Designation: E 132 – ~~97~~04

Standard Test Method for Poisson's Ratio at Room Temperature[1]

This standard is issued under the fixed designation E 132; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the determination of Poisson's ratio from tension tests of structural materials at room temperature. This test method is limited to specimens of rectangular section and to materials in which and stresses at which creep is negligible compared to the strain produced immediately upon loading.

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

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 and health practices and determine the applicability of regulatory limitations prior to use.*

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[1] This test method is under the jurisdiction of ASTM Committee E-28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.03 on Elastic Properties and Definitions on Mechanical Testing.

Current edition approved ~~Apr. 10, 1997.~~ April 1, 2004. Published ~~November 1997.~~ April 2004. Originally ~~published as E 132 – 58 T.~~ approved in 1958. Last previous edition ~~E 132 – 86 (1992).~~ approved in 1997 as E 132 – 97.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

E 4 Practices for Force Verification of Testing Machines

E 8 Test 6 Terminology Relating to Methods for Tension Testing of Metallic Materials[2] Mechanical Testing

E 83 Practice 8 Test Methods for Verification and Classification Tension Testing of Extensometers[2] Metallic Materials

E 111 Test Method 83 Practice for Young's Modulus, Tangent Modulus, Verification and Chord Modulus[2] Classification of Extensometers

E 111 Test Method for Young's Modulus, Tangent Modulus, and Chord Modulus

E 1012 Practice for Verification of Specimen Alignment Under Tensile Loading

3. Terminology

3.1 *Definitions:*

3.1.1 *Poisson's ratio*—the absolute value negative of the ratio of transverse strain to the corresponding axial strain resulting from uniformly distributed an axial stress below the proportional limit of the material.

3.1.2 *Discussion*—Above the proportional limit, the ratio of transverse strain to axial strain will depend on the average stress and on the stress range for which it is measured and, hence, should not be regarded as Poisson's ratio. If this ratio is reported, nevertheless, as a value of "Poisson's ratio" for stresses beyond the proportional limit, the range of stress should be stated.

3.1.3 *Discussion*—Poisson's ratio will have more than one value if the material is not isotropic. Deviations from isotropy should be suspected if the Poisson's ratio, μ, determined by the method described below differs significantly from that determined when the ratio *E/G* of Young's modulus, *E,* to shear modulus, *G,* is substituted in the following equation:

$$\mu = (E/2G) - 1 \tag{1}$$

where *E* and *G* must be measured with greater precision than the precision desired in the measurement of μ.

4. Significance and Use

4.1 When uniaxial force is applied to a solid, it deforms in the direction of the applied force, but also expands or contracts laterally depending on whether the force is tensile or compressive. If the solid is homogeneous and isotropic, and the material remains elastic under the action of the applied force, the lateral strain bears a constant relationship to the axial strain. This constant, called Poisson's ratio, after a French scientist that developed the concept, is a definite an instrinsic material property just like Young's modulus and Shear modulus.

4.2 Poisson's ratio is used for design of structures where all dimensional changes resulting from application of force need to be taken into account, and in the application of the generalized theory of elasticity to structural analysis.

4.3 In this test method, the value of Poisson's ratio is obtained from strains resulting from uniaxial stress only.

5. General Considerations

5.1 The accuracy of the determination of Poisson's ratio is usually limited by the accuracy of the transverse strain measurements because the percentage errors in these measurements are usually greater than in the axial strain measurements. Since a ratio rather than an absolute quantity is measured, it is only necessary to know accurately the relative value of the calibration factors of the extensometers. Also, in general, the values of the applied loads forces need not be accurately known. It is frequently expedient to make the determination of Poisson's ratio concurrently with determinations of Young's modulus and the proportional limit.

6. Apparatus

6.1 *Load*—LoadsForces—Forces shall be applied either by calibrated verified dead weights or in a testing machine that has been calibrated in accordance with Practices E 4.

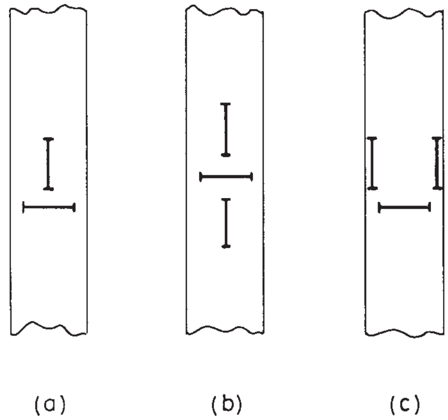
6.2 *Extensometers*—Class B-1 extensometers or better, as described in Practice E 83, shall be used except as otherwise provided in the product specifications.

NOTE 1—If exceptions are provided in the product specification so that extensometers of types other than those covered in Practice E 83 are used, it may be necessary to apply corrections, for example, the correction for the transverse sensitivity[3] of bonded resistance gages.

