Designation: E21 – 20

Standard Test Methods for
Elevated Temperature Tension Tests of Metallic Materials[1]

This standard is issued under the fixed designation E21; 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 U.S. Department of Defense.

1. Scope*

1.1 These test methods cover procedure and equipment for the determination of tensile strength, yield strength, elongation, and reduction of area of metallic materials at elevated temperatures.

1.2 Determination of modulus of elasticity and proportional limit are not included.

1.3 Tension tests under conditions of rapid heating or rapid strain rates are not included.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *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.*

1.6 *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]

E4 Practices for Force Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing
E8/E8M Test Methods for Tension Testing of Metallic Materials
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E74 Practices for Calibration and Verification for Force-Measuring Instruments
E83 Practice for Verification and Classification of Extensometer Systems
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E220 Test Method for Calibration of Thermocouples By Comparison Techniques
E633 Guide for Use of Thermocouples in Creep and Stress-Rupture Testing to 1800°F (1000°C) in Air
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 Definitions of terms relating to tension testing which appear in Terminology E6, apply to this test method. These terms include alignment, axial strain, bending strain, gauge length, elongation, elongation after fracture, extensometer system, necking, reduction of area, tensile strength, yield strength. In addition, the definitions of the following terms relating to tension testing are included.

3.1.1 Definitions of terms relating to tension testing which appear in E6, shall apply to the terms used in this test method.

3.2 *Definitions:*

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

3.2.2 *specified temperature*—the test temperature requested by and reported to the customer.

3.2.3 *temperature-measuring system, n*—a system consisting of one or more temperature-measuring transducers with the appropriate indicating instruments, extension wires, reference junctions or ice points, and data acquisition devices.

3.2.3.1 *Discussion*— The temperature-measuring transducer is usually a thermocouple.

3.2.3.2 *Discussion*—The use of the term measuring system conforms to the definition of "measuring system" in the JCGM: International Vocabulary of Metrology – Basic and General Concepts and Associated terms (VIM).

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

Current edition approved Sept. 1, 2020. Published October 2020. Originally approved in 1933. Last previous edition approved in 2017 as E21 – 17ε1. DOI: 10.1520/E0021-20.

[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* 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

4. Significance and Use

4.1 The elevated-temperature tension test gives a useful estimate of the ability of metals to withstand the application of applied tensile forces. Using established and conventional relationships it can be used to give some indication of probable behavior under other simple states of stress, such as compression, shear, etc. The ductility values give a comparative measure of the capacity of different materials to deform locally without cracking and thus to accommodate a local stress concentration or overstress; however, quantitative relationships between tensile ductility and the effect of stress concentrations at elevated temperature are not universally valid. A similar comparative relationship exists between tensile ductility and strain-controlled, low-cycle fatigue life under simple states of stress. The results of these tension tests can be considered as only a questionable comparative measure of the strength and ductility for service times of many hours. Therefore, the principal usefulness of the elevated-temperature tension test is to assure that the tested material is similar to reference material when other measures such as chemical composition and microstructure also show the two materials are similar.

5. Apparatus

5.1 *Testing Machine:*

5.1.1 The accuracy of the testing machine shall be within the permissible variation specified in Practices E4.

5.1.2 Precaution should be taken to assure that the force on the specimens is applied as axially as possible. Perfect axial alignment is difficult to obtain especially when the pull rods and extensometer rods pass through packing at the ends of the furnace. However, the machine and grips should be capable of loading a precisely made specimen so that the maximum bending strain does not exceed 10 % of the axial strain, when the calculations are based on strain readings taken at zero force and at the lowest force for which the machine is being qualified.

NOTE 1—This requirement is intended to limit the maximum contribution of the testing apparatus to the bending which 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 thermocouple wire, etc. The scant evidence available at this time[3] indicates that the effect of bending strain on test results is not sufficient, except in special cases, to require the measurement of this quantity on each specimen tested.

5.1.2.1 In testing of brittle material even a bending strain of 10 % may result in lower strength than would be obtained with improved axiality. In these cases, measurements of bending strain on the specimen to be tested may be specifically requested and the permissible magnitude limited to a smaller value.

5.1.2.2 In general, equipment is not available for determining maximum bending strain at elevated temperatures. The testing apparatus may be qualified by measurements of axiality made at room temperature using the assembled machine, pull rods, and grips used in elevated temperature testing. The specimen form should be the same as that used during the elevated-temperature tests and designed so that only elastic strains occur throughout the reduced section. This requirement may necessitate use of a material different from that used during the elevated-temperature test. See Practice E1012 for recommended methods for determining specimen alignment.

5.1.2.3 Gripping devices and pull rods may oxidize, warp, and creep with repeated use at elevated temperatures. Increased bending stresses may result. Therefore, grips and pull rods should be periodically retested for axiality and reworked when necessary.

5.1.3 The testing machine shall be equipped with a means of measuring and controlling either the strain rate or the rate of crosshead motion or both to meet the requirements in 9.6.

5.1.4 For elevated-temperature testing of materials that are readily attacked by their environment (such as oxidation of metal in air), the specimen 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 must be made to determine the actual forces seen by the specimen. For instance, compensation must be made for differences in pressures inside and outside of the capsule and for any variation in the forces applied to the specimen due to sealing ring friction, bellows or other 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 9.4.

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 2—The media in which the specimens are tested may 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-measuring system:*

5.3.1 The method of temperature measurement must be sufficiently sensitive and reliable to ensure that the indicated temperature of the specimen is within the limits specified in 9.4.4.

5.3.2 Temperature should be measured with thermocouples as part of an appropriate temperature measuring system.

NOTE 3—Such measurements are subject to two types of error. Thermocouple calibration and instrument measuring errors initially introduce uncertainty as to the exact temperature. Secondly both thermocouples and measuring instruments may be subject to variation with time. Common errors encountered in the use of thermocouples to measure temperatures include: calibration error, drift in calibration due to contamination or deterioration with use, lead-wire error, error arising from method of attachment to the specimen, direct radiation of heat to the bead, heat-conduction along thermocouple wires, etc.

5.3.3 If temperature measurements are made using thermocouples, those thermocouples shall be calibrated using Practice E220. Representative thermocouples should be calibrated from each lot of wires used for making base-metal thermocouples. Except for relatively low temperatures of exposure, base-metal thermocouples are subject to error upon reuse, unless the depth of immersion and temperature gradients

[3] Subcommittee E28.10 on Effect of Elevated Temperature on Properties requests factual information on the effect of nonaxiality of loading on test results.

of the initial exposure are reproduced. Consequently base-metal thermocouples should be verified by the use of representative thermocouples and actual thermocouples used to measure specimen temperatures should not be verified at elevated temperatures. Base-metal thermocouples also shall not be reused without clipping back to remove wire exposed to the hot zone and rewelding or creating a new compression junction.

