



Designation: E292 – 24

Standard Test Methods for Conducting Time-for-Rupture Notch Tension Tests of Materials¹

This standard is issued under the fixed designation E292; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 These test methods cover the determination of the time for rupture of notched specimens under conditions of constant force and temperature. These test methods also includes the essential requirements for testing equipment.

1.2 The values stated in inch-pound units are to be regarded as the standard. The units in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

A453/A453M Specification for High-Temperature Bolting, with Expansion Coefficients Comparable to Austenitic Stainless Steels

E4 Practices for Force Calibration and Verification of Testing Machines

E6 Terminology Relating to Methods of Mechanical Testing
E8/E8M Test Methods for Tension Testing of Metallic Materials

E139 Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E220 Test Method for Calibration of Thermocouples By Comparison Techniques

E344 Terminology Relating to Thermometry and Hydrometry

E633 Guide for Use of Thermocouples in Elevated-Temperature Mechanical Testing

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E1012 Practice for Verification of Testing Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application

3. Terminology

3.1 *Definitions*—The definitions of terms common to mechanical testing that appear in Terminology **E6** shall apply to the terms used in these test methods. These terms include calibration, eccentricity, elongation, error, gauge length, reduced section, reduction of area, residual stress, testing machine, and verification. In addition, some important terms from Terminology **E6** are repeated below.

3.1.1 *indicated temperature, n* —the temperature indicated by the temperature-measuring system that meets the requirements of this standard.

3.1.2 *specified temperature, n* —the test temperature requested by and reported to the customer.

3.2 The terms base metal thermocouple, extension wire, measuring junction, noble metal thermocouple, thermocouple, and thermoelement are used as defined in Terminology **E344**.

4. Significance and Use

4.1 Rupture life of notched specimens is an indication of the ability of a material to deform locally without cracking under multi-axial stress conditions, thereby redistributing stresses around a stress concentrator.

4.2 The time-for-rupture notch tension test is used principally as a qualitative tool in comparing the suitability of materials for designs that will contain deliberate or accidental stress concentrators.

¹ These test methods are under the jurisdiction of ASTM Committee **E28** on Mechanical Testing and is the direct responsibility of Subcommittee **E28.04** on Uniaxial Testing.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

5. Apparatus

5.1 Testing Machine:

5.1.1 The force-measuring system of the testing machine shall conform to the requirements of Practices **E4**.

5.1.2 The rupture strength of notched or smooth specimens may be reduced by bending stresses produced by eccentricity of loading. The magnitude of the effect of a given amount of eccentricity of loading will increase with decreasing ductility of the material and, other things being equal, will be larger for notch than for smooth specimens. Eccentricity of loading can arise from a number of sources associated with misalignments between mating components of the loading train including the specimen. The eccentricity of loading will vary depending on how the components of the loading train are assembled with respect to each other and with respect to the attachments to the testing machine. Thus, the bending stress at a given force can vary from test to test, and this variation may result in a substantial contribution to the scatter in rupture strength **(1, 2)**.³

5.1.3 Zero eccentricity of loading cannot be consistently achieved. However, acceptably low values may be consistently achieved by proper design, machining, and assembly of all components of the loading train including the specimen. Gripping devices that will isolate the applied force from misalignments associated with the testing machine may also be used. For cylindrical specimens, precision-machined loading train components employing either buttonhead, pin, or threaded grips connected to the testing machine through precision-machined ball seat loading yokes have been shown to provide very low bending stresses when used with commercial creep testing machines **(3)**. However, it should be emphasized that threaded connections may deteriorate when used at sufficiently high temperatures and lose their original capability for providing satisfactory alignment.

