



Standard Guide for Verifying Computer-Generated Test Results Through The Use Of Standard Data Sets¹

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^{ε1} NOTE—3.1.2 and 3.1.4 were editorially updated in December 2011.

1. Scope

1.1 This guide establishes a process for the verification of application software used to calculate the mechanical properties of materials.

1.2 This guide has two purposes: (1) it provides guidelines for creating standard data sets for verifying computer-generated test results, and (2) it describes how users can verify whether the calculations in their application software produce accurate, acceptable results. This does not ensure that the software will produce correct results in all cases. The verification is only for those conditions covered by the standard data sets. This guide uses the concept of standard “data sets,” which are made available by the ASTM groups responsible for each of the individual standards.

1.3 This guide defines the terminology, the format, and the process for the use of these data sets and how the data sets are to be used for verification. It does not define the specific data sets required to verify each of the application standards. Rather, such data sets would become a necessary part of the standard and would be classified as an adjunct in accord with the definition in section B29 of the “Form and Style for ASTM Standards.” This classifies an adjunct as any material that is required for use of the standard but is not practicable to publish as an integral part of the standard.

1.4 In **Annex A1** there is an example of how such data sets would be made available for one example standard.

1.5 Because the verification data sets are contained in files supplied to the application software in the computer, this procedure only provides verification of post-test calculations performed by the computer system. It does not evaluate the data acquisition system, real-time calculations, or any other part of the software beyond the post-test calculations.

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2. Referenced Documents

2.1 ASTM Standards:²

E1823 [Terminology Relating to Fatigue and Fracture Testing](#)
E1942 [Guide for Evaluating Data Acquisition Systems Used in Cyclic Fatigue and Fracture Mechanics Testing](#)

E1856 [Guide for Evaluating Computerized Data Acquisition Systems Used to Acquire Data from Universal Testing Machines](#)

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *ASCII*—American National Standard Code for Information Interchange. Data supplied in this form is readable by any computer system and will be displayed on the screen in human readable form.

3.1.2 *raw data*—the sampled values of a sensor output.

3.1.3 *data set*—A self-contained set of data consisting of a preamble, specimen information, and basic data. This may take the form of a printed document or a computer data file.

3.1.4 *derived data*—data obtained through the processing of the raw data.

3.1.5 *expected results*—The results accompanying the data sets that are expected from the computer.

3.1.6 *item separator*—A special character (delimiter) used to separate items that appear on one line of ASCII characters.

3.1.7 *keyword*—A text word or combination of characters that uniquely identify an item of information in the Specimen Information section. Such keywords are defined in a preamble to the data set within the standard in which they are to be used.

3.1.8 *line terminator*—A character or sequence of characters used to signify the end of a line of ASCII characters.

3.1.9 *preamble*—A text section describing the data set, which standard it applies to, any critical information and restrictions for use of the data sets, and the expected values

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.

(derived data) to be found as a result of running the algorithm using the basic data. This section of the data set would not be used by the computer, and would normally be stripped off of the data set prior to its use with the computer.

3.1.10 *segment marker*—A column of data alongside the columns of basic data which indicate different control sections during the test, such as loading versus unloading sections, which might be needed by the algorithm under evaluation.

3.1.11 *specimen information*—Information about a tested specimen, other than the basic data, such as specimen dimensions, speed of testing, and any other relevant information that are required in the analysis.

3.1.12 *status*—The status of the standard data set indicates that it has either been approved by the appropriate ASTM entity, or that it is unapproved. Unapproved data sets may be posted and made available to users for round robin testing or other purposes, but results from the use of an unapproved data set would not meet the requirements of this standard guide.

4. Description of the Use of Basic Data For Software Verification.

4.1 In its most basic form, a mechanical testing system consists of a test frame with grips which attach to a test specimen, a method of applying forces to the specimen, and a number of transducers that measure the forces and deformations applied to the specimen. (See Fig. 1)

4.2 The measurement system may be divided into three sections for the purpose of verification: the mechanical test frame and its components, the electrical measurement system, and the computer processing of data. This guide is specifically concerned only with the final section, namely the computer processing of data once the basic data are acquired.

