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Standard Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases[1]

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1. Scope

1.1 This guide establishes essential and desirable data elements for fiber-reinforced composite materials for two purposes: to establish the material identification component of data-reporting requirements for test reporting and to provide information for the design of material property databases.

1.1.1 This guide is the first part of a two-part modular approach. The first part serves to identify the material and the second part serves to describe testing procedures and variables and to record results.

1.1.2 For mechanical testing, the related document is Guide E1434. The interaction of this guide with Guide E1434 is emphasized by the common numbering of data elements. Data Elements A1 through G13 are included in this guide, and numbering of data elements in Guide E1434 begins with H1 for the next data element block. This guide is most commonly used in combination with a guide for reporting the test procedures and results such as Guide E1434.

1.2 These guidelines are specific to fiber-reinforced polymer-matrix composite materials. Composite materials, which also contain particulates or precipitated particles, are also included provided they can be described adequately as a filler in the matrix.

1.3 The data elements described in this guide are suggested for use in recording data in a computerized database, which is different from contractual reporting of test results. The latter type of information is described in the material specification or shown in business transactions and is subject to agreement between the vendor and the user.

1.4 This guide defines the information that is considered essential to uniquely describe a composite material. Additional data elements that are considered desirable, but not essential, are also defined. The purpose is to facilitate efficient storage and retrieval of information with a computer and to allow the meaningful comparison of data from different sources.

1.5 This guide with Guide E1434 may be referenced by the data reporting section of a test method to provide common data reporting requirements for mechanical tests of high-modulus fiber-reinforced polymer-matrix composite materials. This guide may also be useful for additional tests, for material identification for databases at the property levels or for other uses of material identification of composite materials.

1.6 From this information and a guide such as Guide E1434, the database designer should be able to construct the data dictionary preparatory to developing a database schema.

1.7 Data elements in this guide are relevant to test data, data as obtained in the test laboratory and historically recorded in laboratory notebooks. Property data, data that have been analyzed and reviewed, require a different level of data elements. Data elements for property data are provided in Annex A1.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C274 Terminology of Structural Sandwich Constructions

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D1600 Terminology for Abbreviated Terms Relating to Plastics

D3410/D3410M Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading

D3878 Terminology for Composite Materials

D5467/D5467M Test Method for Compressive Properties of Unidirectional Polymer Matrix Composite Materials Using a Sandwich Beam

D6507 Practice for Fiber Reinforcement Orientation Codes for Composite Materials

E6 Terminology Relating to Methods of Mechanical Testing

[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.

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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.

E1013 Terminology Relating to Computerized Systems (Withdrawn 2000)[3]
E1308 Guide for Identification of Polymers (Excludes Thermoset Elastomers) in Computerized Material Property Databases (Withdrawn 2000)[3]
E1338 Guide for Identification of Metals and Alloys in Computerized Material Property Databases
IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modern Metric System
E1434 Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases
E1443 Terminology Relating to Building and Accessing Material and Chemical Databases (Withdrawn 2000)[3]
E1471 Guide for Identification of Fibers, Fillers, and Core Materials in Computerized Material Property Databases
E1484 Guide for Formatting and Use of Material and Chemical Property Data and Database Quality Indicators (Withdrawn 2000)[3]

2.2 *Other Documents:*
ANSI X3.172-1996 Information Technology—American National Standard Dictionary of Information Technology (ANSDIT)[4]
A Glossary of Terms Relating to Data, Data Capture, Data Manipulation, and Databases, CODATA Bulletin, Vol 23, Nos 1-2, CODATA, Paris, January-June 1991[5]
ISO 8601 Data Elements and Interchange Formats—Information Interchange—Representation of Dates and Times[6]

3. Terminology

3.1 *Definitions*—Terminology in accordance with Terminologies D3878, C274, and E1443 shall be used where applicable.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *category set*—a closed listing of all possible strings which could be included in a particular field of a record. **(E1443)**

3.2.2 *composite material*—a substance consisting of two or more materials, insoluble in one another, which are combined to form a useful engineering material possessing certain properties not possessed by the constituents.

3.2.2.1 *Discussion*—A composite material is inherently inhomogeneous on a microscopic scale but can often be assumed to be homogeneous on a macroscopic scale for certain engineering applications. The constituents of a composite retain their identities; they do not dissolve or otherwise merge completely into each other, although they act in concert. **(D3878)**

3.2.3 *data dictionary*—a collection of the names of all data items used in a software system together with relevant properties of those items; for example, length of data item, mode of representation, and so forth. (CODATA)

3.2.4 *data element*—one individual piece of information used in describing a material or to record test results. For example, a variable name, test parameter, and so forth.