6.2.1 It is recommended that at least two pairs of extensometers be used—one pair for measuring axial strain and the other for transverse strain, with the extensometers of each pair parallel to each other and on opposite sides of the specimen. Additional extensometers may be used to check on alignment or to obtain better average strains in the case of unavoidable variations in thickness. The extensometers should be placed on the specimen with a free distance of at least one specimen width between any extensometer and the nearest fillet, and at least two specimen widths between any extensometer and the nearest grip.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards*, Vol 03.01. volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Perry, C. C., and Lissner, H. R., *The Strain Gage Primer,* McGraw-Hill Book Co., New York, NY, 1955, pp. 141–146.



NOTE 1—Each symbol indicates the location of a pair of extensometers on opposite sides of the specimen.

FIG. 1 Three Possible Arrangements of Extensometers

NOTE 2—Three possible arrangements of extensometers, among the many that have been used, are shown in Fig. 1. Arrangement (a), Fig. 1, which requires only two pairs of extensometers, can be used if the conditions are very nearly ideal with respect to axiality of ~~load~~ applied force and constancy of cross-section within the length in which the extensometers are placed. An additional pair of extensometers is used in arrangement (b) to provide some compensation for the effect of a uniform variation in thickness in the axial direction. The other arrangement of three pairs of extensometers, arrangement (c), provides a check on alignment.

6.3 *Alignment Devices*—Grips and other devices for obtaining and maintaining axial alignment are shown in Test Methods E 8.

7. Test Specimens

7.1 *Selection and Preparation of Specimens*~~—In the selection~~—Select and ~~preparation of~~ prepare test ~~specimens, special care shall be taken to assure obtaining representative~~ specimens that are straight and uniform in thickness and representative of the material being tested.

7.2 *Dimensions*~~—In general, it is~~—The recommended specimen configuration has a tested length of ~~the portion of the specimen that is of constant width be~~ at least five times the tested width, and ~~that the~~ a length ~~of the specimen~~ between the grips ~~be~~ of at least seven times the tested width. The tested width itself ~~should be~~ is at least equal to the tested thickness. ~~If fillets are used near the ends~~ The radius of the ~~specimen as in the~~ fillets of a standard rectangular ~~tension test~~ specimen ~~(see Figs. 6 and Figs. 7 of Methods E 8), these fillets should have a radius~~ is not less than the minimum width of the specimen. The width shall be constant ~~throughout~~ over the entire length ~~over which~~ where the extensometers are placed and for an additional distance at each end ~~and~~ equal to at least this width, unless otherwise provided in the product specifications.

7.3 *Stress Relief*—This test method is intended to produce intrinsic materials properties. Therefore, the specimen needs to be free of residual stresses, which may require ~~a heat treatment to relieve the stresses in the material. The heat treatment procedure consists of~~ an annealing ~~the specimen~~ procedure at $T_m/3$ for 30 min (T_m is the melting point of the material in ~~°K). The procedure must be mentioned in~~ K). If the ~~report section. However, if the~~ intent of the test is to verify the performance of a product, the heat treatment procedure may be omitted. ~~This must be mentioned explicitly~~ Record the condition of the material tested, including any heat treatment, in the ~~report section.~~ test report.

8. Procedure

8.1 *Measurement of Specimens*—All surfaces on the rectangular specimen shall be flat. Opposite surfaces across the width and thickness shall be parallel within 0.001 in. (0.025 mm) and 0.0001 in. (0.0025 mm) respectively. Specimen thickness shall be measured to within 0.001 in. (0.025 mm) and width shall be measured to within 0.0001 in. (0.0025 mm) at three locations and an average determined.

NOTE 3—For thin sheet, a survey of thickness variation by more sensitive devices, such as a pneumatic or electric gage, may be needed to determine thickness~~es~~ with the required accuracy.

8.2 *Alignment*—Procedures for verifying the alignment are described in detail in Practice E 1012. The allowable ~~percentage~~ bending as defined in Practice E 1012 ~~should~~ shall not exceed ~~5.~~

~~8.3 Make~~ 5 %.

8.3 Record simultaneous measurements of ~~load~~ applied force and ~~strain and record the data.~~ strain.

8.4 *Speed of Testing*—The speed of testing shall be low enough to make ~~negligible~~ the thermal effects of adiabatic expansion or contraction~~, a~~ negligible, yet high enough to make creep negligible. In ~~loading~~ applying forces with dead weights, avoid temporary overloading due to inertia of the weights.

8.5 *Applied ~~Loads~~ Forces*—The applied ~~loads~~ forces shall correspond to stresses that are within the linear portion of the stress-strain curve, that is, less than the proportional limit. The precision of the value of Poisson's ratio obtained will depend on the number of data pair of longitudinal and transverse strain taken (see Fig. 2).

