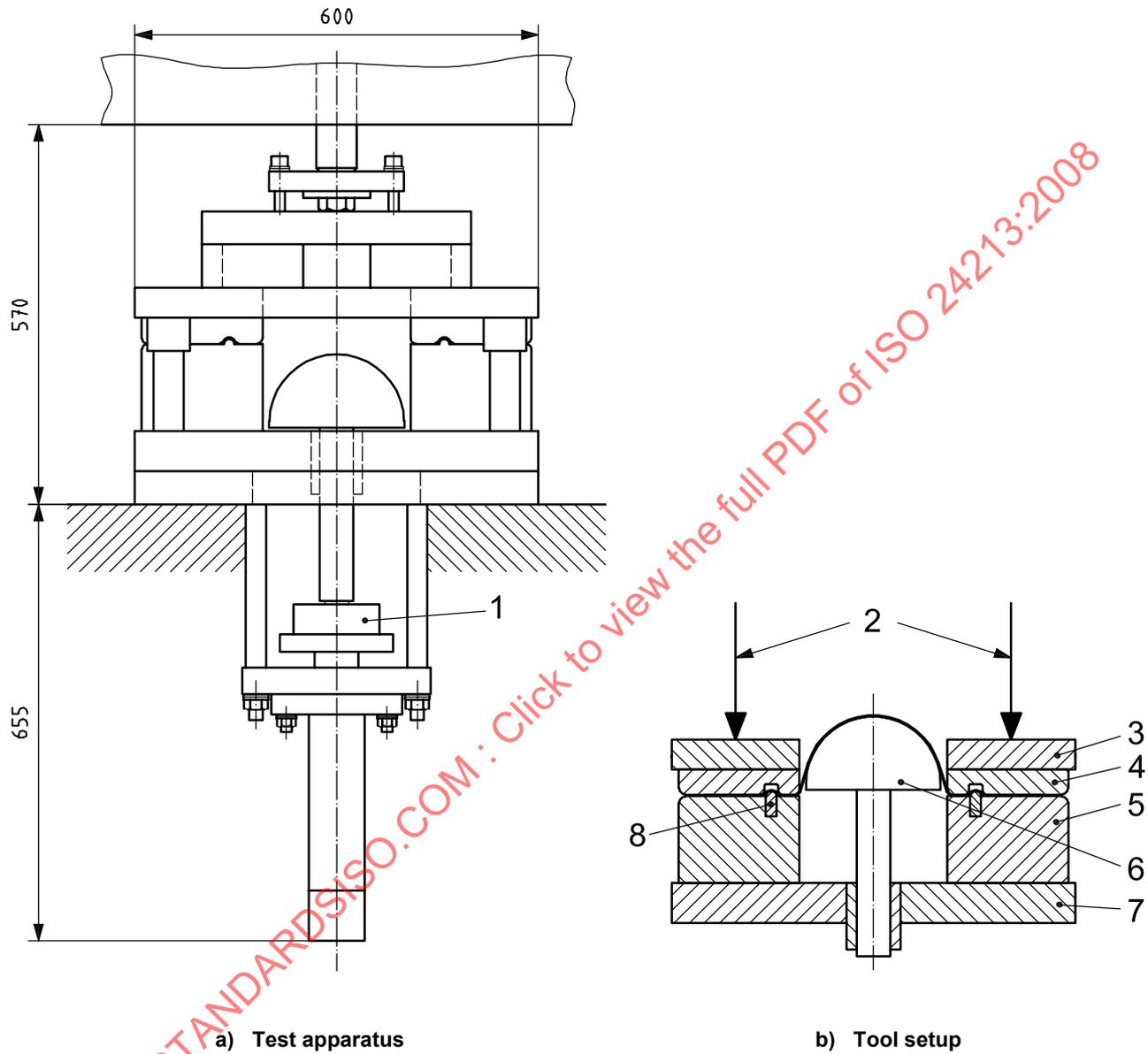
The test apparatus is described below.