5.3.3.1 Noble metal thermocouples are also subject to errors due to contamination, etc., and should be periodically annealed and verified. Thermocouples should be kept clean prior to exposure and during use at elevated temperatures.

5.3.3.2 Measurement of the emf drift in thermocouples during use is difficult. When drift is a problem during tests, a method should be devised to check the readings of the thermocouples on the specimen during the test. For reliable calibration of thermocouples after use the temperature gradient of the testing furnace must be reproduced during the recalibration.

5.3.4 The temperature-measuring system, shall be verified yearly against a secondary standard, such as a precision potentiometer and if necessary re-calibrated. Extension-wire error should be checked with the extension wires in place as they normally are used.

5.4 *Extensometer System:*

5.4.1 Practice E83, is recommended as a guide for selecting the required sensitivity and accuracy of extensometers. For determination of offset yield strength at 0.1 % or greater, a Class B-2 extensometer may be used. The extensometer should meet the requirements of Practice E83 and should, in addition, be tested to assure its accuracy when used in conjunction with a furnace at elevated temperature. One such test is to measure at elevated temperature the stress and strain in the elastic range of a metal of known modulus of elasticity. Combinations of stress and temperature which will result in creep of the specimen during the extensometer system evaluation should be avoided.

NOTE 4—If an extensometer of Class B-2 or better is attached to the reduced section, the slope of the stress-strain curve will usually be within 10 % of the modulus of elasticity.

5.4.2 Non-axiality of loading is usually sufficient to cause significant errors at small strains when strain is measured on only one side of the specimen.[4] Therefore, the extensometer should be attached to and indicate strain on opposite sides of the specimen. The reported strain should be the average of the strains on the two sides, either a mechanical or electrical average internal to the instrument or a numerical average of two separate readings.

5.4.3 When feasible the extensometer should be attached directly to the reduced section. When necessary, other arrangements (discussed in 9.6.3) may be used by prior agreement of the parties concerned. For example, special arrangements may be necessary in testing brittle materials where failure is apt to be initiated at an extensometer knife edge.

5.4.4 To attach the extensometer to miniature specimens may be impractical. In this case, separation of the specimen holders or crossheads may be recorded and used to determine strains corresponding to the 0.2 % offset yield strength. The value so obtained is of inferior accuracy and must be clearly marked as "approximate yield strength." The observed extension should be adjusted by the procedure described in 9.6.3 and 10.1.3.

5.4.5 The extensometer system shall include a means of determining strain rate.

5.5 *Room-Temperature Control*—Unless the extensometer is known to be insensitive to ambient temperature changes, the range of ambient temperature should not exceed 10 °F (6 °C) while the extensometer is attached. The testing machine should not be exposed to perceptibly varying drafts.

6. Sampling

6.1 Unless otherwise specified the following sampling procedures shall be followed:

6.1.1 Samples of the material to provide test specimens shall be taken from such locations as to be representative of the lot from which it was taken.

6.1.2 Samples shall be taken from material in the final condition (temper). One test shall be made on each lot.

6.1.3 A lot shall consist of all material from the same heat, nominal size, and condition (temper).

7. Test Specimens and Sample

7.1 The size and shape of the test specimens should be based primarily on the requirements necessary to obtain representative samples of the material being investigated.

7.2 Unless otherwise specified, test specimens shall be oriented such that the axis of the specimen is parallel to the direction of fabrication, and located as follows:

7.2.1 At the center for products 1.5 in. (38 mm) or less in thickness, diameter, or distance between flats.

7.2.2 Midway from the center to the surface for products over 1.5 in. (38 mm) in thickness, diameter, or distance between flats.

7.3 Specimen configurations described in Test Methods E8/E8M, are generally suitable for tests at elevated temperatures; however, tighter dimensional tolerances are recommended in 7.6. The particular specimen used should be mainly governed by the requirements specified in 7.1. When the dimensions of the material permit, except for sheet and strip, the gauge length of the specimens should have a circular cross section. The largest diameter specimen consistent with that described in 7.1 should be used, except that the diameter need not be greater than 0.500 in. (12.7 mm). The ratio of gauge length to diameter should be 4, as for the standard specimens described in Test Methods E8/E8M. If different ratios are used, the specifics should be reported in the results. (See 11.1.4)

NOTE 5—Specimen size in itself has little effect on tensile properties provided the material is not subject to appreciable surface corrosion, lack of soundness, or orientation effects. A small number of grains in the specimen cross section, or preferred orientation of grains due to fabrication conditions, can have a pronounced effect on the test results. When corrosion is a factor in testing, the results do become a function of

[4] Tishler, D. N., and Wells, C. H., "An Improved High-Temperature Extensometer ," *Materials Research and Standards* , American Society for Testing and Materials, MTRSA, Vol 6, No. 1, January 1966, pp. 20–22.

specimen size. Likewise, surface preparation of specimens, if affecting results, becomes more important as the specimen size is reduced.

7.4 Specimens of circular cross section should have threaded, shouldered, or other suitable ends for gripping which will meet the requirements of 5.1.2.

NOTE 6—Satisfactory axial alignment may be obtained with precisely machined threaded ends. But at temperatures where oxidation and creep are readily apparent, precisely fitted threads are difficult to maintain and to separate after test. Practical considerations require the use of relatively loose-fitting threads. Other gripping methods have been successfully used.[5,6]

7.5 For rectangular specimens some modifications of the standard specimens described in Test Methods E8/E8M are usually necessary to permit application of the force to the specimen in the furnace with the axiality specified in 5.1.2. If the material available is sufficient, the use of elongated shoulder ends to permit gripping outside the furnace is the easiest method. When the length of the specimen is necessarily restricted, several methods of gripping may be used as follows:

7.5.1 A device that applies the force through a cylindrical pin in each of the enlarged ends of the specimen. The pin holes should be accurately centered on extensions of the centerline of the gauge section. Grips of this type can provide good axiality of loading.[5]

7.5.2 High-temperature sheet grips similar to those illustrated in Test Methods E8/E8M and described as self-adjusting grips. These have proven satisfactory for testing sheet materials that cannot be tested satisfactorily in the usual type of wedge grips.