3.2.5 *database schema*—in a conceptual schema language, the definition of the representation forms and structure of a database for the possible collection of all sentences that are in the conceptual schema and in the information base, including manipulation aspects of these forms. **(ANSI X3.172)**

3.2.6 *essential data element*—a data element in a record which must be completed in order to make the record meaningful in accordance with the pertinent guidelines or standard. **(E1443)**

3.2.6.1 *Discussion*—Data elements are considered essential if they are required to make a comparison of property data from different sources meaningful. 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.

3.2.7 *gel point, n (or gel time)*—a point in a cure cycle where a thermosetting polymer resin resolidifies after melting.

3.2.8 *lay-up, n*—a process or fabrication involving the placement of successive layers of materials.

3.2.9 *lay-up code, n*—a designation system for abbreviating the stacking sequence of laminated composites. **(D3878)**

3.2.10 *matrix, n*—in composite materials, the continuous constituent of a composite material which acts as the load transfer mechanism between the discrete dispersed reinforcement constituent.

3.2.10.1 *Discussion*—A composite matrix is a bonding structure which unites, fills, and encloses the composite's reinforcement structures.

3.2.11 *ply count, n*—in laminated composite materials, the number of plies or laminae used to construct the composite.

3.2.12 *prepreg, n*—the admixture of fibrous reinforcement and polymeric matrix used to fabricate composite materials. Its form may be sheet, tape, or tow. For thermosetting matrices, it has been partially cured to a controlled viscosity call "B stage." **(D3878)**

3.2.13 *sandwich construction, n*—a structural panel concept consisting in its simplest form of two relatively thin sheets of structural material bonded to and separated by a relatively thick lightweight core.

3.2.14 *stacking sequence, n*—the arrangement of ply orientations and material components in a laminate specified with respect to some reference direction. **(D3878)**

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

[3] The last approved version of this historical standard is referenced on www.astm.org.
[4] *MIL-HDBK-17-2D, Polymer Matrix Composites*, Vol 2, Section 1.6, Feb. 23, 1994, available from Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094. Attn: NPODS Additional information on handbook availability at http:/mil-17.udel.edu/.
[5] *DOD/NASA Advanced Composites Design Guide*, Air Force Wright Aeronautical Laboratories, Dayton, OH, prepared by Rockwell International Corp., 1983 (distribution limited).
[6] *MIL-HDBK-17*, Vol. 2, Section 1.6.1, available from Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, and Terminology D1600

3.2.15.1 *Discussion*—A closed listing of such string is called a domain or category set.

3.2.16 *void content, n*—the percentage of voids in a composite.

3.2.17 *volatiles content, n*—the percentage of volatiles which are driven off as vapor from a plastic or an impregnated reinforcement.

3.3 Other relevant terminology can be found in Terminologies E6 and E1013.

4. Significance and Use

4.1 This guide provides the recommended data elements for the identification of fiber-reinforced composite materials. The ASTM standards for which this guide was developed are listed in 2.1. The recommended data elements can be used with experimental data records and analyzed property records.

4.2 The intent of this guide is to provide sufficient detail that values are known for the material parameters that may influence test results or material property values. The motivation for this guide is the steadily increasing use of computerized databases. However, these guidelines are equally appropriate for data stored in a hard-copy form.

4.3 This guide is for material identification and description only. It does not include the recommended data elements for mechanical test data or other specific types of test data. These items are covered by separate formats to be referenced in material specifications or other test standards.

4.4 Composite materials are defined as two or more materials that are combined on a macroscale. There is a gray area between composites and other material classes. Two examples of this gray area between polymer matrix composites and plastics are toughened polystyrene and liquid crystal polymer. The present guide may be used to help the database designer determine how to handle materials that fall into this gray area. The selection of which guide to use, this guide or Guide E1308 for plastics, should depend on whether the additional data elements in this guide are required by the data user, as follows. If information on orientation and form of reinforcement is needed by the intended data/database user, the composite materials guide may be more useful since it contains data elements for this information. Appendix X1 contains a table, which provides guidelines for distinguishing between reinforced polymers and polymer matrix composites.

4.5 Composite materials consist of a matrix phase and one or more discrete reinforcements. Reinforcements may be interpreted broadly to include any macroscale second material, including fibers, particulates, precipitated particles, or structured domains of the parent material. The reinforcements covered in this guide include fibers and such particulates and precipitated particles that can be described adequately as filler within the matrix. The reinforcements may be polymers, metals, ceramics, or other materials. Sandwich constructions are not covered by this guide; data recording for test methods which use a sandwich specimen should refer to Guide E1471 for identification of the core material. These guidelines are suitable for the identification of composites in simple shapes of constant thickness; for example, plates or tubes. For complex structures, additional information relevant to a specific application may be required.

