



Standard Test Methods for High Strain Rate Physical Testing of Injection Molded Thermoplastics for use in Finite Element Analysis

1 Scope

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. To capture the effects of strain rate on thermoplastics using these test methods so that simulations can accurately reflect these behaviors. In a material strained at automotive crash rates, the onset of yielding and failure can be very different than if it were strained at quasi-static rates typically used in test labs and in material supplier data sheets. Finite element analysis using material models defined from the test data obtained via the methods described herein are used to simulate and therefore predict the mechanical deformation and failure of thermoplastics across a range of strain rates and temperatures.

1.2 Foreword. General Motors effectively uses high strain rate test data to describe and successfully predict the results of crash events.

These methods provide a way to obtain high strain rate physical properties of unreinforced and reinforced injection molded thermoplastics for the purpose of calibrating mathematical material models in finite element analysis codes. The material models specifically targeted in this standard are used in the analysis of automotive crash events. The rates of material straining are those typically associated with crash events. Materials that exhibit significantly different material properties in the mold filling flow direction from the mold filling cross-flow direction will require that data be generated in both directions.

1.3 Applicability. The data obtained shall be used to generate material models for finite element analysis of injection molded thermoplastics undergoing automotive crash events.

2 References

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

2.1 External Standards/Specifications.

ASTM D789	ISO 960
ISO 294-1	ISO 2818
ISO 527-1	ISO 8256

2.2 GM Standards/Specifications.

GMW16652

3 Resources

3.1 Facilities. A suitable test laboratory with temperature and humidity control where needed.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

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.

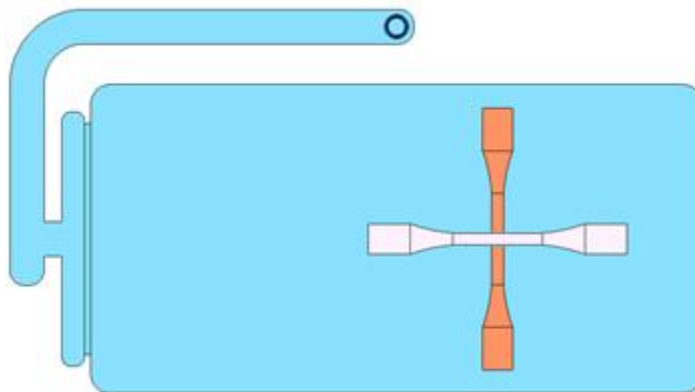
3.1.3 Injection Molding Machine.

3.1.3.1 Tools. Injection molding machine mold to make plaques.

3.1.3.1.1 For fiber reinforced thermoplastics, the mold shall generate plaques that are (3.00 ± 0.02) mm in thickness, (101 ± 2) mm (or 4 inches) or more in width, and (204 ± 2) mm (or 8 inches) or more in length. The plaque shall be gated, with an edge gate across the entire width of mold (see Figure 1).

3.1.3.1.2 Plaque Sample, Gating and Test Sample Locations, Test Bar.

Figure 1: Schematic Diagram of a Plaque Showing the Location for Specimen Extraction



3.1.3.1.3 For unreinforced thermoplastics, the mold shall generate plaques that are of sufficient size cut tensile specimens without edge effects or mold filling effects.