7.5.3 Extension tabs may be welded or brazed to the specimen shoulders and extended to grips outside the furnace. When these are used, care must be exercised to maintain coaxiality of the centerlines of the extensions and the gauge length. Any brazing or welding should be done in a jig or fixture to maintain accurate alignment of the parts. Any machining should be done after brazing or welding.

7.5.4 Grips that conform to and apply force against the fillets at the ends of the reduced section.

7.6 The diameter (or width) at the ends of the reduced section should not be less than the diameter (or width) at the center of the reduced section. It may be desirable to have the diameter (or width) of the reduced section slightly smaller at the center than at the ends. This difference should not exceed 0.5 % of the diameter (or width). When specimens of this form are used to test brittle materials, failure may regularly occur at the fillets. In these cases, the center of the reduced section may be made smaller by a gradual taper from the ends and the exception to the requirements above noted in the report. (See 11.1.4 and 11.1.10.) Specimen surfaces shall be smooth and free from undercuts and scratches. Cold work introduced through machining or handling can produce high residual stresses or other undesired effects and should be minimized. The axis of the reduced section should be straight within ±0.5 % of the diameter. Threads of the specimen should be concentric with this axis within the same tolerance. Other means of gripping should have comparable tolerances.

7.7 For cast-to-size specimens it may not be possible to adhere to the diameter, straightness, and concentricity limitations of 7.6, but every effort should be made to approach these as closely as possible. If the specimen does not meet the requirements specified in 7.6, the report should so state (see 11.1.4 and 11.1.10). The magnitude of the deviations should be reported (see 11.1.10.)

8. Calibration and Standardization

8.1 The following devices should be calibrated against standards traced to the National Institute of Standards and Technology. Applicable ASTM methods are listed beside the device.

Force-measuring system	E4 and E74
Extensometer	E83
Thermocouples[A]	E220
Potentiometers	
Micrometers	

[A] Melting point methods are also recommended for thermocouple calibration.

8.1.1 Axiality of the loading apparatus should be measured as described in 5.1.2.

8.2 Calibrations should be as frequent as is necessary to assure that the errors in all tests do not exceed the permissible variations listed in this test method. The maximum period between calibrations of the testing machine shall be one year. Instruments in either constant or nearly constant use should be calibrated more frequently; those used only occasionally should be calibrated before each use.

9. Procedure

9.1 *Measurement of Cross-Sectional Area*—Determine the minimum cross-sectional area of the reduced section as specified in 7.2 of Test Methods E8/E8M. In addition measure the largest diameter (or width) in the reduced section and compare with the minimum value to determine whether the requirements of 7.6 are satisfied.

9.2 *Measurement of Original Length:*

9.2.1 Unless otherwise specified, base all values for elongation on a gauge length equal to four diameters in the case of round specimens and four times the width in the case of rectangular specimens, the gauge length being punched or scribed on the reduced section.

NOTE 7—Elongation values of specimens with rectangular cross sections cannot be compared unless all dimensions including the thickness are equal. Therefore, an elongation specification should include the specimen cross-sectional dimensions as well as the gauge length. Using a gauge length equal to 4.5 times the square root of the cross-sectional area compensates somewhat for variations in specimen thickness but even this does not result in the same value of elongation when specimens of the

[5] Schmieder, A. K.," Measuring the Apparatus Contributions to Bending in Tension Specimens ," *Elevated Temperature Testing Problem Areas*, ASTM STP 488, American Society for Testing and Materials, 1971, pp. 15–42

[6] Penny, R. K., Ellison, E. G., and Webster, G. A.,"Specimen Alignment and Strain Measurement in Axial Creep Tests," *Materials Research and Standards*, American Society for Testing and Materials, MTRSA, Vol 6, No. 2, February 1966, pp. 76–84.

same material are machined to different thicknesses and tested.[7]

9.2.2 When testing metals of limited ductility gauge marks punched or scribed on the reduced section may be undesirable because fracture may occur at the stress concentrations so caused. Then, place gauge marks on the shoulders or measure the over-all length of the specimen. Also measure the adjusted length of the reduced section to the nearest 0.01 in. (0.2 mm) as described in 9.2.3. If a gauge length, other than that specified in 9.2.1 is employed to measure elongation, describe the gauge length in the records (see 11.2.1). In the case of acceptance tests, any deviation from 9.2.1 must be agreed upon before testing.

NOTE 8—The availability of flexible ceramic fiber cords for mounting of high temperature extensometers with high purity ceramic rods with chisel or vee-chisel ends, provides a good measure of ductility without excessive damage to the gauge section caused by other types of extensometers or traditional punch or scribe marks. Damage to the rods from specimen failure may be minimized through the use of spring loaded attachment fixtures. Non contact extensometers may also be used for this purpose.

9.2.3 When the extensometer is to be attached to the specimen shoulders, measure the adjusted length of the reduced section between points on the two fillets where the diameter (or width) is 1.05 times the diameter (or width) of the reduced section. The strain rate and offset yield calculations are based on this dimension (see 9.6.3, 10.1.2, and 10.3).

NOTE 9—In the yield region, stress is approximately proportional to offset strain to a power which usually lies in the range from zero to 0.20. For specimens of circular cross section the above value of adjusted length of the reduced section was found by calculation to give an error in yield stress of less than ½ % within this range of exponents and for fillet radii ranging from 0.5 to 1 times the diameter of the reduced section. The method of calculation was similar to that used by Thomas and Carlson.[8]

9.3 *Cleaning Specimen*—Wash carefully the reduced section and those parts of the specimen which contact the grips in clean alcohol, acetone, or other suitable solvent that will not affect the metal being tested.

9.4 *Temperature Control:*

9.4.1 Form the thermocouple measuring junction in accordance with Guide E633.

9.4.2 In attaching thermocouples to a specimen, the measuring junction shall be kept in intimate contact with the specimen and shielded from radiation. Shielding may be omitted if, for a particular furnace and specified temperature, the difference in indicated temperature from an unshielded measuring junction and a measuring junction inserted in a hole in the specimen has been shown to be less than one half the variation listed in 9.4.4. The measuring junction should be as small as possible and there should be no shorting of the circuit (such as could occur from twisted wires behind the measuring junction but not in intimate contact with the specimen). Ceramic insulators should be used on the thermocouples in the hot zone. If some other electrical insulation material is used in the hot zone, it should be determined that the electrical insulating properties are maintained at higher temperatures.

