GM	WORLDWIDE ENGINEERING STANDARDS	Test Procedure	GMW18201

Standard Tensile Test Methods for Metallic Materials

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 purpose of this standard is to provide additional information regarding the testing and reporting of results for uniaxial tensile testing of metallic materials, as they pertain to material modeling requirements for use in finite element analysis.

1.2 Applicability. This standard applies to all metallic materials that will be used in finite element analysis, with the exception of metallic foil.

1.3 Remarks. International standards governing tensile testing provide requirements for testing of a single specimen. This standard provides additional details on how to test a collection of specimens for the purpose of calibrating mathematical material models in finite element analysis codes."

2 References

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

2.1 External Standards/Specifications.

ASTM B557/557M	ASTM E8/E8M	ISO 7500-1	ISO/IEC 17025
ASTM E83	ISO 6892-1	ISO 26203-2	

2.2 GM Standards/Specifications.

GMW3335

2.3 Additional References.

- General Motors Supply Power website (https://gmsupplypower.covisint.com/web/portal/home)

3 Resources

3.1 Facilities. All testing, as specified in this document, shall be performed in laboratories that are accredited to ISO/IEC 17025. Lab accreditation documentation shall be provided upon request. Choice of the test lab shall be approved by General Motors Materials Engineering.

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 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 Quasi-static Testing. Follow the requirements in ASTM E8/E8M, ASTM B557/557M, ISO 6892-1 and GMW3335 for specimen dimensions and uniaxial tensile testing machine specifications. Sheet-type specimens, as defined in ASTM E8 shall be used for thicknesses up to 4 mm; otherwise round specimens per ASTM E8 or ASTM B557 shall be used. Strain shall be measured with an extensometer per ASTM E83, Class B2 or better, laser measuring systems or high-speed photography based digital image correlation method (DIC). Strain measurement by the DIC method is preferred.

3.2.2 Intermediate Strain Rate Testing (Strain Rate in the Range 0.1/s to 500/s). Follow the requirements in ISO 26203-2 for specimen dimensions, uniaxial tensile testing machine specifications and force measurement. ASTM E8 small size round bar specimen is acceptable for fastener materials testing only. Strain shall be

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measured with an optical extensometer, laser measuring systems or DIC. Strain measurement by the DIC method is preferred.

3.2.3 Digital Image Correlation Equipment. A stereo DIC system is required for specimen surface deformation and strain measurement. The system shall consist of two cameras, a tripod or a similar mounting structure to support the cameras in the required location, a data acquisition box for image capture and data logging, and an image capture and data processing software. Additional lighting may be needed to provide enough contrast for image capture and to prevent motion blur that can occur with a shorter exposure time during testing at rates 50/s and higher.

The cameras used for quasi-static testing shall have a minimum framing rate of 20 images/s with the lens size of 35 mm or 70 mm.

The cameras used for high strain rate testing (strain rate between 0.1/s and 500/s) shall have a minimum framing rate of 20 000 images/s or a framing rate that can produce at least 30 images to 50 images at the nominal strain rate of 500/s without the loss of resolution (i.e., with the entire gage length of the specimen captured in the image). At least 10 images are required in the linear region of the stress-strain curves for modulus determination.

A universal serial bus (USB) analog data acquisition system with a minimum of 4 channels is required to record the load data corresponding to each image taken by the cameras.

Image capture, and the post-processing of the image data to compute deformation and strain, shall be performed with the same commercially available software according to the instructions provided by the software supplier. The DIC system shall be calibrated before each test session (or any repositioning of the test/optical equipment) according to the instructions provided by the DIC software supplier.

If the DIC system has the capability of the variable image sampling rate, then the number of images generated by the variable sampling rate shall be 1000 to 2000 for strain rates < 0.1/s and 200 to 1000 for strain rates 0.1/s to 500/s. For DIC systems using a constant image sampling rate, the recommended sampling rate for each nominal strain rate is given in Table 1. Any deviations from the recommended rates shall be reviewed and approved by General Motors before testing.