3.1.4 Tensile Testing Machines.

3.1.4.1 Tensile Testing Machines for the Quasi-static Strain Rate only. See ISO 527-1 for apparatus description.

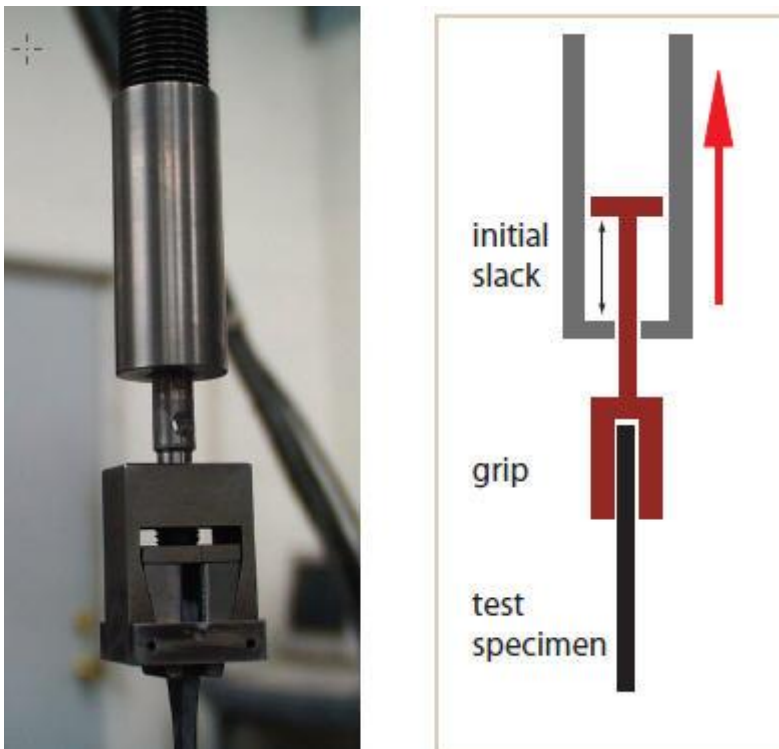
3.1.4.2 Tensile Testing Machine for Straining Rates between 1/s and 100/s. This tensile test system is typically a custom built or specialized instrument manufactured by a major manufacturer of servo-hydraulic test instruments. The physical test instrument is required to maintain reasonable speed control of specimen grips at grip travel rates of (10 to 5000) mm/s. The system must have grip travel equal to or exceeding 250 mm to accommodate specimen straining and to accommodate the use of slack grip systems. The moving grip system must have sufficient to successfully impact the specimen grips and initiate straining without a significant reduction in rate of straining. This is accomplished with a hydraulic piston ≥ 45 mm in diameter (see Figure 2).

Figure 2: Tensile Testing Machine for Straining Rates between 1/s and 100/s



3.1.4.2.1 Tensile Testing Machine for Straining Rates between 1/s and 100/s Slack Gripping System. The gripping system must provide sufficient slack or free movement of the actuator to allow the actuator to achieve the desired velocity prior to engaging the specimen gripper and straining the specimen (see Figure 3).

Figure 3: Slack Gripping System for Straining Rates between 1/s and 100/s



3.1.4.2.2 Tensile Testing Machine for Straining Rates between 1/s and 100/s Force Measuring System. Load shall be measured with a complete load measuring system that exhibits a resonant frequency response > 4 kHz. This is typically accomplished using a piezoelectric force transducer mounted near the gripping system.

3.1.5 Devices for Measuring Width and Thickness of the Test Specimen. See Apparatus according to ISO 527-1.

3.1.5.1 Test Chamber for Elevated and Low Temperatures. The chamber's internal volume shall be sufficient to house the hardware and specimens scheduled for testing as well as permit freedom to mount and remove items in the chamber. Test specimens must be tested at the defined temperature. Specimens may not be removed from an environmental test chamber and placed in a test instrument at a different test temperature.

3.1.5.2 Axial and Transverse Strain Measuring Devices. There are two basic approaches acceptable for measuring straining in the test specimen. Method A, which is preferred, uses a full field imaging technique to locate the high local strain point in the gage section of the test specimen and provides strain data specific to this high local strain point (this is often referred to as "local" strain measurement). Method B, which is more traditional, uses clip-on strain extensometers at the quasi-static strain rate, or Laser tag systems, fiber optic light systems or image correlation systems to determine average strain based on the set distance between pre-set gage marks. In all cases, direct strain measurement shall be used. The use of crosshead position to determine strain in the specimen is not acceptable. Transverse strain measurement is only required for the quasi-static tests. For high strength, low elongation materials, Method A and Method B will likely yield similar results. For medium strength, high elongation materials that exhibit necking, Method A and Method B will likely yield very different results.