4.6 Classification of composite materials is complicated by the fact that composites are formed by combining different materials in varying amounts and configurations; this results in an infinite number of possibilities. An effective identification scheme must be capable of possible combinations without overburdening the system with details relevant only to a limited number of material systems. This guide provides both essential data elements and data elements that are considered desirable but not essential. Data elements are considered essential if they are required to make a meaningful comparison of property data from different sources.

4.7 Identification of constituent materials of the composites is included to the level considered necessary for identification of the composite. Additional information may be necessary when the constituent is considered independently. Guides for polymers (E1308), metals (E1338), and reinforcements (E1471) should be consulted in this case.

4.8 Comparison of property data from different databases will be most meaningful if all the essential information defined by the guide is present. Comparison may still be possible if essential information is omitted, but the usefulness of the comparison may be greatly reduced.

4.9 This information should not be considered restrictive. For example, a database designer may find it useful to aggregate several data elements, such as all data elements in a test method data element set or the material and chemical classes, into a single field. This may affect search strategies and other database operations. These considerations are beyond the scope of this guide.

5. Data Reporting

5.1 This guide is intended to provide common data reporting requirements for material identification when used for reporting testing and material properties based on accumulated results from a number of tests. The data reporting section of standard test methods may reference this guide for material identification in conjunction with Guide E1434 for recording of the test procedure, parameters, and results. In addition, such a data reporting section may identify any usage specific to that document. One example of usage specific to a test method is Test Method D5467/D5467M, which may require additional information to identify the core material for the sandwich specimen from Guide E1471. These requirements do not mean that the information must be reported separately for each specimen or that all information must be reported separately for each batch. Any data elements that are the same for a series of specimens or for a series of batches may be reported once for the entire series, as long as it is clearly indicated that they apply to all specimens or all batches.

5.2 Five levels of requirement are defined in Section 8 and identified in Table 1. The cost of acquiring and storing the data documentation is recognized. Less extensive data reporting requirements may be established for a given program or purpose upon agreement of the parties involved.

5.3 In addition, for identifying materials, some data elements are essential only if relevant. For example, Data Element D3, fabric style is required for material traceability, but is currently used only for certain types of fiber (primarily glass). Fabric styles have not been standardized for carbon fibers.

TABLE 1 Data Elements for Identification of Composite Materials

NOTE 1—Standard Data Element Sets (third column)—enclosed in square brackets.

NOTE 2—Requirement Levels (fifth column):
ET - Essential for Test validity
RT - Recommended for Test validity
EM - Essential for Material traceability
RM - Recommended for Material traceability
O - Optional

No.	Data Element Descriptive Name	Data Type or Standard Data Element Set	Category Set, Value Set, or Units	Level
	A. Composite Material Identification Block			
A1	Material identifier	STRING		ET
A2	Data source identification	STRING		ET
A3	Composite material name	STRING	Calculated	O
A4	Material class	STRING	“Composite”	O
A5	Material subclass	STRING	Calculated	O
A6	Material form	STRING		EM
A7	Matrix class	STRING	“Polymer”	EM
A8	Reinforcement class	STRING	Table 2	EM
A9	Reinforcement subclass	STRING	Table 3	EM
A10	Material specification	[Specification]		RM
A11	Material source (if not from manufacturer)	[Organization]		RM
A12	Material maximum temperature, nominal	REAL	C(F)	O
A13	Material minimum temperature, nominal	REAL	C(F)	O
A14	Material MSDS and assigning organization	STRING		O
A15	Contract number	STRING		O
A16	Data restrictions	STRING		O
	B. Fiber Information Block			
B1	Fiber class	STRING	Table 4	RM
B2	Fiber chemical class	STRING	Table 5	ET
B3	Fiber chemical family	STRING	Table 6	RM
B4	Fiber modulus subfamily	STRING	Table 7	O
B5	Fiber commercial name	STRING		EM
B6	Fiber additional name information	STRING		RM
B7	Fiber manufacturer’s specification	[Specification]		RM
B8	Fiber user’s specification	[Specification]		O
B9	Fiber manufacturer’s internal designation	STRING		O
B10	Fiber manufacturer	[Organization]		RM
B11	Fiber lot	STRING		EM
B12	Fiber date of manufacture	DATE		RM
B13	Fiber batch certification number	STRING		O
B14	Fiber density	REAL	g/cm^3	EM
B15	Fiber density test method	[Test method]		EM
B16	Tow or yarn filament count	INTEGER		EM
B17	Tow or yarn filament count test method	[Test method]		RM
B18	Tow/strand linear density	REAL	tex	O
B19	Tow/strand linear density test method	[Test method]		O
B20	Tow yield	REAL	m/g	O
B21	Fiber filament diameter	REAL	mm	EM
B22	Fiber filament diameter test method	[Test method]		RM
B23	Filament cross-section type	STRING	Table 8	RM
B24	Surface treatment type	STRING	Table 9	RM
B25	Surface treatment detail	STRING		RM
B26	Tow or yarn sizing identification	STRING		RM
B27	Tow or yarn sizing amount	REAL		RM
B28	Tow or yarn twist amount	REAL	t/m	RM
B29	Tow or yarn twist direction	STRING	Table 10	RM
	C. Matrix Information Block			
C1	Matrix subclass	STRING	Table 11	EM
C2	Matrix chemical family	STRING	Table 12	ET
C3	Matrix subfamily	STRING	Table 13	O
C4	Matrix commercial name	STRING		EM
C5	Matrix manufacturer	[Organization]		EM
C6	Matrix lot number	STRING		RM
C7	Matrix date of manufacture	DATE		RM
C8	Matrix filler type	STRING		RM
C9	Matrix filler amount	REAL		RM
C10	Matrix nominal density	REAL	g/cm^3	RM
C11	Matrix nominal density test method	[Test method]		RM
C12	Matrix internal designation	STRING		O

