INTERNATIONAL

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Standard Practice for Verification and Classification of Extensometer Systems[1]

This standard is issued under the fixed designation E83; 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 This practice covers procedures for the verification and classification of extensometer systems, but it is not intended to be a complete purchase specification. The practice is applicable only to instruments that indicate or record values that are proportional to changes in length corresponding to either tensile or compressive strain. Extensometer systems are classified on the basis of the magnitude of their errors.

1.2 Because strain is a dimensionless quantity, this document can be used for extensometers based on either SI or US customary units of displacement.

NOTE 1—Bonded resistance strain gauges directly bonded to a specimen cannot be calibrated or verified with the apparatus described in this practice for the verification of extensometers having definite gauge points. (See procedures as described in Test Methods E251.)

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]

E6 Terminology Relating to Methods of Mechanical Testing

E21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials

E251 Test Methods for Performance Characteristics of Metallic Bonded Resistance Strain Gages

2.2 *Other Standards:*[3]

JCGM 100:2008 Evaluation of measurement data – Guide to the expression of uncertainty in measurement

3. Terminology

3.1 *Definitions:*

3.1.1 In addition to the terms listed, see Terminology E6.

3.1.2 *calibration*—a determination of the calibration factor for a system using established procedures.

3.1.3 *calibration factor*—the factor by which the change in extensometer reading must be multiplied to obtain the equivalent strain.

3.1.3.1 *Discussion*—For any extensometer, the calibration factor is equal to the ratio of change in length to the product of the gauge length and the change in the extensometer reading. For direct-reading extensometers the calibration factor is unity.

3.1.4 *compressometer*—a specialized extensometer used for sensing negative or compressive strain.

3.1.5 *deflectometer*—a specialized extensometer used for sensing of extension or motion, usually without reference to a specific gauge length.

3.1.6 *dot/line tracking optical extensometer system (DLT), n*—an optical extensometer system that uses marks at an initially known distance, physically placed on a specimen or calibration fixture, to establish the gauge length value for determination of strain.

3.1.7 *error, in extensometer systems*—the value obtained by subtracting the correct value of the strain from the indicated value given by the extensometer system.

3.1.8 *extensometer, n*—a device for sensing strain.

3.1.9 *extensometer systems*—a system for sensing and indicating strain.

3.1.9.1 *Discussion*—The system will normally include an extensometer, conditioning electronics and auxiliary device

[1] This practice is under the jurisdiction of ASTM Committee E28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.01 on Calibration of Mechanical Testing Machines and Apparatus.

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[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] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

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

(recorder, digital readout, computer, etc.). However, completely self-contained mechanical devices are permitted. An extensometer system may be one of three types.

3.1.10 *Type 1 extensometer system, n*—an extensometer system which both defines gauge length and senses extension, for example, a clip-on strain gauge type with conditioning electronics.

3.1.11 *Type 2 extensometer system, n*—an extensometer which senses extension and the gauge length is defined by specimen geometry or specimen features such as ridges or notches.

3.1.11.1 *Discussion*—A Type 2 extensometer is used where the extensometer gauge length is determined by features on the specimen, for example, ridges, notches, or overall height (in case of compression test piece). The precision associated with gauge length setting for a Type 2 extensometer should be specified in relevant test method or product standard. The position readout on a testing machine is not recommended for use in a Type 2 extensometer system.

3.1.12 *Type 3 extensometer system, n*—an extensometer system which intrinsically senses strain (ratiometric principle), for example, video camera system.

3.1.13 *gauge length (L), n*—the original length of that portion of the specimen over which strain or change of length is determined.

3.1.13.1 *Discussion*—If the device is used for sensing extension or motion, and gauge length is predetermined by the specimen geometry or specific test method, then only resolution and strain error for a specified gauge length should determine the class of extensometer system.

3.1.14 *laser optical extensometer system, n*—an optical extensometer system that uses a laser to track and measure the extension/strain.

3.1.15 *resolution of the strain indicator*—the smallest change in strain that can be estimated or ascertained on the strain indicating apparatus of the testing system, at any applied strain.

3.1.16 *resolution of the digital type strain indicators (numeric displays, printouts, and so forth)*—the resolution is the smallest change in strain that can be displayed on the strain indicator (may be a single digit or a combination of digits) at any applied strain.