9.4.3 When the length of the reduced section is less than 2 in. (50 mm), attach at least two thermocouples to the specimen, one near each end of the reduced section. For reduced sections greater-than or equal to 2.0 in. (50 mm) add a third thermocouple near the center of the reduced section.

9.4.4 For the portion of the test from the first application of force through the yield strength determination, the difference between the indicated temperature from any thermocouple and the specified temperature shall not exceed the following limits (see 11.1.5).

Specified temperatures up to and including 1800 °F (980 °C)	±5 °F (±3 °C)
Specified temperatures greater than 1800 °F (980 °C)	±10 °F (±6 °C)

9.4.4.1 The temperature limits of 9.4.4 should be maintained as long as practical after the determination of yield. After yield strength determination, the difference between the indicated temperature and the specified temperature may exceed the limits specified in 9.4.4. The indicated temperature at the maximum deviation and the reason for the deviation shall be reported. More restrictive requirements may be placed on the temperature control during the test if agreed to by the laboratory and the customer.

NOTE 10—Deformation of the test specimen can change the indicated temperature for many reasons that are difficult for the laboratory to control. Internal (adiabatic) heating due to plastic working can raise the temperature of the test specimen. Elongation of the test specimen, for example from necking, can carry the thermocouples outside the hot zone of the furnace. Reduction of the diameter of the test specimen due to plastic deformation can cause thermocouples to lose intimate contact with the test specimen.

9.4.5 The term "indicated temperature" means the temperature that is indicated by the temperature measuring device using good quality pyrometric practice.

NOTE 11—It is recognized that true temperature may vary more than the indicated temperature. The permissible indicated temperature variations in 9.4.4 are not to be construed as minimizing the importance of good pyrometric practice and precise temperature control. All laboratories should keep both indicated and true temperature variations as small as practicable. It is well recognized, in view of the extreme dependency of strength of materials on temperature, that close temperature control is necessary. The limits prescribed represent ranges which are common practice.

9.4.6 Indicated temperature overshoots during heating shall not exceed the above limits, unless agreed upon by the customer and the supplier. The heating characteristics of the furnace and the temperature control system should be studied to determine the power input, temperature set point, proportioning control adjustment, and control-thermocouple placement necessary to limit transient temperature overshoots. It may be desirable to stabilize the furnace at an indicated temperature from 10 to 50 °F (6 to 28 °C) below the specified temperature before making the final adjustments. The magnitude and duration of all temperature overshoots shall be reported. (See 11.1.5.)

9.4.7 The time of holding at indicated temperature prior to the start of the test should be governed by the time necessary to ensure that the specimen has reached equilibrium and that the indicated temperature can be maintained within the limits

[7] Stickley, G. W., and Brownhill, D. J., "Elongation and Yield Strength of Aluminum Alloys as Related to Gage Length and Offset," *Proceedings*, American Society for Testing and Materials, ASTEA, Vol 65, 1965, pp 597–616.

[8] Thomas, J. M., and Carlson, J. F., "Errors in Deformation Measurements for Elevated Temperature Tension Tests," *ASTM Bulletin*, ASTM, May 1955, pp. 47–51.

specified in 9.4.4. Unless otherwise specified this time should not be less than 20 min. The time to attain specified temperature and the time at specified temperature before testing shall be maintained in the records (see 11.2.7.)

9.5 *Connecting Specimen to the Machine*—Take care not to introduce nonaxial forces while installing the specimen. For example, threaded connections should not be turned to the end of the threads or "bottomed." If threads are loosely fitted, lightly apply force to the specimen string and manually move it in the transverse direction until the force drops to its minimum value before testing. If packing is used to seal the furnace, it must not be so tight that the extensometer arms or pull rods are displaced or their movement restricted.

9.6 *Strain Measurement and Strain Rate:*

9.6.1 During yield strength determination, maintain the strain rate in the reduced parallel section of the test specimen at 0.005 ± 0.002 in./in./min (mm/mm/min). After yield strength determination, increase the rate of crosshead motion to 0.05 ± 0.01 times the length of the reduced parallel section (A) of any of the specimen configurations described in Test Methods E8/E8M per minute. The speed of testing (strain rate or crosshead speed) shall be maintained in the records (see 11.2.4).

NOTE 12—The tensile properties of material tested at elevated temperature are, in general, affected by the rate of deformation. It is therefore important that this rate be controlled.

9.6.1.1 In cases where it is desired to establish the entire engineering stress strain curve of a specimen, the speed of testing may be maintained at 0.005 ±0.002 in./in./min (mm/mm/min) throughout the entire test

NOTE 13—Maintaining the strain rate in 9.6.1 may require the use of a suitable extensometer system that has a calibrated range to record the entire test and will not be damaged by the failure. Caution is advised since control problems can occur if an extensometer slips or behaves in an unexpected manner.

9.6.1.2 If it has been established that the crosshead speed remains constant within the tolerance above, the extensometer and strain rate indicator may be used to set a strain rate of 0.05 ± 0.01 in./in./min (mm/mm/min) after yield strength determination. To protect it from damage, the sensing element of the extensometer may be removed before maximum force is reached.

NOTE 14—Even with constant crosshead speed, the strain rate in the specimen may still vary. Before maximum force it will be less than the nominal rate due to the elasticity of the machine and grips and the progressive elongation of the specimen. After maximum force it will be greater than the nominal rate due to nonuniform strain during necking. Available experimental evidence does not justify the added complexity of maintaining a constant strain rate throughout the post-yield stages of a tension test.

9.6.2 When yield strength determination is not required, an extensometer need not be used. The rate of crosshead motion shall be maintained at 0.05 ± 0.01 times the adjusted length of the reduced parallel section, per minute throughout the test.

9.6.3 When yield strength determinations are required, observations of force and extension during loading and through yield are necessary. The following three means of making these observations are acceptable:

9.6.3.1 For specimens of normal size and ductility, attach an extensometer to the reduced section.

9.6.3.2 When metals of limited ductility are tested attach the extensometer to the specimen shoulders.

9.6.3.3 For miniature specimens, measure coupling or crosshead separation to determine an approximate yield strength.

9.6.4 When the extensometer is attached to the reduced section, a strain rate indicator or controller shall be used to maintain a rate of 0.005 ± 0.002 in./in./min (mm/mm/min) through the yielding range except within the elastic range where smaller strain rates are permissible.

NOTE 15—With conventional testing machines, the strain rate often cannot be controlled closely if the material yields in a relatively sudden manner. In such cases the speed control should be preset to the rate which experience shows will result in the specified strain rate at the force corresponding to the yield stress. This will usually be at a strain rate which will result from a rate of crosshead motion of 0.005 times the adjusted length of the reduced section, per minute.

