

**Method of determining the plastic strain ratio  
for metallic sheet and strip  
JIS Z 2254 (1996)**

**Introduction** This Japanese Industrial Standard was made on the basis of ISO 10113. Metallic materials-Sheet and strip-Determination of plastic strain ratio, issued in 1991 as the first edition without changing the technical contents except the following points:

[Outline of difference of specified contents]

- ① Part of tensile test conditions is based on JIS Z 2241
- ② Specified of numerical values related to gauge length and additional strain level are added
- ③ Rule for rounding off of numerical values
- ④ Natural oscillation method not specified in the corresponding International Standard is specified in Annex.

1. Scope This Japanese Industrial Standard specifies the method of determining the plastic strain ratio for the metallic sheet and strip.

Remarks 1. The following standards are cited in this Standard:

JIS B 7721 Tensile testing machines  
JIS B 7741 Extensometers used in metallic material tensile testing  
JIS G 0202 Glossary of terms used in iron steel(testing)  
JIS Z 2201 Test pieces for tensile test for metallic materials  
JIS Z 2241 Method of tensile test for metallic materials  
JIS Z 8401 Rules for rounding off of numerical values

2. The following is the corresponding International Standard to this Standard:

ISO 10113:1991 Metallic materials-Sheet and strip-Determination of plastic strain ratio

2. Definitions For the purpose of this Standard, the definitions given in JIS G 0202 and the following definitions apply:

- (1) Testing force Force applied to test piece for the purpose of testing.
- (2) plastic strain ratio The ratio of the true width strain and true thickness strain in a test piece of plate shape has been submitted to uniaxial tensile stress. It is also called r value or Lankford value defined by the equation(1)

$$r = \frac{\varepsilon_w}{\varepsilon_t} \dots\dots\dots(1)$$

where,  $\varepsilon_w$  : true width strain

$\varepsilon_t$  : true thickness strain

The equation (1) is only valid in the region where the plastic strain is homogeneous. In practice, the equation(2) derived from the law of constancy of volume before and after plastic strain is used.

$$r = \frac{\ln \frac{W_0}{W}}{\ln \frac{LW}{L_0 W_0}} \dots\dots\dots(2)$$



where,  $W_0$ :width of test piece before tensile deformation(mm)

$W$  : width of test piece after straining to a specified elongation(mm)

$L_0$ :original gauge length(mm)

$L$  :gauge length after straining to a specified elongation(mm)

- (3) average plastic strain ratio The weighted average value calculation by the formula(3) using the plastic strain ratios for different test piece orientations of parallel, 45° and 90° to the rolling direction of the sheet surface.

$$\bar{r} = \frac{r_0 + 2r_{45} + r_{90}}{4} \dots\dots\dots(3)$$

Where,  $r_0$  :plastic strain ratio measured by taking a test piece parallel to the rolling direction of the sheet surface

$r_{45}$  : plastic strain ratio measured by taking a test piece at an angle of 45° to the rolling direction of the sheet surface

$r_{90}$  : plastic strain ratio measured by taking a test piece at an angle of 90° to the rolling direction of the sheet surface

Remarks:  $r_m$  may be expressed instead of  $\bar{r}$  .

- (4)degree of planar anisotropy The test method shall ,as a rule, be the plastic strain method. In the case where relevant material standard in Japanese Industrial Standard does not specify the kind of test method, and the average plastic strain ratio may be in accordance with the natural oscillation method specified in the Annex.

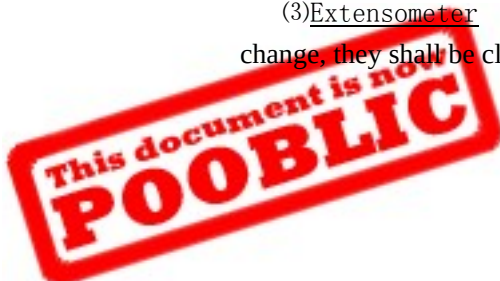
4.Principle of test A test piece is subjected to a tensile test giving uniform plastic strain up to a specified strain level and the plastic strain ratio is calculated from the values of the width and thickness of the test piece before and after plastic strain constant, the plastic strain ratio is calculated by measuring the width of the test piece and the length between the gauge marks before and after tensile deformation.

5.Test equipment The test equipment to be used shall be as follows:

(1)Test machine The testing machine shall be the tensile testing machine specified in JIS B 7721 or that equipped at least with the device for gripping the test piece specified in JIS B 7721 and capable of pulling the test piece at a specified straining speed adding uniaxial testing force and of the construction sufficient enough to withstand the use in the test until the time when the test piece comes to the specified whole elongation or permanent elongation.

(2)Dimension measuring device The device used for measuring the gauge length and test piece width shall be capable of measuring to the precision of  $\pm 0.01\text{mm}$  or finer.

(3)Extensometer Where extensometers are used for determining the gauge length and its change, they shall be class 1 specified in JIS B7741 or better in its range of use.



