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

**GB/T 24173-2016**

Replacing GB/T 24173-2009

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**Steel sheets - Secondary work embrittlement test method**

钢板 二次加工脆化试验方法

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### Foreword

This Standard was drafted in accordance with the rules given in GB/T 1.1-2009. This Standard replaces GB/T 24173-2009, Steel Sheets - Secondary Work Embrittlement Test Method. Compared with GB/T 24173-2009, the major technical changes of this Standard are as follows: -- it replaces "punch pin" with "punch" in the main text; -- it adds the normative references in Article 2; -- it adds the definition of "clearance" in

3.5 and the requirements for clearance in the preparation of cup sample in 5.5; -- in Table 1, it modifies the inner diameter of cup sample and the diameter of punch, and adds the explanations of primary and secondary strains; -- it modifies the test principle in Article 4; -- it adds Table 2, i.e. the selection of dimensions of punch and die; -- it modifies

5.4 and indicates that other materials may also be used as lubricating agents; -- it adds the explanations of impact centring mechanism in

6.4 and specifies that the deviation of impact centre is not greater than

0.5 mm; -- it modifies the original Figures 1 and 2 and adds Figure 3; -- it modifies the requirements for temperature measuring apparatus in

6.5 and indicates that the accuracy shall be  $\pm 1^{\circ}\text{C}$ ; -- it modifies

7.7 and indicates the criterion for the fracturing rate not smaller than 25%; -- it adds the contents of "the designation of test material" and "the clearance of mould and sheet" in test report in Article 8. This Standard was proposed by China Iron and Steel Association. This Standard shall be under the jurisdiction of the National Standardization Technical Committee on Steels (SAC/TC 183). The drafting organizations of this Part. Baoshan Iron and Steel Co. Ltd., China Metallurgical Information and Standardization Institute, Shenzhen

Wance Testing Machine Co., Ltd.. The main drafters of this Part. Fang Jian, Zhou Yedong, Dong Li, Huang Xing, Zhang Weixu. The previous edition of the standard replaced by this Standard is as follows: -- GB/T 24173-2009. Steel Sheets - Secondary Work Embrittlement Test Method

## 1 Application Scope

China's national test method for secondary work embrittlement of steel sheet. It specifies the specimens, the equipment, the procedure and the evaluation for determining the susceptibility of a formed steel sheet to embrittlement in subsequent working. Secondary work embrittlement is a failure that surprises people because the material passed every test before it happened. A deep-drawing steel - typically an interstitial free grade, which owes its formability to having almost no carbon or nitrogen in solution - is drawn into a cup or a shell without difficulty. Then, in a second operation such as flanging, expanding, ironing or simply being struck cold, it splits vertically along the wall with no ductility at all, in a brittle manner quite unlike the failure the same steel shows in a tensile test. The cause lies in the same chemistry that makes the steel formable. With the interstitials removed, the grain boundaries are not pinned, and if phosphorus is present - and it is, because phosphorus is the cheap solid solution strengthener used to give these steels strength - it segregates to the boundaries and weakens them. The drawn material carries residual stress and a worked grain structure, and below a critical temperature the boundaries fail before the grains deform. The failure is therefore temperature-dependent and appears in winter, in cold workshops, and in service in cold climates - and not in the summer trials. The test reproduces it: a cup is drawn to a defined ratio, held at a controlled temperature and then loaded until it fails, and the transition temperature at which the fracture changes from ductile to brittle is what is reported. Issued on 30 December 2016 and in force since 1 September 2017, it replaces GB/T 24173-2009.

This Standard specifies the terms and definitions, test principle, cup sample, test apparatus, test procedure, accuracy of test results and test report of secondary work embrittlement test method for steel sheets. This Standard applies to the secondary work embrittlement test of the sheets made of interstitial free steel and phosphorus bearing steel for punch-forming auto parts and other steel sheets having secondary work embrittlement characteristics for punch forming, with a thickness of

0.45 mm ~

## 2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition dated applies to this document. For undated references, the latest edition of the referenced documents (including all amendments) applies to this Part.