TABLE 1 *Continued*

No.	Data Element Descriptive Name	Data Type or Standard Data Element Set	Category Set, Value Set, or Units	Level
C13	Matrix manufacturer specification	[Specification]		O
C14	Gel time	[Auxiliary test]		O
	D. Preform Information Block			
D1	Preform architecture	STRING	Table 14	EM
D2	Preform identifier	STRING		EM
D3	Preform manufacturer	[Organization]		EM
D4	Preform method of manufacture	STRING	Table 15	
D5	Number of preform layers	INTEGER		EM
	2-D Fabric Information Subblock			
D6	Fabric manufacturer	[Organization]		EM
D7	Fabric weave type	STRING	Table 16	EM
D8	Fabric style number	STRING		EM
D9	Fabric lot	STRING		EM
D10	Fabric date of manufacture	DATE		RM
D11	Fabric batch certification number	STRING		O
D12	Fabric manufacturer specification	[Specification]		O
D13	Fabric user specification	[Specification]		O
D14	Fabric sizing identification	STRING		EM
D15	Fabric sizing content	REAL		EM
D16	Fabric end count (warp)	REAL	/m	EM
D17	Fabric fill fiber (if different)	STRING		EM
D18	Fabric pick count (fill)	REAL	/m	EM
D19	Fabric nominal fiber areal weight	REAL	g/mm^2	O
D20	Tracer warp name	STRING		O
D21	Tracer warp linear density	REAL	g/m	O
D22	Tracer warp spacing	REAL	/mm	O
D23	Tracer warp sizing	REAL		O
D24	Tracer fill name	STRING		O
D25	Tracer fill linear density	REAL	g/m	O
D26	Tracer fill spacing	REAL	/mm	O
D27	Tracer fill sizing	REAL		O
	3-D Woven Materials Subblock			
D28	Interlock description	STRING		EM
D29	Warp fiber filament count	INTEGER		EM
D30	Weft fiber filament count	INTEGER		EM
D31	Angle fiber filament count	INTEGER		EM
D32	Weaver yarn filament count	INTEGER		EM
D33	Percentage of warp yarn	REAL	%	EM
D34	Percentage of weft yarn	REAL	%	EM
D35	Angle of angle yarn (positive with respect to axial yarn)	REAL	degrees	EM
D36	Percentage of angle yarn	REAL	%	EM
D37	Percentage of weaver yarn	REAL	%	EM
D38	Percentage of through-thickness yarn	REAL	%	EM
D39	Pitch length	REAL	in.	EM
D40	Warp end count	REAL	tow/in.	EM
D41	Weft end count	REAL	tow/in.	EM
D42	Unit cell width	REAL	in.	O
D43	Unit cell length	REAL	in.	O
D44	Unit cell depth	REAL	in.	O
	Stitching Information Subblock			
D45	Stitch type	STRING		EM
D46	Stitch thread	STRING		EM
D47	Stitch axial pitch	REAL	degrees	EM
D48	Stitch row spacing	REAL	in.	EM
D49	Stitch denier	REAL	denier	RM
D50	Stitch filament count	INTEGER		EM
D51	Bias yarn end count	INTEGER		EM
D52	Bias yarn angle	REAL	degrees	EM
	Braiding Information Subblock			
D53	Braid description	STRING		EM
D54	Axial fiber type	STRING		EM
D55	Braid fiber type	STRING		EM
D56	Axial fiber filament count	INTEGER		EM
D57	Braid fiber filament count	INTEGER		EM
D58	Braid angle	REAL	degrees	EM
D59	Percentage of axial yarn	REAL	%	EM
D60	Percentage of braid yarn	REAL	%	EM
D61	Axial yarn spacing in braids	REAL	in.	RM
D62	Unit cell width	REAL	in.	O
D63	Unit cell length	REAL	in.	O
D64	Braider identification	STRING		RM
D65	Number of carriers	INTEGER		RM
	Winding Information Block			
D66	Winding description	STRING		EM