### 6.1 Stretch-bending testing device for springback evaluation.

An example of the stretch-bending device used in the test is shown in Figure 2. The radius of the semi-cylindrical punch shall be  $(100 \pm 1)$  mm. However, the radius of the punch tip and its tolerance may be determined by agreement between the parties involved.

**6.2 Device for determining the radius of curvature of a test piece.** The principle for determining the radius of curvature with a dial gauge is shown in Annex C, in which a dial gauge with an accuracy of 0,001 mm shall be employed. The use of optical micrometers or other non-contacting length probes is also recommended.

Dimensions in millimetres



a) Test apparatus

b) Tool setup

**Key**

- 1 load cell
- 2 blank holding force
- 3 die top plate
- 4 die
- 5 blank holder
- 6 punch (R100)
- 7 die bottom plate
- 8 draw beads

**Figure 2 — Example of stretch-bending test apparatus for springback evaluation**

## 7 Test piece

The test piece used for the test shall be as follows.

- a) The test piece shall be rectangular in shape,  $(500 \pm 10)$  mm in length and  $(50 \pm 1)$  mm in width.
- b) Its thickness shall be the original thickness of the sheet.
- c) The test piece shall be cut parallel and perpendicular to the rolling direction.
- d) The edges of the test piece shall be as cut. Unnecessary alteration or heating of the test piece shall be avoided, unless otherwise specified or caused by cutting.
- e) The surface of the test piece shall be free from harmful defects, such as scratches, that may affect the test results.

## 8 Procedure

Testing shall be conducted as follows.

- a) **Testing temperature.** The ambient temperature shall be within the range of  $10\text{ }^{\circ}\text{C}$  to  $35\text{ }^{\circ}\text{C}$ , and the temperature shall be recorded, if necessary. When the temperature control is especially necessary, it shall be kept in the range of  $(23 \pm 5)\text{ }^{\circ}\text{C}$ .
- b) **Stretch bending.** A test piece shall be fixed in position on the blank holder (see Figure 2); the blank holding pressure shall then be applied. The maximum blank holding pressure should be 2 % to 3 % of the tensile strength of the test material. The punch is pushed up until the amount of punch penetration  $h$  reaches a predetermined value. The amount of punch penetration, which should be determined so that the spread angle  $2\theta$  of the test piece around the punch tip becomes greater than  $120^{\circ}$  (see Figure B.1), and lubricant shall be agreed between the parties involved. The amount of friction between the test piece and the punch surface should be as small as possible; preferably the coefficient of friction should be less than 0,05, so that the nominal tensile stress applied to the test piece should be distributed uniformly over the punch head. A thin sheet of polymer film and machine oil is recommended for the lubricant on the punch surface. The polymer film shall be replaced with a new one before each test. The amount of punch penetration shall be measured with a displacement gauge, and the punch force  $F_p$  with a load cell. The minimum levels of resolution on the displacement gauge for punch penetration and on the load cell for the punch force should be less than 0,5 mm and 100 N, respectively.
- c) **Calculation of tension.** The calculation shall be as shown in Annex B.
- d) **Determination of radius of curvature and calculation of springback.** The radius of curvature  $r'$  of the inner surface of the test piece, after removal of the force, shall be determined at the centre of the stretch-bent specimen in its longitudinal direction, using a dial gauge as described in Annex C. The radius of curvature  $r$  of the inner surface of the test piece under force shall be the radius of the punch tip. The amount of springback  $\eta$  is calculated using the equation in 3.2. The width of the base of a dial gauge  $w$ , for determining the curvature of the test piece, after removal of the force, is recommended to be 20 mm, see Annex C. This is based on the observation, in preliminary experiments, that the curvature of the specimen after springback was almost uniform in the central 20 mm section of the specimen.
- e) **Rounding.** Measured data shall be rounded according to ISO 31-0.

## 9 Test report

If a test report is required, the reported items shall be determined by agreement between the parties and shall be selected from the following:

- a) test conditions: punch radius, amount of punch penetration, lubricant, type and thickness of polymer film, punch force, blank holding pressure;
- b) test results: nominal tensile stress, amount of springback  $\eta$ ;
- c) type and thickness of material;
- d) an estimate of the uncertainty (or precision and bias) for all the measurements reported.