4.3 The principle of using data sets is that a standard may publish as an adjunct a set of basic data and expected results

that may be used to verify that software designed to implement the calculations is performing correctly. The user of the data set inputs such data into their computer either automatically, manually, or a combination of both.

4.3.1 For example, it may prove most convenient to input the specimen information (described in 4.7) manually, and then have the computer read the basic data as a file. The user then starts the computation and compares the actual results with expected results supplied along with the data set. If such results agree with the expected results within the specified tolerance, the computer algorithms may be considered verified. If not, the user must explore the reason for the difference.

4.4 When supplied in the form of a computer-readable file, the data set shall be in industry-standard ASCII format.

4.5 *Preamble Characteristics*—The preamble to the data set is a section of text containing at least the following:

4.5.1 Unique ID of the form: ASTM standard number to which this data set applies, DSxx, where xx is the data set number (revision year.) For example, E 1234-DS2(2005);

4.5.2 Title;

4.5.3 Any parameters required by the algorithm, and the units to be used;

4.5.4 Short description of the content of the data file and what test conditions this data set is verifying;

4.5.5 Details of the segment markers on the data file, if any;

4.5.6 Expected results (in appropriate units), as well as the allowable tolerance (in %); and

4.5.7 Contact information for ASTM International.

4.6 The preamble is initiated with the marker <preamble>, and terminated by the marker </preamble>.

4.7 *Specimen Information Characteristics:*

4.7.1 The specimen information section consists of a number of rows of information essential for use by the algorithm

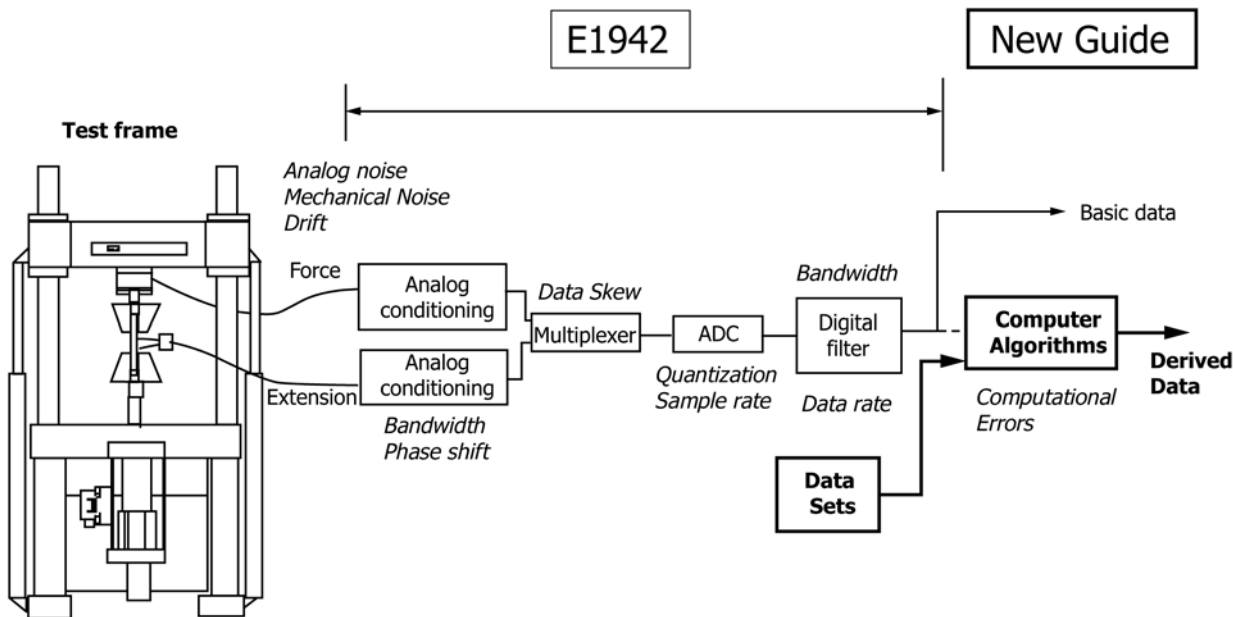


FIG. 1 Schematic of a typical test system

under evaluation. Such information might, for example, include the gage length of an extensometer, the dimensions of a specimen, or the test temperature. Each row has this format: keyword (text), item separator, value (numeric), units (text).