3.1.16.1 *Discussion*—If the strain indication, for either type of strain indicator, fluctuates more than twice the resolution, as described in 3.1.15 or 3.1.16, the resolution expressed as a strain shall be equal to one-half the range of fluctuation.

3.1.17 *verification*—a determination that a system meets the requirements of a given classification after calibration according to established procedures.

3.1.18 *verification apparatus*—a device for verifying extensometer systems.

3.1.18.1 *Discussion*—This device is used to simulate the change in length experienced by a test specimen as a result of the applied force. The extensometer may either be attached directly to the mechanism or interfaced with it in a manner similar to normal operation (that is, possibly without contact for some optical extensometers).

3.2 *virtual optical extensometer system, n*—an optical extensometer system in which the initial datum points used to establish the gauge length value for determination of strain are chosen by the user based on a location in the image in software – the gauge length is not defined by discrete marks on the specimen.

3.3 *working distance, (WD), n*—the physical distance that the optical extensometer system is from the surface of the specimen or verification apparatus, the distance is measured from the front of the optical extensometer system.

3.3.1 *Discussion*—The WD measurement can be made from the camera body to the front of the specimen or verification apparatus. While it is not important where the physical distance is measured from it is important to measure the distance and report where the measurements were made. Doing this will enable the user to recreate the conditions under which the optical extensometer system was verified.

4. Verification Apparatus

4.1 The apparatus for verifying extensometer systems shall provide a means for applying controlled displacements to a simulated specimen and for measuring these displacements accurately. It may consist of a rigid frame, suitable coaxial spindles, or other fixtures to accommodate the extensometer being verified, a mechanism for moving one spindle or fixture axially with respect to the other, and a means for measuring accurately the change in length so produced,[4] or any other device or mechanism that will accomplish the purpose equally well. The mechanism provided for moving one spindle relative to the other shall permit sensitive adjustments. The changes in length shall be measured, for example, by means of an interferometer, calibrated standard gauge blocks and an indicator, a calibrated micrometer screw, or a calibrated laser measurement system. If standard gauge blocks and an indicator, or a micrometer screw, are used, they shall be calibrated and their limits of accuracy and sensitivity stated. The errors of the verification apparatus shall not exceed one third of the permissible error of the extensometer.

4.2 The verification apparatus shall be calibrated at intervals not to exceed two years.

NOTE 2—He-Ne laser interferometer measurement systems based on the 0.633 µm wavelength line are considered to be primary-based displacement standards and do not require recalibration.[5]

4.3 If the verification apparatus is to be used to verify extensometers used for bidirectional tests, the errors of the verification apparatus should be measured in both directions of travel so as to include any backlash present.

[4] A review of some past, current, and possible future methods for calibrating strain measuring devices is given in the paper by Watson, R. B., "Calibration Techniques for Extensometry: Possible Standards of Strain Measurement," *Journal of Testing and Evaluation*, JTEVA, Vol. 21, No. 6, November 1993, pp. 515–521.

[5] A letter from NIST (National Institute of Standards and Technology) has been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: E28-1013.

5. Verification Procedure for Extensometer Systems

5.1 *General Requirements*—The verification of an extensometer system should not be done unless the components of the system are in good working condition. Thoroughly inspect all parts associated with smooth operation of the instrument to ensure there are no excessively worn components. Repair or replace parts as necessary. Remove any dirt particles which may have accumulated through normal use of the instrument. Verification of the system shall be performed whenever parts are interchanged or replaced. Some extensometers have parts that are designed to be interchanged such as gauge length extenders and lenses used with video extensometers. If these parts can be shown to be interchangeable without degrading the verified classification of the extensometer, they may be interchanged between scheduled verifications of the extensometer. Verification of the extensometer with all combinations of interchangeable parts that are anticipated to be used for testing is required.

5.1.1 The verification of an extensometer system refers to a specific extensometer used with a specific readout device. Unless it can be demonstrated that autographic extensometers and recorders of a given type may be used interchangeably without introducing errors that would affect the classification of the extensometer, the extensometer shall be calibrated with the readout device with which it is to be used.

5.1.2 Prior to the initial verification, the extensometer should be calibrated according to the manufacturer's instructions or established procedures. The calibration procedure may include adjustment of span or determination of calibration factor, or both.

