



Standard Practice for Reporting Uniaxial Strength Data and Estimating Weibull Distribution Parameters for Advanced Ceramics¹

This standard is issued under the fixed designation C 1239; 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 practice covers the evaluation and subsequent reporting of uniaxial strength data and the estimation of probability distribution parameters for advanced ceramics that fail in a brittle fashion. The failure strength of advanced ceramics is treated as a continuous random variable. Typically, a number of test specimens with well-defined geometry are failed under well-defined isothermal loading conditions. The load at which each specimen fails is recorded. The resulting failure stresses are used to obtain parameter estimates associated with the underlying population distribution. This practice is restricted to the assumption that the distribution underlying the failure strengths is the two-parameter Weibull distribution with size scaling. Furthermore, this practice is restricted to test specimens (tensile, flexural, pressurized ring, etc.) that are primarily subjected to uniaxial stress states. Section 8 outlines methods to correct for bias errors in the estimated Weibull parameters and to calculate confidence bounds on those estimates from data sets where all failures originate from a single flaw population (that is, a single failure mode). In samples where failures originate from multiple independent flaw populations (for example, competing failure modes), the methods outlined in Section 8 for bias correction and confidence bounds are not applicable.

1.2 Measurements of the strength at failure are taken for one of two reasons: either for a comparison of the relative quality of two materials, or the prediction of the probability of failure (or, alternatively, the fracture strength) for a structure of interest. This practice will permit estimates of the distribution parameters that are needed for either. In addition, this practice encourages the integration of mechanical property data and fractographic analysis.

1.3 This practice includes the following:

	Section
Scope	1
Referenced Documents	2
Terminology	3
Summary of Practice	4
Significance and Use	5

Outlying Observations	6
Maximum Likelihood Parameter Estimators for Competing	7
Flaw Distributions	
Unbiasing Factors and Confidence Bounds	8
Fractography	9
Examples	10
Keywords	11
Computer Algorithm MAXL	X1
Test Specimens with Unidentified Fracture Origins	X2

1.4 The values stated in SI units are to be regarded as the standard.

2. Referenced Documents

2.1 ASTM Standards:

C 1145 Terminology of Advanced Ceramics²

C 1322 Practice for Fractography and Characterization of Fracture Origins in Advanced Ceramics²

D 4392 Terminology for Statistically Related Terms³

E 6 Terminology Relating to Methods of Mechanical Testing⁴

E 178 Practice for Dealing With Outlying Observations⁵

E 456 Terminology Relating to Quality and Statistics⁵

2.2 Military Handbook:

MIL-HDBK-790 Fractography and Characterization of Fracture Origins in Advanced Structural Ceramics⁶

3. Terminology

3.1 Proper use of the following terms and equations will alleviate misunderstanding in the presentation of data and in the calculation of strength distribution parameters.

3.1.1 *censored strength data*—strength measurements (that is, a sample) containing suspended observations such as that produced by multiple competing or concurrent flaw populations.

3.1.1.1 Consider a sample where fractography clearly established the existence of three concurrent flaw distributions (although this discussion is applicable to a sample with any number of concurrent flaw distributions). The three concurrent flaw distributions are referred to here as distributions A, B, and C. Based on fractographic analyses, each specimen strength is

¹ This practice is under the jurisdiction of ASTM Committee C28 on Advanced Ceramics and is the direct responsibility of Subcommittee C28.02 on Design and Evaluation.

Current edition approved Oct. 10, 2000. Published January 2001. Originally published as C 1239 – 93. Last previous edition C 1239 – 95.

² *Annual Book of ASTM Standards*, Vol 15.01.

³ *Discontinued*—see 1992 *Annual Book of ASTM Standards*, Vol 07.02.

⁴ *Annual Book of ASTM Standards*, Vol 03.01.

⁵ *Annual Book of ASTM Standards*, Vol 14.02.

⁶ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.