5.1.4 Whatever method of gripping is employed, the testing machine and loading train components when new should be capable of loading a verification specimen at room temperature as described in **7.2** so that the maximum bending strain is 10 % or less at the lowest anticipated test force in the time-for-rupture notch tension test. It is recognized that this measurement will not necessarily represent the performance in the time-for-rupture notch tension test, but it is designed to provide a practical means of evaluating a given testing machine and its associated loading train components. Generally, the eccentricity of loading at elevated temperatures will be reduced by the higher compliance, lower modulus of various mating parts as compared with the alignment verification test at room temperature. However, it should be recognized that depending on the test conditions, the fits between mating parts may deteriorate with time and that furnace seals if not properly installed could cause lateral forces to be applied to the pull rods. In either case, misalignments may be increased relative to the values measured at room temperature for new equipment. Axiality requirements and alignment verifications may be omitted when testing performed is for acceptance of material to minimum strength requirements. As discussed in **5.1.2**, excessive bending

would result in reduced strength or conservative results. In this light, should acceptance tests pass minimum requirements, there would be little benefit to reducing eccentricity of loading. However, if excessive bending resulted in high rejection rates, economics would probably favor reducing eccentricity of loading.

5.1.4.1 Test Method **E1012** or equivalent shall be used for the measurement and calculation of percent bending for cylindrical or flat specimens.

5.1.4.2 This requirement is intended to limit the maximum contribution of the testing apparatus to the bending that occurs during a test. It is recognized that even with qualified apparatus different tests may have quite different percent bending strain due to chance orientation of a loosely fitted specimen, lack of symmetry of that particular specimen, lateral force from furnace packing and thermocouples, etc.

5.1.5 The testing machine should incorporate means of taking up the extension of the specimen so that the test force will be maintained within the limits specified in **5.1.1**. The extension of the specimen should not allow the loading system to introduce eccentricity of loading in excess of the limits specified in **5.1.4**. The take-up mechanism should avoid introducing shock forces or torques to the specimen, and overloading due to friction, or inertia in the loading system.

5.1.6 The testing machine should be erected to secure reasonable freedom from vibration and shock due to external causes. Precautions should be made to minimize the transmission of shock to neighboring test machines when a specimen fractures.

5.1.7 For high-temperature testing of materials that are readily attacked by their environment (such as oxidation of metal in air), the sample may be enclosed in a capsule so that it can be tested in a vacuum or inert gas atmosphere. When such equipment is used, the necessary corrections to obtain and maintain accurate test forces shall be made. For instance, compensation shall be made for differences in pressures inside and outside of the capsule and for any test force variation due to sealing ring friction, bellows, or other load train features.

5.2 Heating Apparatus:

5.2.1 The apparatus for and method of heating the specimens should provide the temperature control necessary to satisfy the requirements specified in **5.3.1** without manual adjustment more frequent than once in each 24 h period after application of force.

5.2.2 Heating shall be by an electric resistance or radiation furnace with the specimen in air at atmospheric pressure unless other media are specifically agreed upon in advance.

NOTE 1—The medium in which the specimens are tested can have a considerable effect on the results of tests. This is particularly true when the properties are influenced by oxidation or corrosion during the test.

5.3 Temperature Control:

5.3.1 Indicated temperature variations along the reduced section and notch(es) on the specimen should not exceed the following limits initially and for the duration of the test:

Up to and including 1800 °F (980 °C)	± 3 °F (1.7 °C)
Above 1800 °F (980 °C)	± 5 °F (2.8 °C)

5.3.1.1 Guide **E633** or equivalent shall be used for the thermocouple preparation and use.

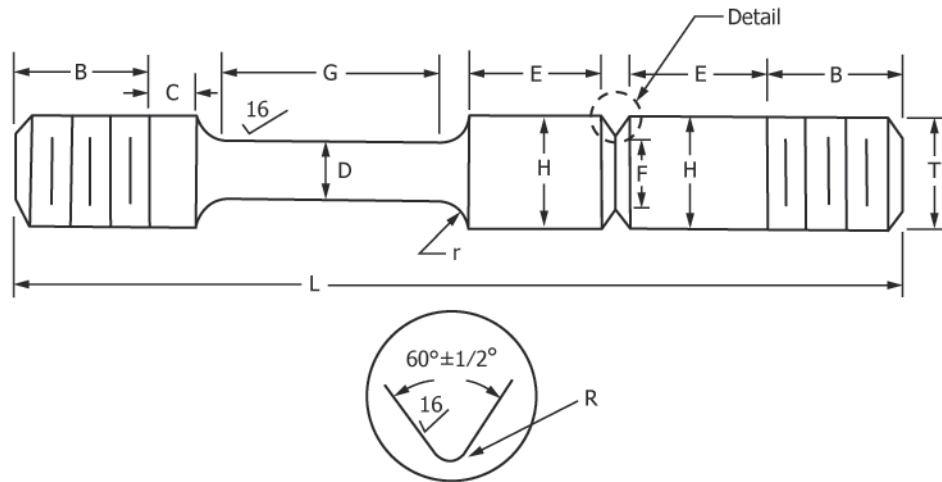
³ The numbers in boldface type refer to the list of references at the end of this standard.