TABLE 1 *Continued*

No.	Data Element Descriptive Name	Data Type or Standard Data Element Set	Category Set, Value Set, or Units	Level
D67	Winder identification	STRING		RM
D68	Mandrel identification	STRING		EM
	E. Prepreg Information Block			
	Prepreg Identification Subblock			
E1	Prepreg type	STRING	Table 17	EM
E2	Prepreg commercial name	STRING		EM
E3	Prepreg manufacturer	[Organization]		EM
E4	Prepreg manufacturer's internal spec	[Specification]		O
E5	Prepreg source	[Organization]		O
E6	Prepreg dimension parameter	STRING	Table 18	RM
E7	Prepreg dimension value	REAL		RM
E8	Prepreg reinforcement orientation(s)	STRING		RM
E9	Scrim fiber chemical class	STRING	Table 5	RM
E10	Scrim fabric style	STRING		RM
E11	Prepreg additional information	STRING		RM
	Prepreg Batch Information Subblock			
E12	Prepreg batch number	STRING		EM
E13	Prepreg batch certification date	STRING		O
E14	Prepreg batch expiration date	DATE		RM
E15	Prepreg batch roll number	STRING		RM
	Prepreg Auxiliary Test Subblock			
E16	Prepreg fiber areal weight	[Auxiliary test]	g/m^2	EM
E17	Prepreg volatile content, wt%	[Auxiliary test]	wt%	EM
E18	Prepreg fiber content, vol%	[Auxiliary test]	vol%	RM
E19	Prepreg matrix content, wt%	[Auxiliary test]	Wt%	RM
E20	Prepreg matrix flow	[Auxiliary test]	Wt%	RM
E21	Prepreg matrix gel time	[Auxiliary test]		RM
E22	Prepreg tack	[Auxiliary test]		O
E23	Prepreg drape	[Auxiliary test]		O
	F. Process Information Block Process Specification Subblock			
F1	Process specification	[Specification]		RM
F2	Process reinforcement application	STRING	Table 19	EM
F3	Process mold type	STRING	Table 20	EM
F4	Tackifier common name	STRING		RM
F5	Tackifier chemical class	STRING	Table 12	RM
F6	Tackifier form	STRING	Table 21	RM
F7	Tackifier manufacturer	STRING		RM
	Process Description Subblock			
F8	Process stage type	STRING	Table 22	RM
F9	Process stage temperature	REAL	C(F)	RM
F10	Process stage pressure	REAL	psig	RM
F11	Process stage vacuum	REAL	psig	RM
F12	Process stage duration	REAL	min	RM
F13	Process ramp rate	REAL	C/min (F/min)	RM
F14	Process stage other parameter	STRING	degrees	RM
F15	Processor	[Organization]		EM
F16	Process start date	DATE		RM
F17	Process end date	DATE		RM
F18	Process records reference	STRING		RM
	G. Part Information Block Part Description Subblock			
G1	Part form	STRING	Table 23	EM
G2	Material orientation code	STRING		EM
G3	Part specification	[Specification]		RM
G4	Part dimension parameter	STRING		RM
G5	Part dimension value	REAL		RM
G6	Part history	STRING		EM
G7	Part additional information	STRING		RM
	Part Auxiliary Test Subblock			
G8	Part resin content by weight	[Auxiliary test]	wt%	
G9	Part fiber content, by volume	[Auxiliary test]	vol%	EM
G10	Part fiber areal weight	[Auxiliary test]	g/m^2	
G11	Part void content, by volume	[Auxiliary test]	vol%	EM
G12	Part mass density	[Auxiliary test]	g/cm^3	EM
G13	Part glass transition temperature—dry	[Auxiliary test]	C(F)	EM
G14	Part glass transition temperature—wet	[Auxiliary test]	C(F)	EM
G15	Footnotes	STRING		EM

TABLE 2 Value Set for Reinforcement Class

Fiber	Filler	Core