5.2 *Gauge Length Measurement Method*—Measure the gauge length of self-setting instruments by either the direct or indirect method.

NOTE 3—The following is an example of an indirect method. Set the extensometer to its starting position and mount it on a soft rod of the typical specimen size or diameter. After the extensometer is removed, measure the distance between the marks left by the gauge points (or knife edges). If there are four or more gauge points, take the average of the individual lengths as the gauge length. The differences between individual measurements shall not exceed the tolerance given for the class of extensometer. If there are two gauge points (or knife edges), but on opposite sides of the specimen, attach the extensometer twice rotating it 180° with respect to the rod. Take the average of the lengths thus established on each side of the rod as the gauge length.

5.2.1 Make two measurements of the gauge length. Determine and record the error from each measurement, which is the difference between the measured gauge length and the specified gauge length, expressed as a percent of the specified gauge length.

5.2.2 For extensometer devices that do not have a self-setting gauge length during use, such as deflectometers and some high-temperature tensile or creep extensometers, verification run errors should be calculated using the gauge length for which the device is used. Separate classifications should be established for each gauge length or range used.

5.2.3 Some extensometers have the capability to measure the gauge length set by or chosen by the user. If this measurement is used in the calculation of strain, then it is the inherent measurement accuracy that is the important factor rather than the error between the chosen length and the actual.

NOTE 4—An example of an extensometer that is described by 5.2.3 is an optical extensometer that measures the position of "flags" attached to the test specimen. The flags are positioned at the approximate required gauge length and the instrument measures the position of the flags (the actual gauge length) before and after the specimen is stressed. Although this kind of device usually has a stated accuracy of gauge length, it must be verified by either direct or indirect methods at the appropriate gauge lengths.

5.3 *Position of Extensometer*—Carefully position the extensometer on or interface it to the verification device in the same manner as it is normally used for typical specimens. For extensometers that attach directly to the specimen, the verification device should allow attachment to pieces that are similar to the specimen on which the extensometer will be attached.

5.4 *Temperature Control*—Verify the extensometer at approximately the same temperature at which it will be used. Allow sufficient time for the verification device and extensometer to reach satisfactory temperature stability. Maintain temperature stability by excluding drafts throughout the subsequent verification. Record the temperature during each verification run.

NOTE 5—Extensometers used for high-temperature testing may be verified at ambient temperature to insure proper operation, but fixtures should be designed to verify performance at the actual test temperature. This is especially true with optical extensometers which may be adversely affected by air density changes associated with thermal gradients and turbulence, environmental chamber windows, or specimen changes due to the environment. See Appendix X2.

5.5 *Method of Reading*—Read the instrument or, in the case of an autographic extensometer, measure the record in the same manner as during use.

5.5.1 For extensometer with dial micrometers or digital readouts, the readings shall be recorded. Extensometers that use autographic methods shall have their charts read and recorded using a suitable measuring device, such as a vernier or dial caliper. The use of an optical magnifying device is recommended when reading and measuring autographic records.

NOTE 6—When autographic extensometer systems are used, care should be taken to minimize errors introduced by variances in the graph paper. These errors can be due to dimensional changes from reproduction or humidity changes. Direct measurement of the trace soon after it was made eliminates the graph paper errors and is desirable for systems verification.

NOTE 7—If an extensometer is equipped with a dial micrometer, it may be necessary to lightly tap the dial micrometer to minimize the effects of friction and to ensure that the most stable and reproducible readings are obtained. If the dial micrometer is tapped during the verification procedure, include this information in the report.

5.6 *Zero Adjustment*—After temperature stability has been achieved, displace the verification device (with extensometer in the test position) to a slightly negative value and return to zero. If the reading does not return to zero, adjust and repeat the procedure until the reading does return to zero.

5.7 *Number of Readings*—For any strain range, verify the extensometer system by applying at least five displacement values, not including zero, at least two times, with the difference between any two successive displacement applications being no greater than one-third the difference between the selected maximum and minimum displacements.

5.7.1 Extensometers need not be verified beyond the range over which they will be used. Multi-range (multi-magnification) extensometers shall be verified for each range to be used.