9.6.5 When the extensometer is attached to the specimen shoulders, use the adjusted length of the reduced section to calculate the setting of the strain-rate indicator or pacer during yielding. Otherwise the procedure is the same as that described above.

9.6.6 When the stock size requires use of specimens less than 0.25 in. (6.4 mm) in diameter, the approximate 0.2 percent offset yield strength may be determined from a record of coupling or crosshead separation. In order to adjust for the extension which occurs outside the reduced section, two specimens must be tested, one with the standard reduced section and the other, a shortened specimen, with similar grip ends and shoulders but without fillets and reduced section. The latter need only be tested to the force level required to yield the former (see 10.1.3).

9.6.7 To allow for the elastic strain in the machine parts, pull rods and grips, set the rate of crosshead motion during yielding at or slightly higher than the upper limit of the recommended range, that is 0.007 times the adjusted length of the reduced section per minute. At strains exceeding that corresponding to the yield strength of the material being tested, apply the method of 9.6.2.

9.7 *Recording Maximum Force*—If an autographic recorder of force and extension is used, continue the recording of force after the sensing element of the extensometer is removed. In any case observe the maximum force and record manually. (See 11.2.3.)

9.8 *Measurements of Specimen After Test:*

9.8.1 For measuring elongation, fit the ends of the fractured specimen together carefully and measure the distance between gauge marks or the over-all length to the nearest 0.01 in. (0.3 mm) at room temperature.

9.8.2 If any part of the fracture surface extends beyond the middle half of the reduced section, the elongation value obtained may not be representative of the material. In the case of an acceptance test, if the elongation meets the minimum requirements specified, no further testing is required; but if the elongation is less than the specified minimum the test may be discarded and a retest made.

9.8.3 For measuring reduction of area of specimens of circular cross section, fit the ends of the fractured specimen together carefully and measure the minimum diameter to the nearest 0.01 in. (0.3 mm) at room temperature. If the fracture cross section is not round, make sufficient measurements to establish the cross-sectional area at fracture. If the fracture occurs at a fillet or gauge mark the reduction of area may not be representative of the material. In the case of an acceptance test, if the reduction of area meets the specified minimum, no further testing is required, but if the reduction of area is less than the specified minimum the test may be discarded and a retest made.

10. Calculations

10.1 *Yield Strength:*

10.1.1 Unless otherwise specified determine the yield strength reported at an offset of 0.2 % as described in Test Methods E8/E8M.

NOTE 16—The accurate measurement of proportional limit and offset yield strength of 0.02 % or less is extremely difficult at elevated temperatures. Even though the extensometer has the required accuracy and sensitivity during room-temperature calibration, this is not assurance that the strain measurements during the elevated-temperature tension test will have equal accuracy. High temperature at the attachment points and extensometer rods passing through the furnace packing will probably reduce the accuracy significantly. Therefore, the determination of proportional limit and offset yield strength of 0.02 % or less is not recommended.

10.1.2 If the extensometer must be attached to the specimen shoulders, base the offset extension (inches or millimeters) on the adjusted length of the reduced section, that is, 0.002 times the adjusted length of the reduced section for 0.2 percent offset yield strength and corresponding values for other yield strengths.

10.1.3 If coupling or crosshead separation are recorded adjust the observed extension in the following two steps. First, to compensate for machine elasticity, grip distortion and shoulder strain, reduce values for the standard specimen by the values for the shortened specimen (9.6.6) at corresponding applied forces. Second, treat this adjusted strain datum by the method of 10.1.2. Report only yield strengths with offsets of 0.2 % or more and label these "approximate yield strength" (see 11.1.7.1 – 11.1.7.3.)

10.2 *Tensile Strength*—Calculate the tensile strength by dividing the maximum force, during a test carried to fracture, by the original minimum cross-sectional area of the reduced section.

10.3 *Elongation:*

10.3.1 When the gauge length is marked on the reduced section having a nominally uniform cross-sectional area, the elongation is equal to the gauge length after fracture minus the original gauge length, the difference expressed as a percentage of the original gauge length. If the gauge length includes fillets, shoulders, threads, etc., the change in gauge length is expressed as a percentage of the adjusted length of the reduced section.

10.3.2 A method that can sometimes be used when there is autographic recording of strain up to the moment of fracture, is to read the elongation as strain offset from the initial, linear, loading line. This can be useful in the case of materials of very low ductility. Since these values are usually lower than those measured from the broken specimen, the method of measurement shall be stated with the results (see 11.1.7.5.)

10.4 *Reduction of Area*—Reduction of area is equal to the minimum cross-sectional area of the reduced section before testing minus the minimum cross-sectional area of the reduced section after testing, the difference expressed as a percentage of the area before testing. Reduction of area is reported only for specimens of circular cross section (see 11.1.7.6.)

10.5 *Rounding*—Unless otherwise specified, for purposes of determining compliance with specified limits, observed or calculated values shall be rounded as indicated below, in accordance with the Rounding Method of Practice E29 as follows:

Quantity Measured	Rounded Unit for Observed or Calculated Value
Tensile or Yield Strength	Nearest 500 psi (3.5 MPa)
Elongation or Reduction of Area	Nearest 0.5 %

11. Report and Records

11.1 The following information shall be included in the report, unless otherwise agreed upon between the customer and supplier:

11.1.1 Reference to the standard used (ASTM E21)

11.1.2 Specimen identification.

11.1.3 Material identification (for example alloy, temper, heat treatment(s), product form and thickness or diameter).

11.1.4 Specimen type (for example round, rectangular, full cross section) and specimen reference (for example specimen drawing, Test Methods E8/E8M).

11.1.5 Specified temperature and the magnitude and duration of all temperature overshoots discussed in 9.4.4 and 9.4.6.

11.1.6 Speed of testing if different than that required in the material specification or that specified in 9.6.1.

11.1.7 Elevated temperature properties that are specified by the material specification. These typically include, but are not limited to yield strength, tensile strength, elongation and reduction of area.

11.1.7.1 Yield strength and the method of calculation (for example 0.2 % offset yield strength, 0.02 % offset yield strength, upper yield strength, see Test Methods E8/E8M; approximate yield strength, see 10.1.3).

11.1.7.2 If strain was measured from the specimen shoulders, or if strain was not measured directly from the specimen (for example from an extensometer that was attached to grips or adapters), this shall be stated in a footnote to the values.

