



Metallic Sheet, Mechanical Properties Testing

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. The tests described herein are used to determine properties required in product specifications or for failure analysis. Variation in testing methods are to be avoided by use of the stringent requirements to the allowable limits set forth in ISO standards. In some cases testing requirements may be unique or in conflict with these procedures, in those cases the requirements of the product specification will be followed.

1.2 Applicability. This standard covers procedures for mechanical testing of metallic sheet product. These flat or tubular sheet materials are typically aluminum and steel and are used in the manufacture of automotive bodies or components.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM E6	ISO 7438	ISO 10275	JSA JIS Z 2248
ASTM E8/8M	ISO 7500-1	ISO 17025	
ISO 377	ISO 9513	ISO/TS 16949	
ISO 6892-1	ISO 10113	JSA JIS Z 2241	

2.2 GM Standards/Specifications.

GMW2	GMW3399	GMW15192
GMW3032	GMW14400	

3 Resources

3.1 Facilities. The laboratory must be certified to ISO 17025 or approved to the latest version of ISO/TS 16949.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label. Calibration in accordance to ISO 7500-1 and ISO 9513 is required.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Tensile Testing. Test equipment must fulfill the requirements of ISO 6892-1. There are two types of loading systems, mechanical and hydraulic. These differ in the capabilities of the rate of load application. All modern screw and hydraulic machines permit step-less variation throughout the range of speeds.

3.2.1.1 Non-proportional test pieces are to be used for tensile testing all thicknesses of product governed by this test method.

3.2.1.2 The values in *Système International* (SI) units are to be used for all reporting. Values determined by conversion from English (inch-pound) units shall be reported as such.

3.2.1.3 Elongation values determined in English unit gage lengths (2 in) may be reported as SI unit gage lengths (50 mm) as applicable.

3.2.2 Bend Testing. Test equipment shall be in accordance with ISO 7438, and punch geometry shall be determined according to the respective material specification. Press hardened steels shall be tested according to procedures listed in GMW14400.

3.3 Test Vehicle/Test Piece. Steel sheet, aluminum sheet, and tubes manufactured from either sheet are to be tested according to procedures outlined in this document.

3.4 Test Time. Varies by supplier resources.

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Not applicable.

4 Procedure

4.1 Preparation.

4.1.1 Samples must have all oils, lubes, or dry films removed prior to measurement. Galvanized samples may have the zinc coating removed, and the measured sample condition (with coating, without coating, and/or assumed coating thickness) shall be reported.

4.1.2 Milling, water-jet cutting, or Electrical Discharge Machining (EDM) fabrication are the preferred methods of preparation. Laser fabrication shall be allowed for press hardened steel preparation. During milling care must be taken such that minimal cold work is imparted to the edges of the reduced section.

4.1.3 Samples shall be flat and free of defects such as scores, wrinkles, die marks, etc. One sample is needed for standard tensile test; sample orientation relative to the coil rolling direction is defined in the product specification.

4.2 Conditions.

4.2.1 Environmental Conditions. Conditions shall be defined appropriately by respective testing procedure specification.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.3 Instructions.

4.3.1 Bend Test. Unless otherwise stated in this test procedure, the procurement, preparation, sample dimensions and measurement of bend test samples should follow the requirements of:

- ISO 377 Steel and steel products - Location and preparation of samples and test pieces for mechanical testing. To avoid coil edge effects, samples shall be cut out at a minimum distance of 50 mm from edges.
- ISO 7438 Metallic Materials – Bend Test, and
- Procedures shall be in accordance with respective material specifications.

4.3.1.1 Bend Test Machine Operating Parameters. For bend testing the referenced crosshead control speed as defined in Table 1 shall be used.

Table 1: Crosshead Speeds

	Crosshead Control (mm/s)
Ramp	0.3

Bend testing of press hardened steel shall follow the requirements set in GMW14400.

4.3.2 Tensile Test. Unless otherwise stated in this test procedure the procurement, preparation, and measurement of test samples should follow the requirements of:

- ISO 377 Steel and steel products - Location and preparation of samples and test pieces for mechanical testing. To avoid coil edge effects, samples shall be cut out at a minimum distance of 50 mm from edges.
- ISO 6892-1 Metallic Materials – Tensile Testing Part 1: Method of test at room temperature.
- ISO 10113 Metallic Materials – Sheet and Strip – Determination of plastic strain ratio.
- ISO 10275 Metallic Materials – Sheet and Strip – Determination of tensile strain hardening exponent.

4.3.2.1 Procurement of Samples.

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Page 2 of 11



Documents

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4.3.2.1.1 For standard Plastic Strain Ratio (r -value) testing, one longitudinal 0° or one transverse 90° coupon is needed.

4.3.2.1.2 For Weighted Average Plastic Strain Ratio (r Bar) or Degree of Planar Anisotropy (Δr) testing, one longitudinal 0° , one diagonal 45° , and one transverse 90° sample are required. The r Bar and Δr are calculated from individual r -value tests.

4.3.2.1.3 Modul-R testing methods may be used for calculating r -values for process control of raw material. If this method is used, it must be specifically called out on the test report. In case of disagreements, the method specified herein shall be used.

4.3.2.1.4 Care shall be taken to insure that the samples be cut exactly at 0° , 45° , or 90° to the coil rolling direction.