NOTE 8—If the connection between the gauge points attached to the specimen and the indicating device is made through geared wheels or micrometer screws, relatively large periodic errors may exist which might not be disclosed by this overall procedure. For such extensometers it may be necessary to take additional readings within one turn of any geared wheel, micrometer screw, or the travel of one tooth of any meshing gear.

5.7.2 When it is desired to establish the range of an extensometer system designed to automatically select or extend ranges below 10 % of full scale without the influence of the operator, the number of readings shall depend on how many overlapping decades are in the range. Extensometer readings should be chosen starting with the minimum reading and are grouped in overlapping decades such that the maximum reading on one decade is the minimum on the next decade. There are to be at least five strain applications per decade, unless the maximum, or the minimum strain on the range is reached before completing the decade. Strain (displacements) in each decade are to be approximately 1:1, 2:1, 4:1, 7:1, and 10:1, starting with the minimum strain in each decade.

5.7.2.1 In no case should the distance between two successive strains (displacements) within a decade differ by more than one-third the difference between the minimum and maximum strains in that decade. Strains in the second successive run are to be approximately the same as those of the first run. Report all percent values of accuracy, and report the indicator resolution at least once per decade.

5.7.3 *Lower Limit Criteria*—as indicated in Table 1, all verified strain readings must have a resolution at least one-half the allowable error, that is, the resolution is a limiting factor to determine a lower limit of the range. The lowest verified strain reading must be at least 100 times the indicator resolution. Extensometer results used below the lowest verified strain reading may not comply with the error limit specified by this standard practice.

NOTE 9—*Example:* For an extensometer with a gauge length of 1 in. and 50 % strain, the full scale displacement value is 0.5 in. If the machine (system) resolution is 0.00005 in., which meets the criteria for the B1 class, the lower limit (verification range) would be 0.00005 in. × 100 = 0.005 in., or 0.5 % strain. The suitable verification points for a single range extensometer system would be in percent strain 0.5, 1.0, 2.0, 3.5, 5, 10, 20, 35, and 50. (See for single range system Fig. X1.1 and Fig. X1.2 for multirange.)

5.8 *Number of Runs*—Take at least two complete sets of extensometer readings for the same changes of length. After the first run, an operation that simulates normal operation should be used to check repeatability. An extensometer that attaches directly to the specimen should be removed and then reattached to the verification device between runs. An extensometer that does not attach directly to the specimen should be moved away from the verification device (or the device moved away from the extensometer) to simulate the changing of test specimens.

5.8.1 If the initial verification run (the "as found" run) produces satisfactory results which classify an extensometer system according to Table 1 specifications, then the data may be used as run—one of the two required for the verification report.

5.8.2 If the initial verification run produces results which are outside of expectations, for example, Class C instead of B1, and adjustments are necessary, then this first verification run might be reported "as found" data and used in accordance with applicable quality control programs. Calibration adjustments may then be made to the extensometer system after which two required verification runs shall be conducted and reported on the verification report and certificate.

5.8.3 The algebraic difference between errors of the two verification runs shall not exceed the required Classification criteria listed in Table 1.

5.9 *Direction of Verification Displacement:*

5.9.1 *Extensometers Used for Unidirectional Tests*—Extensometers used for unidirectional tests (for example, tension tests) shall be verified by applying displacement in the direction of testing normally used. If start-up backlash is evident, the verification device (with extensometer in place) may be displaced to a slightly negative value and returned to zero before each run.

NOTE 10—This verification procedure does not measure the initial backlash in the extensometer that may appear after it is first attached to the specimen. If the extensometer is used with open or closed loop-type test equipment in load control, the users should disregard readings taken during the initial part of the loading curve. If the extensometer is used with

TABLE 1 Classification of Extensometer Systems

Classification[A]	Relative Error of gauge Length (max %) (See 5.2)	Resolution not to Exceed the Greater of:		Error of Strain[B] not to Exceed the Greater of:	
		Fixed Value (in./in., m/m)	% of Reading	Fixed Error (in./in., m/m)	Relative Error (% of strain)
Class A	±0.1	0.00001	0.05	±0.00002	±0.1
Class B-1	±0.25	0.00005	0.25	±0.0001	±0.5
Class B-2	±0.5	0.0001	0.25	±0.0002	±0.5
Class C	±1	0.0005	0.5	±0.001	±1
Class D	±1	0.005	0.5	±0.01	±1
Class E	±1	0.05	0.5	±0.1	±1

[A] Class A classification is very difficult to achieve at short (1 in. (25 mm) or less) gauge lengths, so the commercial availability of an extensometer system that meets this requirement may be very limited or nonexistent.
[B] The strain of an Extensometer System is the ratio of applied extension to the gauge length.

closed loop test equipment in strain control, the backlash could result in large tension or compression loads during the initial part of the loading curve.

