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.

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An American National Standard

Standard Guide for Assessment of Measurement Uncertainty in Fire Tests[1]

This standard is issued under the fixed designation E2536; 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.

INTRODUCTION

The objective of a measurement is to determine the value of the measurand, that is, the physical quantity that needs to be measured. Every measurement is subject to error, no matter how carefully it is conducted. The (absolute) error of a measurement is defined in Eq 1.

All terms in Eq 1 have the units of the physical quantity that is measured. This equation cannot be used to determine the error of a measurement because the true value is unknown, otherwise a measurement would not be needed. In fact, the true value of a measurand is unknowable because it cannot be measured without error. However, it is possible to estimate, with some confidence, the expected limits of error. This estimate is referred to as the uncertainty of the measurement and provides a quantitative indication of its quality.

Errors of measurement have two components, a random component and a systematic component. The former is due to a number of sources that affect a measurement in a random and uncontrolled manner. Random errors cannot be eliminated, but their effect on uncertainty is reduced by increasing the number of repeat measurements and by applying a statistical analysis to the results. Systematic errors remain unchanged when a measurement is repeated under the same conditions. Their effect on uncertainty cannot be completely eliminated either, but is reduced by applying corrections to account for the error contribution due to recognized systematic effects. The residual systematic error is unknown and shall be treated as a random error for the purpose of this standard.

General principles for evaluating and reporting measurement uncertainties are described in the Guide on Uncertainty of Measurements (GUM). Application of the GUM to fire test data presents some unique challenges. This standard shows how these challenges can be overcome. An example to illustrate application of the guidelines provided in this standard can be found in Appendix X1.

$$\varepsilon \equiv y - Y \tag{1}$$

where:

ε = measurement error;
y = measured value of the measurand; and
Y = true value of the measurand.

1. Scope

1.1 This guide covers the evaluation and expression of uncertainty of measurements of fire test methods developed and maintained by ASTM International, based on the approach presented in the GUM. The use in this process of precision data obtained from a round robin is also discussed.

1.2 The guidelines presented in this standard can also be applied to evaluate and express the uncertainty associated with fire test results. However, it may not be possible to quantify the uncertainty of fire test results if some sources of uncertainty cannot be accounted for. This problem is discussed in more detail in Appendix X2.

1.3 Application of this guide is limited to tests that provide quantitative results in engineering units. This includes, for

[1] This guide is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.31 on Terminology and Services / Functions.

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example, methods for measuring the heat release rate of burning specimens based on oxygen consumption calorimetry, such as Test Method E1354.

1.4 This guide does not apply to tests that provide results in the form of indices or binary results (for example, pass/fail). For example, the uncertainty of the Flame Spread Index obtained according to Test Method E84 cannot be determined.

1.5 In some cases additional guidance is required to supplement this standard. For example, the expression of uncertainty of heat release rate measurements at low levels requires additional guidance and uncertainties associated with sampling are not explicitly addressed.

1.6 This fire standard cannot be used to provide quantitative measures.

1.7 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.8 *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]

E84 Test Method for Surface Burning Characteristics of Building Materials

E119 Test Methods for Fire Tests of Building Construction and Materials

E176 Terminology of Fire Standards

E230 Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E1354 Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter

E2989 Guide for Assessment of Continued Applicability of Reaction to Fire Test Reports Used in Building Regulation

2.2 *ISO Standards:*[3]

ISO 29473 Fire tests — Uncertainty of measurements in fire tests

ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories

GUM Guide to the expression of uncertainty in measurement

2.3 *CEN Standard:*[4]

EN 13823 Reaction to fire tests for building products – Building products excluding floorings exposed to the thermal attack by a single burning item

3. Terminology

3.1 *Definitions:* For definitions of terms used in this guide and associated with fire issues, refer to the terminology contained in Terminology E176. For definitions of terms used in this guide and associated with precision issues, refer to the terminology contained in Practice E691.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *accuracy of measurement, n*—closeness of the agreement between the result of a measurement and the true value of the measurand.

3.2.2 *combined standard uncertainty, n*—standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariances of these other quantities weighted according to how the measurement result varies with changes in these quantities.

3.2.3 *coverage factor, n*—numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty.

3.2.4 *error (of measurement), n*—result of a measurement minus the true value of the measurand; error consists of two components: random error and systematic error.

3.2.5 *expanded uncertainty, n*—quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand.

3.2.6 *measurand, n*—quantity subject to measurement.

3.2.7 *precision, n*—variability of test result measurements around reported test result value.

3.2.8 *random error, n*—result of a measurement minus the mean that would result from an infinite number of measurements of the same measurand carried out under repeatability conditions.

3.2.9 *repeatability (of results of measurements), n*—closeness of the agreement between the results of successive independent measurements of the same measurand carried out under repeatability conditions.

3.2.10 *repeatability conditions, n*—on identical test material using the same measurement procedure, observer(s), and measuring instrument(s) and performed in the same laboratory during a short period of time.

3.2.11 *reproducibility (of results of measurements), n*—closeness of the agreement between the results of measurements of the same measurand carried out under reproducibility conditions.

[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, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[4] Available from European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, http://www.cen.eu.