11.1.7.3 When strain was not measured directly from the specimen, the yield strength value shall be listed as approximate followed by the offset, for example "approximate yield strength (offset = 0.2 %)" (see 10.1.3).

11.1.7.4 Tensile strength.

11.1.7.5 Elongation, the method of measure (elongation after fracture or elongation at fracture) and gauge length (for example, 2 in. for rectangular specimens or 4D or 5D for round).

11.1.7.6 Reduction of area for specimens with circular cross section.

11.1.8 Specification limits and disposition of each test result (conforming/non-conforming), when required by customer.

11.1.9 Location of fracture, if outside of center half of gauge length.

11.1.10 Test or specimen anomalies, for example incorrect test speed, failure in the grip threads, specimen machined out of tolerance, magnitude of deviations from those specified in 7.6, nonstandard atmosphere and heating methods, and exceptions to required dimensional accuracy and axiality of loading. If a replacement test is performed to replace an invalid result, the reason for replacement test result shall be maintained in the records (see 11.2.5).

11.1.11 Identification of the individual who approved the test or report.

11.1.12 Date of report approval.

11.2 The following information shall be maintained in the records (in addition to the information in the report in 11.1):

11.2.1 Gauge length, distance between measurement points on specimen shoulder (if used) and overall length (if used).

11.2.2 Measured critical dimensions used to determine the minimum cross-sectional area of the reduced section (for example, diameter or width and thickness).

11.2.3 Stress, strain, force, maximum force, displacement, indicated temperature, time data. In cases where yield strength measurements are not required, see 9.6.2, a subset including stress, force, displacement, indicated temperature, and time data may be recorded.

11.2.4 Speed of testing (for example, strain rate or cross-head speed).

11.2.5 If a replacement test is performed to replace an invalid result, the specimen identification for the invalid test and reason for replacement shall be maintained in the records.

11.2.6 Equipment identification, including testing machine, extensometer, furnace, thermocouple type and traceability, laboratory test methods, etc.

11.2.7 Time to attain specified temperature and time at specified temperature before testing.

11.2.8 Identification of individual who performed the test.

11.2.9 Date of test.

12. Precision and Bias

12.1 *Precision*—An inter-laboratory test program[9] gave the following values for coefficients of variation for the most commonly measured tensile properties:[10]

Coefficient of Variation, % Tensile Properties at 600 °F (316 °C)

	Tensile Strength	Yield Strength offset = 0.2 %	Elongation gauge length = 4 diameters	Reduction of Area
CV $\%_r$	1.0	3.0	3.8	4.6
CV $\%_R$	1.4	5.1	8.2	4.9

CV $\%_r$ = repeatability coefficent of variation in percent within a laboratory.
CV $\%_R$ = repeatability coefficient of variation in percent between laboratories.

[9] Supporting data are available from ASTM Headquarters. Request RR:E28-1015.

[10] For further information, see Practice E177 and Practice E691.

Coefficient of Variation, % Tensile Properties at 1100°F (593°C)

	Tensile Strength	Yield Strength offset = 0.2 %	Elongation gauge length = 4 diameters	Reduction of Area
CV $\%_r$	2.8	4.2	6.8	2.8
CV $\%_R$	4.5	7.6	15.6	4.5

CV $\%_r$ = repeatability coefficent of variation in percent within a laboratory.
CV $\%_R$ = repeatability coefficient of variation in percent between laboratories.

12.1.1 The values shown are the averages from tests on four frequently tested metals at two specified temperatures, selected to include most of the normal range for each property listed above. When these materials are compared, a large difference in coefficient of variation is found. Therefore, the values above should not be used to judge whether the difference between duplicate tests of a specific material is larger than expected. The values are provided to allow potential users of this test method to assess, in general terms, its usefulness for a proposed application.

12.2 *Bias*—The procedures in Test Methods E21 for measuring tensile properties have no bias because these properties can only be defined in terms of a test method.

13. Keywords

13.1 elevated temperature; elongation; reduction of area; strain rate; tensile strength; yield strength

SUMMARY OF CHANGES

Committee E28 has identified the location of selected changes to this standard since the last issue (E21 – 17$^{\epsilon 1}$) that may impact the use of this standard.

(1) Section 3—revised to add *indicated temperature*, *specified temperature*, and *temperature-measuring system*.
(2) Throughout—clarified temperature terminology to clearly describe "indicated" and "specified" temperatures. Added references to "temperature-measuring system" where needed for clarification.
(3) Throughout—standardized units to conform with the H4 inch-pound unit designation. Changed fractions to equivalent decimal units.
(4) Sections 7, 9, 10, and 11— revised reporting and recording requirements throughout.
(5) Added Section 13, Keywords.
(6) Section 9.4.4—clarified requirements for the temperature limits (indicated versus specified) after yield strength determination. Added note describing reasons for temperature differences caused by factors other than the heating apparatus.
(7) Section 12—Corrected values for coefficient of variation at 1100 °F (593 °C)

Designation: E1471 – 92 (Reapproved 2014)

Standard Guide for Identification of Fibers, Fillers, and Core Materials in Computerized Material Property Databases[1]

This standard is issued under the fixed designation E1471; 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 This guide establishes the essential and desirable elements of data required for the identification in computerized material property databases of fibers, fillers, and core materials used in composite materials. A recommended format for entry of these fields into a computerized database is provided. Examples of the application of this guide are also included.

1.2 The recommended format described in this guide is suggested for use in recording data in a database, which is different from contractural reporting of actual test results. The latter type of information is described in materials specifications shown in business transactions and is subject to agreement between vendor and purchaser.

1.3 The materials covered by this guide include fibers, both continuous and discontinuous, and fillers of various geometries which are used as reinforcements in composite materials, as well as core materials used in sandwich composites. Cores may be foam, honeycomb, or naturally occurring materials such as balsa wood. These materials are distinguished from bulk materials by the importance of their specialized geometric forms to their properties. This difference is reflected in the use of geometry, along with chemistry, as a primary basis for classification. Identification of composite materials is discussed in Guide E1309.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C274 Terminology of Structural Sandwich Constructions
D123 Terminology Relating to Textiles
D883 Terminology Relating to Plastics
D3878 Terminology for Composite Materials
E1309 Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases
E1443 Terminology Relating to Building and Accessing Material and Chemical Databases (Withdrawn 2000)[3]

3. Terminology

3.1 *Definitions*—Terminology D3878 shall be used where applicable.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *core, n*—a generally, centrally located layer or composite component of a sandwich construction, usually low density, which separates and stabilizes the facings and transmits shear between them and provides most of the shear rigidity of the construction (see Terminology C274).