8.6 *Strain Readings*—Read all extensometers at the same~~ load.~~ applied force.

8.7 *Temperature*—Record the temperature. Avoid changes in temperature during the test.

9. Evaluation of Data

9.1 ~~T~~Plot the average longitudinal strain, ϵ_l, indicated by the longitudinal extensometers and the average transverse strain, ϵ_t, indicated by the transverse extensometers~~, are plotted~~ against the applied~~ load,~~ force, *P*, as shown in Fig. 2.~~ A~~ Draw a straight line ~~is drawn~~ through each set of points, and determine the slopes, $d\epsilon_l/dP$, and $d\epsilon_t/dP$, of these~~ lines are determined.~~ lines. Calculate Poisson's ratio~~ is then calculated~~ as follows:

$$\mu = (d\epsilon_t/dP)/(d\epsilon_l/dP) \tag{2}$$

9.2 The errors~~ which may be~~ introduced by drawing a straight line through the points can be reduced by applying the method of least squares.[4, 5, 6] The value of Poisson's ratio thus obtained should coincide with that obtained for a single large~~ load~~ force increment~~ for~~ between stresses below the proportional limit.

NOTE 4—For the method of least squares, random variations in the data are considered as variations in strain. In determining the stress range~~ (load~~ (force range) for which data should be used in the calculations, it is helpful to examine the data using the strain deviation method described in Test Method E 111. Due to possible small offsets at zero~~ load~~ applied force and small variations in establishing the load path in the specimen during the first small increment of~~ loading,~~ force application, the readings at zero~~ load~~ applied force and the first small increment of~~ load~~ force application are typically not included in the calculations, and the line is not constrained to pass through zero.

10. Report

10.1 Report the following information:

10.1.1 *Specimen Material*~~—Describe the specimen~~—Specimen material, alloy, heat treatment, mill batch number, grain direction, and~~ so forth, as applicable.~~ other relevant material information.

10.1.2 *Specimen Configuration*~~—Include a sketch~~—Sketch of the specimen configuration or reference to the specimen drawing.

10.1.3 *Specimen Dimensions*~~—State the actual~~—Actual measured dimensions for~~ each~~ the specimen.

10.1.4 *Test Fixture*—Descri~~be~~ption of the test fixture or reference to fixture drawings.

10.1.5 *Testing Machine and Extensometers*~~—Include the make,~~— Manufacturer, model, serial number, and~~ load~~ force range of the testing machine and the extensometers.

10.1.6 *Speed of Testing*~~—Record the test~~—Test rate and mode of control.

10.1.7 *Temperature*~~—Record the~~—Test temperature.

10.1.8 *Stress-Strain Diagram*~~—Include the stress-strain~~—Stress-strain diagram showing both longitudinal and transverse strain with scales, specimen number, test data, rate, and other pertinent information.

10.1.9 *Poisson's Ratio*~~—Report~~—Value and method to determine the value in accordance with Section 9.

11. Precision and Bias

11.1 Elastic properties such as Poisson's ratio, shear modulus and Young's modulus are not determined routinely and are

[4] Youden, W. J., *Statistical Methods for Chemicals,* John Wiley and Sons, Inc., New York, NY, Chapter 5, 1951, pp. 40–49.

[5] Natrella, M. G., "Experimental Statistics," *National Bureau of Standards Handbook 91,* U.S. Dept. of Commerce, Chapter 5.

[6] Bowker, A. H., and Lieberman, G. J., *Engineering Statistics,* Prentice-Hall, Inc., Englewood Cliffs, NJ, 1959, Chapter 9.

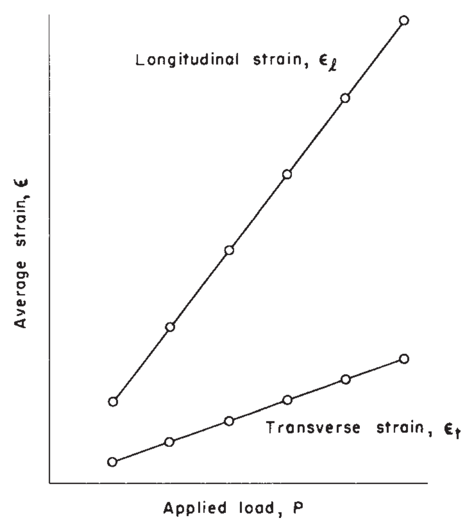


FIG. 2 Plot of Average Strains *versus* ~~Loa~~Applied Force for Determination of Poisson's Ratio

generally not specified in materials specifications. Precision and bias statements for this test method are therefore not available.

12. Keywords

12.1 axial strain; longitudinal strain; Poisson's ratio; stress-strain diagram; transverse strain