STANDARDSISO.COM : Click to view the full PDF of ISO 24213:2008

## Annex A (normative)

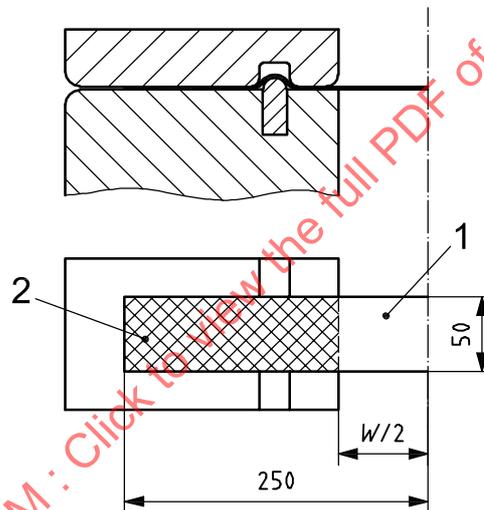
### Method for calculating blank holding pressure

The blank holding pressure shall be calculated using Equations (A.1) and (A.2) (see Figure A.1):

$$p = \frac{F_h}{S} \quad (\text{A.1})$$

$$S = 50 \times \left( 250 - \frac{W}{2} \right) \times 2 = 50 \times (500 - W) \quad (\text{A.2})$$

Dimensions in millimetres



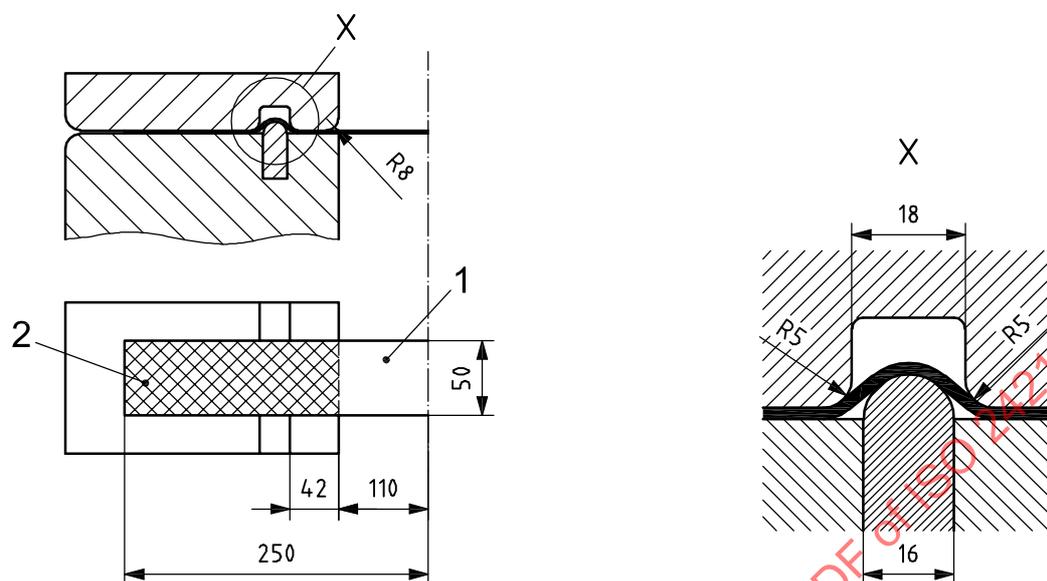
#### Key

- 1 test piece
- 2 total surface area of test piece in contact with dies

**Figure A.1 — Contact area of test piece with dies**

An example of the dimensions of the tool [Figure 2 b)] is shown in Figure A.2.

Dimensions in millimetres



**Key**

- 1 test piece
- 2 total surface area of test piece in contact with dies

**Figure A.2 — Example of dimensions of tool**

STANDARDSISO.COM : Click to view the full PDF of ISO 24213:2008