5.9.2 *Extensometers Used for Bidirectional Tests*—Extensometers used for bidirectional tests (for example, hysteresis tests, fatigue tests, and so forth) (See Appendix X3) shall be verified by applying both increasing and decreasing values of displacement over the total range of intended use. Displace the verification device (with extensometer in place) to a slightly negative value and return to zero before each run. During each run, displace the extensometer to the maximum positive value, then to the maximum negative value, and then back to zero, stopping at each verification point along the way in each direction.

5.10 *Determination of Errors*—Calculate the error of the extensometer system for each change in length of the verification apparatus. Errors are based on net values from the zero point to each successive verification point, not on increments between verification points.

6. Classification of Extensometer Systems

6.1 Classify extensometer systems in accordance with the requirements as to maximum error of strain indicated by the extensometer system shown in Table 1. The maximum allowable error in each class is the fixed error or the variable error, whichever is greater. The fixed error will establish the maximum allowable error for readings near zero, but the variable error may establish the maximum allowable error for readings near full scale. Two examples of this procedure are presented in Appendix X1. In addition, the gauge length error for Type 1 extensometers shall not exceed the greater of the values shown in Table 1.

6.1.1 Type 2 extensometer systems shall be classified using the smallest gauge length for which they are used. They may be verified at additional gauge lengths if desired.

6.1.2 Type 3 extensometer systems, operating over a range of gauge lengths, shall be verified at the minimum and maximum gauge lengths used. They may be verified at additional gauge lengths if desired.

NOTE 11—For Type 3 systems, precision marked, divided test pieces may be used to establish known gauge lengths on the calibration device. Known extensions enable the applied strains to be set. These applied strains are compared with the indicated strains from the Type 3 extensometer systems, in order to establish its classification in accordance with the requirements for resolution and strain error in Table 1.

6.2 Separate classifications may be established for different ranges of multi-range (multiple-magnification) extensometer systems.

7. Verification of Multiple Strain Readouts

7.1 When an extensometer is to be used with two or more readout devices (for example, a graphic recorder and a digital readout), steps must be taken to assure that errors are not introduced by interactions (mechanical or electrical) between the readout devices or between the readouts and the extensometer, and that values from each readout device satisfy appropriate performance criteria. (Different accuracy classifications could be given to the systems using different readout devices.) This can best be accomplished by verifying each system (extensometer and readout device) individually and also in combinations that would be used simultaneously. As an alternative, after individual verifications have been made, the combination can be checked at three points (about 20 %, 50 %, and 90 % of full scale range are recommended); and, if values for each system do not differ from the individual verification values by more than 20 % of the class tolerance, the combined system shall be considered to meet the same requirements as the individual systems. If readout devices are always used in combination, individual verifications are not required when the combined system is verified as a unit.

8. Verification of Data Acquisition Systems

8.1 Extensometer systems in which strain values are indicated on displays or printouts of data acquisition systems, be they instantaneous, delayed, stored or retransmitted, which are verified in accordance with the provisions of Section 5 and classified in accordance with the provisions of Section 6, shall be deemed to comply with this practice.

9. Time Interval Between Verifications

9.1 It is recommended that extensometer systems be verified annually unless more frequent verification is required to comply with product or customer specifications. In no case shall the time interval between verifications exceed 18 months unless an extensometer is being used on a long-time test running beyond the 18-month period. In such cases, the extensometer system shall be verified immediately after completion of the test. (See Note 12.)

9.1.1 An extensometer system shall not be used after an adjustment or repair that could affect its accuracy without first verifying its accuracy utilizing the procedure described in this practice.

NOTE 12—If a test is expected to last more than 18 months, it is recommended that the extensometer system be verified immediately before as well as upon completion of the test.