4.7.2 It is required for ease of use that the specimen information section contain only essential information for the calculations to be performed by the computer. Such information would include the length of the basic data file. Other information, such as specimen identification, relative humidity, and so forth which might normally be included in a test report should not be included in the specimen information section of the data set.

4.7.3 The specimen information section is initiated with the marker <specimen_info> and terminated by the marker </specimen_info>.

4.8 Basic Data Characteristics:

4.8.1 Following the specimen information section are two or more columns of synchronous data in a table representing or containing data acquired from a test. The order and contents of each column are defined by the standard using the data set. For example, the first column might be values for Crack-Tip Opening Displacement (COD), and the second might be the corresponding force values. The first row of the table contains column descriptors (text). The second row contains units (text) for each column of data. For example, the COD values might be in mm, and the force values in Newtons.

4.8.2 The data is initiated with the marker <data>, and terminated by the marker </data>.

4.8.3 Following the two rows of column headings are rows of basic data. Each row has the format: X value (numeric), item separator, Y value (numeric), [item separator], [Y2 value (numeric)], [item separator],...[segment marker], line terminator.

4.8.4 Items enclosed by square brackets [] in 4.8.3 are optional .

4.8.5 The segment marker is an optional field in the data that indicates different sections of data, such as an initial loading section, or loading and unloading compliance sections. Its inclusion depends on whether it is required for the algorithm being tested.

4.9 Basic Data Types:

4.9.1 Two or more types of Basic Data are suitable for evaluating computer algorithms, absolute and typical, as follows.

(1) Absolute data sets are made of straight lines and segments, which have only one, absolute correct answer (for example, a very tight accuracy tolerance).

(2) Typical data sets more closely resemble the actual data one might expect from a test, such as, non-linear curves, discontinuities, or other data characteristics typical of the standard test.

4.10 Validity Testsⁱ

4.10.1 It is up to the Task Group or Committee responsible for the Standard to create and recommend data sets that will adequately test the software for valid or invalid results. That is, if the software must be configured to catch certain things that

make a test invalid, the data set and expected results must be configured to test these validity checks.

4.11 Expected Results:

4.11.1 The expected results are supplied along with the basic data set and provide the correct, calculated (derived) results that should be produced by the software. Also included with the expected results is a tolerance band (+ or – a certain % of the result) within which the derived data must fall in order to be considered acceptable. If the derived data falls outside the tolerance band, then it is presumed that the calculations, or calculation parameters, are incorrect or improperly selected.

4.12 Reformatting:

4.12.1 It is expected that in many cases the data set may have to be reformatted prior to use, for example, to remove the preamble and some or all of the specimen information. This may be readily done using a suitable software tool to produce a reformatted data file that meets the needs of the computer. Note that reformatting does not include or permit any content changes.

4.13 ASCII File format:

4.13.1 In the preamble section of the data set, there are no format requirements other than that it be in ASCII format and readable by any standard text reader. In the specimen information and data sections, items are in columns separated by the tab separator <09h>. The end-of-line terminator should be a sequence of carriage return followed by linefeed <0Dh> <0Ah>. Zeroes before decimal separators and after the last significant digit are optional. Numbers shall not use a thousands separator.

5. System Requirements

5.1 No materials specimens or testing machines are required for this evaluation. All that is necessary is the computer loaded with the software (algorithm) to be evaluated

5.2 The specimen information is supplied to the computer either by being manually typed in, or by direct input if the software can adapt to the format supplied.

5.3 The basic data is then entered by being read from a file on the computer, or from a storage medium such as a CD.

6. Procedure for Creating Data Sets

6.1 Each Committee responsible for a standard that wishes to add a test data set to their standard should undertake the following steps:

6.1.1 *Decide on Parameters to be Verified*, The committee should decide which parameters determined by the standard might be implemented by computer algorithms and should be verified.