5.3.2 The indicated temperature should be measured and recorded at least once each working day. Manual indicated temperature readings may be omitted on non-working days provided the period between reading does not exceed 48 h. Automatic recording capable of ensuring the above indicated temperature limits at the notch(es) may be substituted for manual readings provided the record is read on the next working day.

5.3.3 For a notch-only specimen, a minimum of one thermocouple at or near the notch (either notch for a flat specimen) shall be used. For a combination specimen with smooth and

notched section such as Fig. 1, in addition to the one thermocouple required at or near the notch, one or more thermocouples in the unnotched gauge section shall be used. If the gauge length of the unnotched section is 1 in. (25.4 mm) or less, a minimum of one additional thermocouple shall be placed at the center of the gauge length. If the gauge length of the unnotched section is greater than 1 in. (25.4 mm), at least two additional thermocouples shall be placed at or near the fillets.

5.3.3.1 If thermal gradients are suspected to be greater than the limits given in 5.3.1, additional thermocouples should be



	Specimen 1		Specimen 2		Specimen 3		Specimen 4		Specimen 5		Specimen 6	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
D- Gauge Diameter	0.125±0.001	3.18±0.012	0.150±0.001	3.81±0.012	0.160±0.001	4.06±0.012	0.178±0.001	4.52±0.012	0.252±0.001	6.4±0.025	0.357±0.001	9.07±0.025
G-Gauge Length	0.50±0.05	12.7±1.3	0.60±0.05	15.2±1.3	0.65±0.05	16.5±1.3	0.75±0.05	19.05±1.3	1.0±0.05	25.4±1.3	1.5±0.05	38.1±1.3
R- Notch Root Radius	0.0035±0.0005	0.09±0.01	0.004±0.0005	0.10±0.01	0.0045±0.0005	0.11±0.01	0.005±0.0005	0.13±0.01	0.0075±0.0005	0.19±0.01	0.010±0.0005	0.25±0.01
E-Shoulder length (approx)	¼	6.4	⅝	8.0	⅝	8.0	¾	9.5	½	12.7	¾	19.0
H-Shoulder diameter (Major)	0.177±0.003	4.5±0.08	0.212±0.003	5.4±0.08	0.226±0.003	5.7±0.08	0.250±0.003	6.4±0.08	0.375±0.003	9.5±0.08	0.500±0.003	12.7±0.08
r-Fillet Radius	⅜	2.4	⅜	2.4	⅜	2.4	⅝	3.2	⅜	4.7	¼	6.4
K _t -Stress concentration factor	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9

NOTE 1—Surfaces marked 16, finish to 16 μ in., rms or better.

NOTE 2—The difference between dimensions F and D shall not exceed 0.001 in. (0.025 mm).

NOTE 3—Taper the gauge length, G, to the center so that the gauge diameter, D, at the end of the gauge length exceeds the gauge diameter at the center of the gauge length by no less than 0.0005 in. (0.01 mm) nor more than 0.0015 in. (0.04 mm).

NOTE 4—All sections shall be concentric about the specimen axis within 0.001 in. (0.025 mm).

NOTE 5—Threads, T, may be any convenient size, but root diameter must be greater than F. Some brittle materials may require root diameter equal to or greater than H.

NOTE 6—Dimensions L and B are not specified, but B shall be equal to or greater than T.

NOTE 7—Shoulder length, C, shall be ⅝ in. (3.2 mm) min.

NOTE 8—Stress concentration factor, K_t, (see Ref (4)).

FIG. 1 Standard Cylindrical Combination Specimens