Table 1: Recommended DIC Sampling Rates

Target Strain Rate	Suggested DIC frames per second
0.002/s	2
0.1/s	250
1.0/s	1500
100/s	50 000
500/s	120 000

3.3 Test Vehicle/Test Piece. Parts to be characterized, if needed, shall contain sufficient volume of material to provide standard test specimens per ASTM E8/E8M, ASTM B557/B557M or ISO 6892-1 standards.

3.4 Test Time. The total coordination and test time are dependent on the type of testing and the number of specimens tested and shall not exceed 15 days for quasi-static testing or 30 days for high strain rate testing.

3.5 Test Required Information. For specimens cut from production parts the following shall be provided: part name and number, alloy, heat treatment, location in part, part production or pre-production phase and, if applicable, manufacturing line.

3.6 Personnel/Skills. Test personnel shall be fully trained in the execution of test procedures described in test methods cited in Section 2. Additionally, test personnel shall be fully trained on the DIC methodology and the specific DIC software used during testing.

4 Procedure

4.1 Preparation. Specimen preparation shall be conducted as specified in GMW3335. For quasi-static tests at unbaked condition, the specimens shall be cut in 0°, 45° and 90° orientation with respect to the rolling/extrusion

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direction of the material. For paint baking tests, as described in 4.1.1, and intermediate speed tests, as described in 4.3.2, the specimens shall be cut in 0° orientation with respect to the rolling/extrusion direction of the material.

4.1.1 Paint Baking. For materials exhibiting bake hardening, test specimens shall be cut and prepared according to GMW3335 first. Specimens shall be pre-strained at the following strain levels:

- 0%
- 2%
- 5%
- 10%

In case the uniform elongation of the material is < 10%, a maximum pre-strain level close to the uniform elongation shall be selected and reported.

Specimens shall then be treated in an oil bath. Recommended oil for the bath is Xiameter 100 CST Silicone. Oil bath shall be heated to 170 °C and allowed to stabilize for 5 minutes. After the oil temperature has been stabilized, the specimens shall be submerged in the oil and the oil temperature shall be allowed to stabilize at 170 °C again. After the specimens have been in the oil bath for 20 minutes the specimens shall be removed from the oil bath and left on an absorbent surface to cool down to the room temperature (23 °C ± 2 °C). Once cooled, the specimens shall be cleaned with Hexane and water before they can be used for testing.

Specimens cut from parts shall not be subject to paint baking.

4.1.2 DIC Specimens. Specimens tested using the DIC method shall have a black-and-white contrast pattern applied to the surface facing the cameras, after the surface preparation according to GMW3335. It is recommended that the specimen is first painted with a thin, uniform, white flat paint layer across the gauge area. Black paint dots shall then be applied on the top of the white paint layer such that no single black dot exceeds 25% of the pixel subset size chosen for DIC post-processing. Paint chosen shall adhere to the specimen until the completion of the test without affecting the specimen properties.

4.2 Conditions.

4.2.1 Environmental Conditions. Environmental test conditions as specified in ASTM E8/E8M, ASTM B557/B557M or ISO 6892-1 shall be applied.

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 Number of Test Specimens The tests shall be performed in 5 replicates for each specimen orientation, strain rate, pre-strain level and bake condition (if applicable).

4.3.2 Test Speed. The test speed shall be determined based on the specimen size and equipment used to achieve the following nominal strain rates that are constant in the gage section of the specimen (refer to ASTM E8 and ISO 26203-2 for more details):

- 0.002/s (quasi-static)
- 0.1/s
- 1.0/s
- 100/s
- 500/s

For materials exhibiting bake hardening, the specimens at all pre-strain levels defined in 4.1.1 shall be tested at 0.002/s only. Unbaked specimens shall be tested at all strain rates.

Any deviation from the requirements for the strain rate, orientation, or number of tests shall be agreed upon by General Motors before testing.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Not applicable.

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