6. Test piece Test piece shall be as specified in JIS Z 2201 and as follows:

- (1) The test piece shall be obtained in accordance with the requirements of the relevant material standard or, if not specified therein, as agreed between the interested parties.
- (2) The shape of the piece shall be as specified in each relevant material standard. Unless otherwise specified, the test piece of any one of No.5, No.13A or No.13B specified in JIS Z 2201 shall be used, as a rule.
- (3) The change of width of the parallel-sided portion of the test piece (the maximum value-the minimum value) between the two gauge marks shall not be more than 0.1% of the mean width.
- (4) The test piece thickness shall be the full sheet thickness unless otherwise specified.
- (5) The surface of the test piece shall not be damaged by harmful defect likely to affect the test result such as scratches, etc.

7. Test The test procedure shall be as specified in JIS Z 2241 and as follows:

- (1) The test temperature shall be within a range of 10°C to 35°C and the test carried out under controlled conditions, if necessary, shall be made at a temperature of  $23 \pm 5^\circ\text{C}$ , provided the temperature specified in the material standard, if any, shall be applied.
- (2) In advance of adding strain to the test piece, the width of the test piece and the gauge length shall be measured at least to the nearest 0.01mm. When measuring the width, at least three points including the both ends and the middle point of the gauge length and the mean value of these measurements using automatic measuring machine, the one point measurement may be taken as the width of the test piece.
- (3) The gauge length and additional strain level shall be as specified in the relevant material standard, provided the agreement between the interested parties is applied, if any. Unless otherwise specified, table 1 applies.

In any material, the additional strain level shall not be more than the limit of uniform elongation of each material.

Table 1. Gauge length and additional strain level

| Shape of test piece | Gauge length(mm) | additional strain level(mm) |
|---------------------|------------------|-----------------------------|
| No.5                | 20.25.50         | 10 to 20                    |
| No.13A              | 50.80            | 10 to 20                    |
| No.13B              | 20.25.50         | 10 to 20                    |

Remarks 1. It is recommended that the gauge length of No.5 or No.13B test piece is 20mm or 25mm. However, if the gauge length of 50mm is used for the test piece of No.5 or No.13B, the measurement of the width of test piece shall be made within the range of uniform strain distribution and the difference between the plastic strain ratio obtained at the time of the gauge length of 20mm or 25mm shall not exceed 0.1.

2. Even in the lower limit of additional strain level shown in Table 1, for the materials exceeding the uniform elongation limit, the additional strain level shall be specified by the agreement between the interested parties.

- (4) A specified whole elongation or permanent elongation shall be given to a test piece. The test speed in this case shall be that the strain increasing rate shall not exceed 80% per minute in the parallel-sided portion of the test piece and be constant in the plastic region. If the test speed is specified in the relevant material standard, it shall apply.



- (5) After adding strain to the test piece, the length between the gauge marks or its increased length and the test piece width or its decreased length shall be measured at least to the nearest 0.01 mm. The measurement is carried out in general under the condition that the testing force is not applied but the measurement under the condition that the testing force is applied is allowed.
- (6) If the correct width cannot be measured by reason that the test piece to which strain was added shows any transverse bow, the test shall be invalid.
8. Calculation of test value
- (1) The plastic strain ratio shall be calculated using the formula (2) for practical use and rounded it off to the first decimal place. If the formula (3) or formula (4) is used for calculation, the plastic strain ratio shall be obtained down to the second decimal place. In any cases, the values shall be rounded off in accordance with JIS Z 8401.
- (2) The average plastic strain ratio shall be calculated by using the formula (3) and rounded it off to the first decimal place. The rounding off of the numerical values shall be in accordance with JIS Z 8401.
- (3) The degree of planar anisotropy shall be calculated by using the formula (4) and rounded it off to the first decimal place, the numerical values shall be in accordance with JIS Z 8401.
- (4) If there is any question about the test value obtained from automatic determination of the test piece width or the gauge length before and after adding the strain, the test method based on the manual determination shall be considered the reference test method.

#### Annex Natural oscillation method

1. Scope This Annex specifies the method for determining the plastic strain ratio of steel sheet or steel strip in coil excluding stainless steel, based on the natural oscillation method.
2. Definitions For the purpose of this Annex, the definitions given in JIS G 0202 and the following definition apply:

Average Young's modulus Weighted mean value obtained by the formula (1) using the Young's modulus measured by taking the test pieces in the directions parallel, 45° and 90° relative to the rolling direction of the sheet surface.

$$\bar{E} = \frac{E_0 + 2E_{45} + E_{90}}{4} \dots\dots\dots(1)$$

Where,  $E_0$  : Young's modulus measured taking the test piece in parallel to the rolling direction of the sheet surface. (N/mm<sup>2</sup>)

$E_{45}$  : Young's modulus measured taking the test piece at the angle of 45° to the rolling direction of the sheet surface. (N/mm<sup>2</sup>)

