



**NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA**

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**Metallic materials - Sheet and strip - Method for spring back
evaluation - Part 1: Stretch bending**

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1 Scope

This document specifies a method for evaluating the amount of springback of sheets and strips of metallic materials under plane-strain stretch bending. Plane-strain stretch bending is a typical deformation mode of stamping parts, which can show a significant amount of springback. By using this method, the amount of springback under stretch bending can be evaluated accurately and quantitatively.

This document applies to material characterization, forming process control, die design and finite element program calibration for sheets and strips of metallic materials with springback control requirements.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the version corresponding to that date is applicable to this document; for undated references, the latest version (including all amendments) is applicable to this document.

GB/T 8170, Rules of rounding off for numerical values & expression and judgment of

limiting values

3 Terms and definitions

The following terms and definitions are applicable to this document.

3.1 Curvature Reciprocal of the radius of curvature measured at the centre of a stretch-bent test piece on the inner surface in the longitudinal direction.

Note: See Formula (1).

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

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

Appendix 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.

7 Test piece The test piece used for the test shall be as follows:

- a) The test piece shall be rectangular in shape, (500 ± 10) mm in length and (50 ± 1) mm in width.
- b) The thickness shall be the original thickness of the sheet or strip;
- c) The test piece shall be cut either parallel or perpendicular to the rolling direction as agreed between the parties;
- d) The edges of the test piece shall be 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 affect the test results.

8 Test procedures Testing shall be conducted as follows.

- a) Testing temperature: The ambient temperature shall be within the range of $10\text{ }^{\circ}\text{C} \sim 35\text{ }^{\circ}\text{C}$, 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 the position on the blank holder (see Figure 2); the blank holding pressure shall then be applied. The blank holding pressure shall be calculated in accordance with Appendix A; the maximum blank holding

pressure shall be 2% ~ 3% of the tensile strength of the test material. The punch is pushed up until the amount of punch penetration reaches a predetermined value. The amount of punch penetration shall be determined so that the spread angle, 2θ , of the test piece around the punch tip becomes greater than 120° (see

Figure B.1); the lubricant shall be agreed between the parties involved. The

amount of friction between the test piece and the punch surface shall be as small as possible. Preferably, the coefficient of friction should be less than 0.05, so that the nominal tensile stress 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 (h) and the punch force (FP) shall be measured with a displacement gauge and a load cell, respectively. 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 nominal tensile stress: The calculation shall be as shown in

Appendix 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 test piece in its longitudinal direction, using a measurement device as specified in Appendix 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, η , is calculated using the Formula (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 Appendix 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 GB/T 8170.

Note: Keep three significant figures.

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

- a) reference to this document;
- b) test conditions: punch radius, amount of punch penetration, lubricant, type and thickness of polymer film, punch force, blank holding pressure, and orientation of the test piece to the material rolling direction;
- c) test results: nominal tensile stress, amount of springback, η ;

- d) type, thickness, designation and status of test materials;
- e) an estimate of the uncertainty (or precision and bias) for all the measurements reported.

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