10. Accuracy Assurance Between Verifications

10.1 Some product-testing procedures may require daily, weekly, or monthly spot checks to ascertain that an extensometer, recorder, or display, and so forth, or combinations thereof etc., are capable of producing accurate strain values between the verifications specified in Section 9. Spot checks may be performed on ranges of interest or at strain levels of interest utilizing a verification device that complies with Section 4 for the strain level(s) at which the spot checks are made.

10.2 Check the extensometer gauge length (see 5.1).

10.3 Make spot checks of extensometer readings at approximately 10 % and 50 % of a range unless otherwise agreed upon or stipulated by the material supplier or user.

10.4 The extensometer gauge length and strain measurement errors shall not exceed the allowable errors at the spot check points for the specified class of extensometer. Should errors be greater than allowable at any of the spot check points, the extensometer system is to be completely verified immediately.

10.5 When spot checks are made, a clear, concise record must be maintained as agreed upon between the supplier and the user. The record shall contain gauge length and spot check test data; the name, serial number, verification date, verification agency of the verification device(s) used to make spot checks; the name of person making the spot check; and documentation of the regular verification data and schedule.

10.6 The extensometer system shall be considered verified up to the date of the last successful spot check verification provided that the extensometer system is verified in accordance with Section 5 on a regular schedule in accordance with Section 9. Otherwise, spot checks are not valid.

11. Report

11.1 The report shall include the following:

11.1.1 Method of gauge length verification used.

11.1.2 Serial numbers and names of the manufacturers of all apparatus used in verifying the extensometer system.

11.1.3 Serial number and name of the manufacturer of the extensometer verified, or if it is an extensometer system composed of separable components, the serial number and manufacturer of each component of the systems verified.

11.1.4 gauge length of the extensometer. For variable gauge length extensometers, state the gauge lengths verified.

11.1.5 Temperature of the extensometer during verification.

11.1.6 Complete record of the readings of the extensometer and of the verification apparatus.

11.1.7 Calibration factor, if applicable.

11.1.8 Error in gauge length for each measurement of gauge length.

11.1.9 Error and relative error of the extensometer for each extensometer reading, the maximum algebraic error difference (repeatability) and the associated resolution for each range (decade).

11.1.10 Class of the extensometer system. If separate classifications are established for various ranges, report the range (or magnification) and strain values associated with each classification.

11.1.11 If the classification applies to bidirectional testing, it shall be so stated. Otherwise, the classification shall be considered to be unidirectional in the direction of normal use (that is, opening for tension testing, closing for compression testing, and so forth).

11.1.12 The name of the person performing the classification and the date it was performed.

11.2 Information to be available upon request shall include the following:

11.2.1 A statement indicating how, by whom, and when the most recent calibration of the apparatus used in verifying the extensometer system was made.

11.2.2 A statement of the errors of the verification apparatus.

11.2.3 Position of the extensometer during verification.

11.2.4 Method of interfacing or attaching the extensometer to the verification device.

ANNEX

(Mandatory Information)

A1. OPTICAL EXTENSOMETER SYSTEMS

A1.1 Optical extensometer systems typically use some combination of lasers, sensors, cameras, and lenses to sense and indicate strain. This Annex supplements the requirements of the standard.

A1.2 Verification Procedure

A1.2.1 In addition to the verification procedure requirements of Section 5, observe the requirements of this annex when verifying optical extensometer systems.

A1.2.2 As nearly as possible, match the setup, position, conditions, and lighting of the optical extensometer system when in use.

A1.2.3 Report the nominal field of view (FOV) length and width at the specimen or calibration fixture if available. Equipment manufacturers may not provide the nominal FOV values for both length and width. At a minimum, the nominal FOV in the direction of extensometer travel shall be reported.

A1.2.3.1 For DLT or virtual optical extensometer systems, report either the nominal FOV, or image size (in pixels) and average image magnification (for example, pixels/mm), in the verification report. In addition, report the particular camera and lens configuration in the verification report.

A1.2.3.2 For laser optical extensometer systems, report the length and width of the laser scan or sheet that is used for measurement.

A1.2.3.3 The optical extensometer system may be verified over a reduced portion of the FOV. Select the number of verification readings as described in 5.7.