$E_{90}$  : Young's modulus measured taking the test piece at the angle of 90° to the rolling direction of the sheet surface. (N/mm<sup>2</sup>)

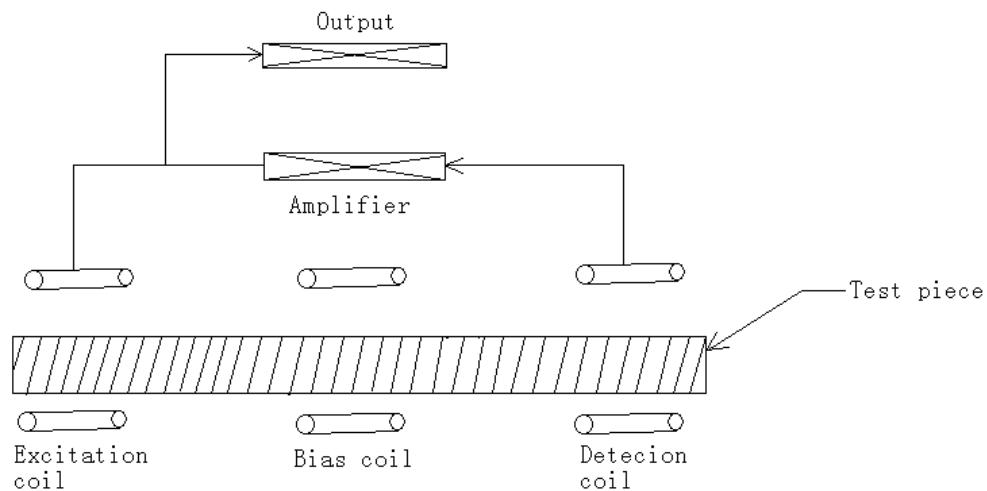


3.Principle of test The average Young's modulus is obtained at first by the resonance method of magnetostrictive vibration method and then, using the fact that this modulus is in a strong relation with the average plastic strain ratio obtained by the plastic strain method, the average plastic strain ratio is obtained indirectly from the regression formula which is obtained by statistic analysis.

Remarks: When based on the resonance method magnetostrictive vibration method, the object to be tested shall be the ferromagnetic material.

4.Test equipment The test equipment shall be constructed as shown in Annex Fig.1 as a rule and be capable of detecting the frequency with detection coil by adding the high frequency vibration to the test piece using the excitation coil.

Annex Fig.1 Diagram of construction of resonance frequency measuring equipment based on natural oscillation method.



5.Test piece test piece shall be as follows:

- (1) Sampling of test piece shall be as specified ,in each relevant material standard. Unless otherwise specified, the agreement between the interested parties applies.
- (2) The test piece specified for each measuring instrument shall be used. The tolerance on the dimension shall be  $\pm 0.025\text{mm}$ .

6. Test Test procedure shall be as follows:

- (1) Test temperature the test temperature shall be within a range of  $10^{\circ}\text{C}$  to



3°C and the test carried out under the controlled conditions, if necessary, shall be made at a temperature of  $23 \pm 5^\circ\text{C}$ .

(2) Measurement of test piece length The test piece length shall be measured to the nearest 0.025mm in precision. If the processing precision of the test piece is controlled sufficiently within a tolerance of  $\pm 0.025\text{mm}$ , the nominal length may be used.

(3) Measurement of resonance frequency of test piece The resonance frequency of the test piece taken in the direction of parallel,  $45^\circ$  to the rolling direction of the sheet surface shall be measured using the test equipment specified in 4 to the integer place.

7. Calculation of average plastic strain ratio The procedure of calculation shall be as follows:

(1) Young's modulus of the test piece taken in the direction of parallel,  $45^\circ$  and  $90^\circ$  to the rolling direction of the sheet surface shall be obtained by the formula (2)

$$E = 4\sigma l^2 f^2 \dots\dots\dots (2)$$

Where, E: Young's modulus. ( $\text{N/mm}^2$ )

$\sigma$ : bulk density ( $7.87\text{g/cm}^3$ )

l: length of test piece (mm)

f: resonance frequency (Hz)

(2) Average Young's modulus shall be calculated using the formula (1) and be rounded off to four places of effective digits, The rounding off of numerical values shall be in accordance with JIS Z 8401.

(3) Average plastic strain ratio shall be calculated by formula (3) using the average Young's modulus and rounded off down to the first decimal place. The rounding off of numerical values shall be in accordance with JIS Z 8401.

$$\bar{r} = \frac{101.44}{(145.0 \times \bar{E} \times 10^{-6} - 38.83)^2} - 0.564 \dots\dots\dots (3)$$

(4) If there is any question about the test value obtained by the natural oscillation method, the test method based on plastic strain method shall be considered the reference test method.

8. Calculation and correction of average plastic strain ratio by plastic strain method Obtain the calibration curve by using the average plastic strain ratio resulted from the plastic strain method and correct the average plastic strain ratio obtained by the natural oscillation method. If the difference between both values is within 0.1, the correction is unnecessary