4.3.2.2 Sample Type and Dimensions. The standard sheet type test specimen dimensions are given in Table 2, and the specimen drawing is shown in Figure 1. Subsize tensile specimens per ASTM E8/8M shall be allowed if sample size does not allow the use of standard size tensile bars. The following sample types and/or test pieces may be designated by the local operating unit for test results:

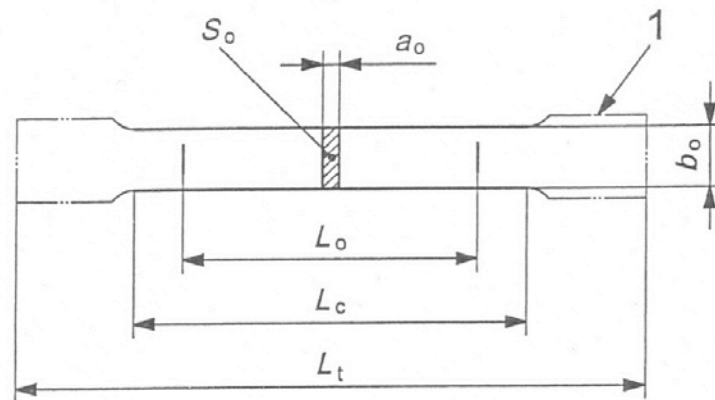
- **Type 1 (ISO I):** According to ISO 6892-1 Annex B, type 1 in Tables B1 and B2 (corresponds to ASTM E8/8M Figure 1 - Sheet Type Sample).
- **Type 2 (ISO II):** According to ISO 6892-1 Annex B, type 2 in Tables B1 and B2.
- **Type 3 (ISO III):** According to ISO 6892-1 Annex B, type 3 in Tables B1 and B2 (corresponds to Japanese Standards Association (JSA) JIS Z 2241 No. 5 specimen. JSA JIS Z 2248 standard sample preparation and dimensions are applicable instead of those specified by ISO 6892-1. All other aspects of GMW3335 must be followed to adhere to the requirements of GMWxxxxM-ST-S or GMWxxxxM-AL-S specifications (M = metal, ST = steel, S = sheet, AL = aluminum)).

Table 2: Test Specimen Dimensions

	Type 1 (ISO I = ASTM E8/8M- sheet type)	Type 2 (ISO II – typical in Europe)	Type 3 (ISO III – JIS Z2241 no. 5 sheet type)
Gauge length L_0	50 mm $\pm$ 0.10 mm	80 mm $\pm$ 0.10 mm.	50 mm $\pm$ 0.10 mm
Width b_0 ^{Note 1}	12.50 mm $\pm$ 0.25 mm	20 mm $\pm$ 0.25 mm	25 mm $\pm$ 0.25 mm
Parallel length L_c , minimum	57 mm	90 mm	60 mm

Note 1: For the three sizes of specimens, the ends of the parallel length section shall not differ in width by > 0.06 mm, 0.12 mm or 0.12 mm, respectively. Also, there may be a gradual decrease in width from the ends to the center, but the width at each end shall not be more than 1% larger than the width at the center.

Independent of preparation method, the roughness of edges on parallel length (R_z) shall be $R_z \leq 6.3 \mu\text{m}$.



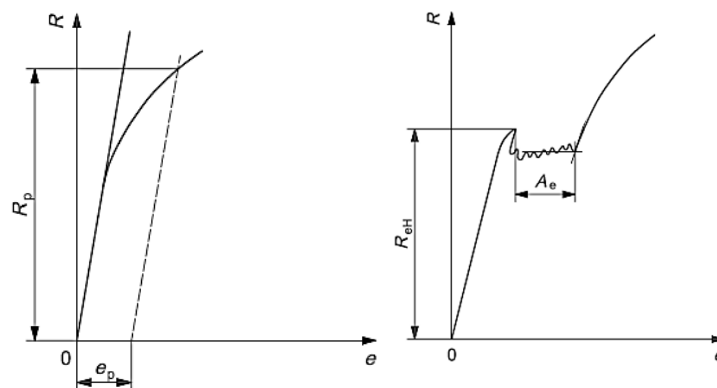
- a_o Original thickness of a flat test piece
 L_o Gauge length
 L_c Parallel length
 L_t Total length of test piece
 b_o Original width of the parallel length of a flat test piece
 S_o Original cross-sectional area of the parallel length

Figure 1: Test Specimen Diagram

All other dimensions and tolerances of ISO 6892-1 Annex B and ASTM E8/8M for non-proportional test pieces apply if not defined in GMW3335.

4.3.2.3 Tensile Test Machine Operating Parameters.

4.3.2.3.1 Test Speed. Ramp 1, as shown in Table 3, shall be used beyond yield strength (R_p , YS, or S_y —refer to Figure 2(a)) or beyond yield point elongation (A_e or YPE—refer to Figure 2(b)). Ramp 2, as shown in Table 3, shall be used subsequently.



(a) Yield strength (R_p or YS) at defined plastic extension (b) Yield point elongation (A_e or YPE)

(Refer to ISO 6892-1)		(Refer to ASTM E6 and ASTM E8/8M)	
e	percentage extension	e	strain
e_p	percentage of plastic extension		
R	stress	S	stress
R_{eH}	upper yield strength	UYS	upper yield strength
R_p	proof strength at plastic extension	YS, S_y	yield strength at an offset strain
A_e	yield point elongation	YPE	yield point elongation

Note: Figure symbols correspond to ISO 6892-1.

Figure 2: Definition of Yield Strength ($R_p/YS/S_y$) and Yield Point Elongation (A_e/YPE)

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