3.2.2 *essential field, n*—a field in a record which must be filled to meet the requirements of a stated type of database (see Terminology E1443).

3.2.2.1 *Discussion*—Fields are considered essential if they are required to make a meaningful comparison of property data from different sources. A comparison of data from different sources may still be possible if essential information is omitted, but the value of the comparison may be greatly reduced.

3.2.3 *fiber, n—in textiles*, the general term for a filamentary material having a length at least ten times its nominal diameter.

3.2.4 *field, n*—an elementary unit of a record that may contain a data item, a data aggregate, a pointer, or a link (see E1443).

3.2.5 *field name, n*—a name or code associated with a field and used for identification (see Terminology E1443).

3.2.6 *filler, n*—a relatively inert material added to a plastic to modify its strength, permanence, working properties, or other qualities, or to lower cost (see Terminology D883).

3.2.7 *strand, n—in textile fibers*, a normally untwisted bundle of filaments.

3.2.8 *value set, n*—an open listing of representative, acceptable strings which could be included in a particular field of a record (see Terminology E1443).

[1] This guide is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.01 on Editorial and Resource Standards.

Current edition approved April 1, 2014. Published April 2014. Originally approved in 1992. Last previous edition approved in 2008 as E1471 – 92 (2008). DOI: 10.1520/E1471-92R14.

[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* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

4. Significance and Use

4.1 This guide defines the information which is considered essential to uniquely describe a fiber, filler, or core material in a computerized database. A format is recommended for placing these data in fields suitable for a computerized database. Additional fields which are considered desirable, but not essential, are also defined. The purpose is to facilitate efficient storage and retrieval of the information with a computer and to allow meaningful comparison of data from different sources.

4.2 Comparison of property data from different sources will be most meaningful if all the essential information defined by the guidelines is present. Comparison may still be possible if essential information is omitted, but the value of the comparison may be greatly reduced.

4.3 While at this time there is no generally accepted numbering system for these materials, analogous to those for metals and alloys, a field for an identifying number (Material Reference Number) is included should such a system be developed in the future.

4.4 This information should not be considered restrictive. For example, a database designer may find it useful to aggregate several fields, such as the material and chemical class fields, into a single field. This may affect search strategies and other database operations. These considerations are beyond the scope of this guide.

5. Guidelines

5.1 The following fields are recommended for identification of fibers, fillers, and core materials used in composites. For certain fields, lists of recommended entries are included. Where possible, entries should be chosen from these lists. However, these lists should not be regarded as exhaustive.

5.2 *Primary Identifiers:*

5.2.1 *Material Reference Number*—Identifying number or code, if any, for the particular material.

5.2.2 *Class*—Classification by form, either fiber, filler, or core.

5.2.3 *Subclass*—Further subdivision by geometric form within the class. See Table 1 for list.

5.2.4 *Chemical Family*—Classification of the material by its generic chemical composition family. See Table 1 for list.

5.3 *Commercial Specification:*

5.3.1 *Common Name*—Name by which the material is known in the industry.

5.3.2 *Additional Name Information*—Additional information on the name, such as chemical composition details on the material.

5.3.3 *Specification Organization*—A company, industry, government, national, regional, or international organization issuing the specification; for example, ASTM.

5.3.4 *Specification Number*—The specification number within the organization referenced.

5.3.5 *Specification Version*—The year or revision code of the specification.

5.3.6 *Specification Designation*—The designation used for the material in the specification.

TABLE 1 Class, Subclass, Chemical Family, and Forms for Fibers, Fillers, and Core Materials

NOTE 1—These are lists. The table is not intended to be read horizontally.

Class	Subclass	Chemical Family	Form
Fiber	continuous	aramid	tow or end or impregnated tow strand
	discontinuous, long	glass	plied yarn
	discontinuous, short	silicon carbide	yarn roving
	staple	aluminum oxide	mat
	milled	aluminum	other (specify)
	whisker	boron	
	pulp	other (specify)	
	other (specify)		
Filler	particulate	calcium carbonate	powder
	platelet	kaolin clay	slurry
	hollow sphere	titanium dioxide	other (specify)
	hollow cylinder	mica	
	other (specify)	talc	
		other (specify)	
Core	honeycomb	glass reinforced	block
	foam	aluminum	other (specify)
	other (specify)	aramid reinforced	
		polyvinyl chloride	
		balsa wood	
		polyurethane	
		polymethacrylimide	
		other (specify)	

5.4 *Characteristics:*

5.4.1 *Density.*

5.4.2 *Cross-Section Type*—Geometry of cross section of the material. See Table 2 for list.

5.4.3 *Dimension Parameter*—Name of dimension characteristic of the material; for example, diameter. Dimension parameter, units, and value should be given for each characteristic dimension. See Table 3 for list.

5.4.4 *Dimension Value*—Mean or nominal numerical value of the specified dimension in appropriate units.

5.4.5 *Dimension Distribution Parameter Type*—Name of the parameter used to characterize the distribution of values for the specified dimension. See Table 4 for list.

5.4.6 *Dimension Distribution Parameter Value*—Numerical value of the distribution parameter for the specified dimension. Units are assumed to be the same as those of the dimension itself.

5.4.7 *Dimension Distribution Sample Size*—The number of samples from which the dimension distribution parameter value is determined.

5.5 *Source:*

5.5.1 *Manufacturer.*

5.5.2 *Manufacturer's Identification*—Code, part number, or other identification used by the manufacturer to identify this material.

5.5.3 *Lot Number*—Manufacturer's reference for traceability of this lot of material.

TABLE 2 Cross-Section Types for Fibers, Fillers, and Core Materials

Circular
Rectangular
Oval
Irregular
Other (specify)

TABLE 3 Dimension Parameters for Fibers, Fillers, and Core Materials

Length
Width
Inside diameter
Outside diameter
Thickness
Wall thickness
Cell size
Percent open cell
Denier
Filament count
Fiber yield
Other (specify)

TABLE 4 Dimension Distribution Parameters for Fibers, Fillers, and Core Materials

Standard deviation
Range (+−)
Coefficient of variation (%)
Other (specify)

5.5.4 *Date of Manufacture*—YYYYMMDD.

5.6 *Process Descriptors:*

5.6.1 *Process Conditions*—Conditions under which the material was produced. (This refers to production of the primary form of the material; for example, fiber. If a secondary form such as fabric or braid is actually tested, its processing should be described according to Guide E1309.)