GB/T 10623, Metallic Material - Mechanical Testing - Vocabulary

GB/T 15825.3, Sheet Metal Formability and Test Methods - Part

### 3 Terms and Definitions

Those defined in GB/T 10623 and GB/T 15825.3 and the following terms and definitions apply to this document.

3.1 secondary work embrittlement; SWE The phenomenon that interstitial free steel (IF steel) and phosphorus bearing steel have certain interstitial internal stress after punch forming (primary processing), so they are liable to fracture on the grain boundary subjected to an external force (especially an impact force under low temperature conditions, secondary work).

3.2 secondary work embrittlement temperature; SWET

3.3 draw ratio; DR The ratio of the diameter of round billet to the diameter of punch during punch forming.

### 4 Test Principle

Place a cup sample on the base at some test temperature; make the heavy punch of a certain angle of cone and mass to fall freely to impact the rim part of the cup sample.

### 5 Cup Sample

5.1 See Table 1 for the dimensions of cup sample and the diameters of punch.

5.2 The head, tail and edge of sheet steels shall be avoided for the parts selected from steel sheet billets (except those with special requirements); the surface shall be free from defects including scratches and roll marks. The widths of cup sample no.1 and no. 2 shall not be less than 74 mm and 108 mm.

5.4 The punching of round billets into cylindrical cup sample is performed on a forming property testing machine, using the draw ratio DR 2.1, the corner radius of punch

0.5 mm, the blank holder force

14.7 kN and the rising speed of punch normally not greater than 40 mm/min, and using polypropylene film of thickness

0.040 mm  $\pm$

0.005 mm as the lubricating agent to reduce the wrinkling of cup sample and reduce the abrasion of mould. Record the blank holder force used for deep drawing cup. For coating materials, clean mould after each time of punching.

5.6 The earing on the edge of cylindrical cup sample is processed by turning on the lathe; the height of the cup sample processed by turning is as specified in Table 1.

## 6 Test Apparatus

Warning. In order to ensure safety, the punch head shall not fall even if it is subjected to a certain external force at least when it is fixed at the setting position; it shall not fall in case of unexpected power outages.

6.1 The apparatus required for secondary work embrittlement test. mould for punching round billets, punch, lathe, punch impact testing machine for secondary work embrittlement test, cooling equipment, polypropylene film.

6.4 A centring mechanism is preferably provided on the impact base for the centring of cup sample and punch head impact centre, as shown in Figure 3, to ensure the centring of the centre of cup sample and the impact centre of punch head.

## 7 Test Procedure

7.1 Processed cup sample is fully immersed in the cooling equipment containing an appropriate cooling liquid at a given temperature; the lowest temperature of the cooling equipment shall be capable of achieving - 60°C at least.

7.2 Lift the punch head of testing machine to 1 000 mm  $\pm$  5 mm; take cup sample from cooling equipment; place it on the base right below the base with the rim upwards; release the punch head to make it fall freely; impact cup sample. It shall be finished within 3 s from taking cup sample out of cooling equipment to impacting cup sample.

7.4 If none of the 4 cup samples fracture, then lower the temperature and repeat test on 4 cup samples. The temperature interval is subjected to the experiences and convenience degree of test personnel (e.g. 10°C or 20°C). NOTE Cup sample will show plastic expansion without fracturing if the temperature is above secondary work embrittlement temperature.

7.5 If only one of the 4 cup samples fractures, carry out test on 8 cup samples at this temperature (adding 4 cup samples).

7.6 If at least two of 4 cup samples fracture, then improve test temperature by 5°C and repeat test on 4 cup samples, until at least two of the 4 cup samples fracture. Carry out test on 8 cup samples at this temperature (adding 4 cup samples for the test).

7.7 If at least two of 8 cup samples fracture, i.e. the maximum temperature, at which the fracturing rate is not smaller than 25%, is the secondary work embrittlement temperature SWET (SWET is the integer multiples of 5°C, e.g. - 35°C, - 40°C, -45°C and so on).