NOTE A1.1—Some extensometers exhibit a non-linearity in their readings due to uncompensated lens distortion. The impact of lens distortion can be greater towards the edges of the image. If, during verification, an optical extensometer system exhibits undesirable levels of non-linearity, restricting the portion of the FOV verified may improve the verification.

A1.2.3.4 If a reduced portion of the FOV is used for the verification, then describe that reduced portion in the verification report.

A1.2.4 Follow the manufacturer's requirements and limits on the optical axis position.

NOTE A1.2—Many optical extensometer systems are designed to position the optical axis perpendicular to the surface marks being measured; variation from this perpendicular orientation can result in errors.

A1.2.5 Match the marking of a specimen or calibration fixture used for the verification as closely as possible to the markings that will be used on the specimens to be tested.

A1.2.6 Report the type of markings on the verification report.

A1.2.7 Verify the optical extensometer system at the WD at which it will be used. The optical extensometer system verification is only valid at the WD, or range of working distances, used in the verification. Use the verification of WD method provided by the manufacturer, if available. Some optical extensometer systems have software that optimizes the WD. If this feature is used when actual specimen testing is performed, the optimization feature should be used for this verification.

NOTE A1.3—Often suppliers of optical extensometer systems will recommend an optimal WD, or range of distances for best performance based on a specific lens and camera configuration as well as a recommended method to verify the WD.

A1.2.7.1 If the optical extensometer is not held in a fixed position where the user cannot change the WD, report the WD value or range of distances and identify where the measurement of the WD was made on the verification report.

A1.2.8 Consider the effect of out-of-plane movement on the optical-extensometer-system-measured strains. This requirement does not apply to optical extensometers systems that have been shown to unaffected by out-of-plane movement such as those employing telecentric optics or stereo camera systems (sometimes called 3D camera systems).

NOTE A1.4—Out of plane movement is movement of the specimen or calibration device towards or away from the optical extensometer (or movement of the optical extensometer towards or away from the specimen or calibration device). For optical extensometers that are affected by out of plane movement, even small changes in the distance between the optical extensometer and the specimen or calibration device can introduce errors. These errors become more significant at lower strains.

A1.2.9 For dot/line tracking and virtual optical extensometer systems that are used with multiple interchangeable lenses or different cameras, perform a separate verification for each camera/lens combination.

A1.2.9.1 If the optical extensometer system uses a variable magnifying lens, identify specific, repeatable magnification settings, and verify the optical extensometer system at each setting.

NOTE A1.5—Because the magnification can be easily or accidently changed in variable-magnification lenses care should be taken once the lens is adjusted to ensure these settings are not inadvertently changed. Some lenses offer locking features that reduce or eliminate this possibility.

A1.2.9.2 Report the lens magnification settings on the verification report if available.

A1.3 Gauge Length

A1.3.1 When verifying an optical extensometer system in strain units, establish a reference gauge length.

NOTE A1.6— If a displacement-measuring verification apparatus is used to verify the optical extensometer system, the gauge length must be known to derive strain from the verification apparatus.

NOTE A1.7—This process is often referred to as setting the gauge length.

A1.3.1.1 Metrologically Traceable gauge blocks or certified step blocks may be used to establish a reference gauge length as shown in Fig. A1.1.

A1.3.1.2 Other acceptable methods for establishing a reference gauge length may be specified by the manufacturer, but shall be metrologically traceable.

A1.3.2 The second measurement of the gauge length as required in 5.2.1 may be omitted for optical between the optical extensometer systems.

A1.3.3 Determine the error associated with the reference gauge length. This value will be used in the overall classification of the extensometer system.

A1.3.4 Verify the optical extensometer system over the range of nominal gauge lengths used during testing. If three or more nominal gauge lengths are used during testing, verify the optical extensometer system at the minimum, maximum, and middle gauge lengths.

NOTE A1.8—Typically, optical extensometer systems have a continuously variable gauge length capability. However, suppliers of optical extensometer systems will typically specify a minimum gauge length.

A1.4 Optical extensometer systems can have other manufacturer specific software and hardware user selectable settings that can affect their measurement performance. Refer to the manufacturer's descriptions of these user settings. This verification only applies to the settings used for the verification.

A1.4.1 Report the values and settings of all user-selectable settings used during the verification that can affect the results of the optical extensometer system measurement results in the verification report.