6.1.2 *Obtain Data*, The committee should obtain one or several sets of basic data (absolute or typical, or both) that are representative of test data that might be obtained from a physical test. These should then be formatted as described in this standard for circulation.

6.1.3 *Provide Expected Results & Tolerance*, The committee should agree on the expected result(s) from each of the data

sets provided, along with an acceptable tolerance band (percentage of the result). Ideally a round-robin should be performed to obtain expected results from the test data.

6.1.4 The committee should agree what, if any, supporting documentation should be associated with the data set. This documentation includes background information and pertinent to the data set but not required for its use.

NOTE 1—Care should be taken to provide data sets that adequately test for valid and invalid tests.

6.1.5 *Issue Standard Data Set*, The Committee ballots and then publishes the standard data set and supporting documentation as an adjunct to their standard.

6.1.6 *Storage and Maintenance of the Standard Data Set*, Once issued, the standard data set is given a unique identification and made available as adjuncts.

7. Procedure for Using Data Sets

7.1 Standard data sets are intended to be used with application software that allows the import of ASCII data. As

appropriate, the user should set up the application software (method) to produce the exact same results that are available in the data set (for example, EEFF, Pmax, and so forth, as shown in the attached sample data set). The application software should then be used to generate test results from the data set, and the results compared to those provided in the data set. Both sets of results should agree to within the tolerance provided in the data set in order to meet the requirements of this verification.

8. Report

8.1 After the algorithm under test has processed the basic data, the results are compared with the expected results given in the preamble. If the results agree within the stated percentage, then the algorithm may be considered to be acceptable.

9. Keywords

9.1 algorithm; calculation; data acquisition; mechanical properties; software; standard data sets; validation; verification

ANNEX

A1. EXAMPLE OF A STANDARD DATA TEST

A1.1 See [Table A1.1](#).

TABLE A1.1 Example of a Standard Data Set

Note: The Standard Data Set has a unique ID and three sections: Preamble, Specimen Information, and Data.

The Preamble does not have a fixed format. It is in plain language and may be translated into other languages. It is initiated with the marker <Preamble> and terminated with </Preamble>. The Specimen Information has a fixed format and lists only parameters defined in the Preamble and their corresponding values, with units. It is initiated with <Specimen_Info> and terminated with </Specimen_Info>. The Data section consists of two or more columns of data. The first row of each column has text naming the parameter, and the second row names the units. The Data section is initiated with <Data> and terminated with </Data>.

The values given in the example below, including the tolerances on the Expected Results, are only for illustration.

<Preamble>

E399/1-DS1(2005)

Contact information: ASTM International,
www.astm.org/[appropriate subcommittee]

Status: Approved

This is a Standard Data Set E399/1 to evaluate computer algorithms for ASTM Standard E399. It assumes a C(T) specimen geometry. Its format of this Data Set complies with ASTM Standard EXXXX-YYYY. Required parameters within the Specimen Information are the following:-

BVALUE = Specimen Thickness

WVALUE = Specimen Width

AVALUE1 = First value for Crack Length

AVALUE2 = Second value for Crack Length

AVALUE3 = Third value for Crack Length

SIGMAYS = Yield Strength

The Expected Results are:-

EEFF = Youngs' Modulus in GPa = 65.18 ± 1.0 %

PMAX = Maximum load in kN = 20.52 ± 0.5 %

PQ = Load at point Q in kN = 14.61 ± 0.4 %

KQVAL = Validity of KQ = FALSE

KQ = Stress intensity Factor in MPa√m = 51.98 ± 1.0 %

KICVAL = Validity of KIC = FALSE

</Preamble>

<Specimen_Info>

BVALUE 10.16 mm

WVALUE 76.29 mm

AVALUE1 39.16 mm

AVALUE2 38.96 mm

AVALUE3 38.76 mm

SIGMAYS 400 MPa

</Specimen_Info>

<Data>

COD Load

mm kN

0.006096 0.346944

0.012446 0.458144

0.018542 0.564896

0.2794 0.693888

0.037084 0.805088

0.040386 0.91184

... ..

...

</Data>

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