5.6.2 *Surface Treatment Type*—Type of process used to modify the surface chemistry. See Table 5 for list.

5.6.3 *Surface Treatment Detail*—Details of the surface treatment, including time, temperature, pressure, and environment, if applicable.

5.7 *Sample Formats*—The format in Table 6 identifies, with an asterisk (*), the essential information for computerized data retrieval as defined in 4.2. There are three columns of information:

5.7.1 *Field Number*—A reference number for ease of dealing with the individual fields within this format guideline. It has no permanent value and does not become part of the database itself.

TABLE 5 Surface Treatment Types for Fibers, Fillers, and Core Materials

Chemical oxidation
Plasma etching
Adhesion promoting
Sizing
Anti-corrosion
Finish free
Lubricant
Release treatment
Other (specify)

TABLE 6 Generic Format for Identification of Fibers, Fillers, and Core Materials

Field Number[A]	Field Name	Value Sets or Units
Primary Identifiers:		
1	Material reference number	alphanumeric string
2	* Class	fiber, filler, or core
3	* Subclass	See Table 1
4	* Chemical family number	See Table 1
Commercial Specification:		
5	* Common name	alphanumeric string
6	Additional name information	alphanumeric string
7	Specification organization	alphanumeric string
8	Specification number	alphanumeric string
9	Specification version	alphanumeric string
10	Specification designation	alphanumeric string
Characteristics:		
11	* Density	g/cm^3 ($lb/in.^3$)
12	Cross-section type	See Table 2
13	* Dimension parameter[B]	See Table 3
14	* Dimension value	floating point
15	Dimension distribution parameter[C]	See Table 4
16	Dimension distribution parameter value	floating point
17	Dimension distribution sample size	integer
Source:		
18	Manufacturer	alphanumeric string
19	Manufacturer's identification	alphanumeric string
20	Lot number	alphanumeric string
21	Date of manufacture	YYYYMMDD
Process History:		
22	Process conditions	alphanumeric string
23	Surface treatment type	See Table 5
24	Surface treatment detail	alphanumeric string

[A] Field numbers are for information only.

[B] Dimension parameter and value should be given for each relevant dimension. Type is essential information if value is given.

[C] For each dimension in which distribution width is relevant. Parameter is essential if parameter value is given.

* Denotes essential information.

5.7.2 *Field Name and Description*—The complete name of the field, descriptive of the element of information that would be included in this field of the database.

5.7.3 *Value Sets or Units*—A listing of the types of information that would be included in the field or, in the case of properties or other numeric fields, the units in which the numbers are expressed. Value sets are representative sets, listing sample (but not necessarily all acceptable) inputs to the field.

5.7.4 Examples of the application of this guide to fibers, fillers, and cores are included in Tables 7-9. Only those fields appropriate to the particular material form should be used.

6. Keywords

6.1 computerization; core material; fiber; filler; materials databases; material identification

TABLE 7 Example—Identification of a Fibrous Reinforcement

Field Number	Field Name	Value
Primary Identifiers:		
1	Material reference number	to be assigned
2	Material class	fiber
3	Material subclass	continuous
4	Chemical family	carbon
Commercial Specification:		
5	Common name	IM-6[A]
6	Additional name information	PAN-based
7	Specification organization	Advanced Composites Corp.
8	Specification number	C22-457
9	Specification version	Release 1.2
10	Specification designation	Type III
Characteristics:		
11	Density	1.72 g/cm^3 (0.062 lb/in.^{3})
12	Cross-section type	circular
13	Dimension parameter	diameter
14	Dimension value	0.145 mm (0.0057 in.)
13'	Dimension parameter	Filament count
14'	Dimension value	12 000
15	Dimension distribution parameter	not applicable
16	Dimension distribution parameter value	not applicable
17	Dimension distribution sample size	not applicable
Source:		
18	Manufacturer	Hercules, Inc.
19	Manufacturer's identification	IM6-G-12K
20	Lot number	X627-31
21	Date of manufacture	19841204
Process History:		
22	Process conditions	unknown
23	Surface treatment type	chemical oxidation
24	Surface treatment detail	unknown

[A] Registered trademark of Hercules, Inc.

TABLE 8 Example—Identification of Filler

Field Number	Field Name	Value
Primary Identifiers:		
1	Material reference number	to be assigned
2	Class	filler
3	Subclass	particulate
4	Chemical family	calcium carbonate
Commercial Specification:		
5	Common name	calcium carbonate
6	Additional name information	MgCO:3 3 % max; acid insolubles 3 % max
7	Specification organization	Texas Composites, Inc.
8	Specification number	TC25-654
9	Specification version	Revision 89-2
10	Specification designation	Filler 3
Characteristics:		
11	Density	2.71 g/cm^3 (0.0978 lb/in.^{3})
12	Cross-section type	irregular
13	Dimension parameter	median size
14	Dimension value	2.3 µm
15	Dimension distribution parameter	standard deviation
16	Dimension distribution parameter value	1.2 µm
17	Dimension distribution sample size	5
Source:		
18	Manufacturer	Georgia marble
19	Manufacturer's identification	
20	Lot number	G1634
21	Date of manufacture	unknown
Process History:		
22	Process type	unknown
23	Process conditions	unknown
24	Surface treatment type	none

TABLE 9 Example—Identification of a Core Material

Field Number	Field Name	Value
Primary Identifiers:		
1	Material reference number	to be assigned
2	Class	core
3	Subclass	honeycomb
4	Chemical family	aramid
Commercial Specification:		
5	Common name	nomex[A] aramid honeycomb
6	Additional name information	phenolic coated
7	Specification organization	Aircraft, Inc.
8	Specification number	143.67
9	Specification version	original issue
10	Specification designation	Organic HC
Characteristics:		
11	Density	0.048 g/cm^3 (1.73E-3 $lb/in.^3$)
12	Cross-section type	rectangular
13	Dimension parameter	thickness
14	Dimension value	13 mm (0.5 in.)
13′	Dimension parameter	cell size
14′	Dimension value	3.18 mm (0.125 in.)
15	Dimension distribution parameter	not applicable
16	Dimension distribution parameter value	
Source:		
17	Manufacturer	Hexcel
18	Manufacturer's identification	HRH 10 (1) 3 pcf
19	Lot number	XXXXX
20	Date of manufacture	19860930
Process History:		
21	Process conditions	unknown
22	Surface treatment type	impregnated
23	Surface treatment detail	phenolic resin dip

[A] Registered trademark of Hexcel, Inc.