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Standard Guide for Determining Uses and Limitations of Deterministic Fire Models[1]

This standard is issued under the fixed designation E 1895; 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 guide provides a methodology for the systematic evaluation of fire models, which may be used in fire hazard analyses.

1.2 This guide provides a means of identifying both general and specific limitations of fire models for specific applications.

1.3 This guide is intended to assist model developers, model users, and authorities having jurisdiction in assuming the responsible use of fire models.

1.4 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 176 Terminology of Fire Standards[2]

E 603 Guide for Room Fire Experiments[2]

E 1355 Guide for Evaluating the Predictive Capability of Fire Models[2]

E 1472 Guide for Documenting Computer Software for Fire Models[2]

E 1474 Test Method for Determining the Heat Release Rate of Upholstered Furniture and Mattress Components of Composites Using a Bench Scale Oxygen Consumption Calorimeter[2]

E 1546 Guide for Development of Fire-Hazard-Assessment Standards[2]

E 1591 Guide for Data for Fire Models[2]

2.2 *Other Documents:*

Survey of Computer Models for Fire and Smoke, Raymond Friedman, Factory Mutual[3]

NIST Handbook 146, Technical Reference Guide for the Hazard I Fire Hazard Assessment[4]

Technical Reference Guide for FPE Tool, Version 3.2, NISTIR 5486[4]

The SFPE Handbook of Fire Protection Engineering, 2nd Edition, Section 3, Chapter 15[5]

3. Terminology

3.1 *Definitions*—Definitions used in this guide are in accordance with Terminologies in E 176, unless otherwise indicated.

4. Significance and Use

4.1 This guide provides recommendations for fire model users and authorities having jurisdiction in establishing the limitations of fire models in fire risk and fire hazards assessments. The guide also makes recommendations for fire model developers to identify appropriate uses and limitations of their model.

4.2 This guide is intended to assist in evaluating the appropriate use of fire models in fire assessment. These types of assessments are employed in product development, as well as in design and construction. Further guidance can be found in Guide E-1546.

4.3 This guide is not intended to address all or limit any methods of evaluating proper use of a fire model. It does address the use of fire models in fire hazard assessment. Other uses of fire models include post-fire analysis, research, education, and litigation.

4.4 The primary emphasis of this guide is on zone models of compartment fires. However, other types of mathematical models need similar evaluations of their prediction capabilities.

5. Guidance for Model Users

5.1 A model user's first step should be to define the scope of the intended fire risk or fire hazard assessment, or both, and then determine if fire modeling is an appropriate tool to provide information for the decision making process.

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[1] This guide is under the jurisdiction of ASTM Committee E-15 on Fire Standards and is the direct responsibility of Subcommittee E05.33 on Fire Safety Engineering.

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[2] *Annual Book of ASTM Standards*, Vol 04.07.

[3] Available from Factory Mutual Engineering Corporation, 1511 Boston Providence Turnpike, Norwood, MA 02062.

[4] Available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

[5] Available from National Fire Protection Association, One Batterymarch Park, Quincy, MA 02269.

5.2 The user should then determine what models are available for use. Some are proprietary or not otherwise accessible.

5.2.1 The ability of the user's computer hardware, considering the size and complexity of the assessment, will also limit what fire models can be used.

5.2.2 A Factory Mutual report entitled "Survey of Computer Models for Fire and Smoke" provides a listing of fire models available in 1994.

5.3 For those models being considered, procure the available documentation and determine if it adequately addresses the issues described in Guide E 1472.

5.4 The user should then determine which model(s) fit the requirements of the assessment. For example, a single compartment model may or may not be of any use in a multicompartment assessment. A list of questions which may be used to consider the suitability of a model for a particular use is included in the Appendix.

5.5 If the model(s) do not fit the user's requirements, then the user must determine the feasibility of appropriately modifying the model.

5.5.1 It is strongly recommended that any modification to the code of a fire model be made in collaboration with the model developer. Modifications must be well documented.

5.5.2 The new code should be extensively validated for the application of interest. A methodology for validation can be found in Guide E 1355.

5.6 The use of other fire science tools, such as small and large scale fire tests; for example, Test Method E 1474 and Guide E 603, respectively, or a stochastic model as described in the SFPE Handbook of Fire Protection Engineering may be more appropriate than an existing model or otherwise necessary in the absence of an acceptable computer fire model.

5.7 If the model(s) appear to fit the user's requirements, then the following issues should be researched, understood, and documented as part of the assessment.

5.7.1 Verify the known or published limitations of the fire model, such as room geometry, ventilation, or fire size. The impact of these limitations on the user's assessment must be addressed.

5.7.2 Determine the underlying assumptions of the models, such as a two-layer assumption in zone fire models. The impact of these assumptions on the user's assessment must be addressed.

5.7.3 Determine the characteristic variables in the model.

5.7.4 Determine the input data required for the model. Also, determine the availability of relevant data and what standard test methods may be employed to develop the necessary input data. Guide E 1591 can be referenced to determine sources for some data types. The uncertainty associated with the input data should also be determined.

5.7.5 Determine the rigor of the numerics and evaluate any potential related problem, such as a failure of the model to converge within the constraints of the assessment.

5.7.6 Determine the extent of validation for each model to establish its appropriate uses within the realm of the assessment. Validation includes comparison to other validated models, comparison to fire test results, and agreement with actual fire experience. A method for validation is included in Guide E 1355.

5.7.7 If validation data is not available, then sensitivity analysis must be conducted to determine the impact of change in the important input variables to the estimation of the fire hazard and to provide the engineering bounds for the output results.

5.8 The use of fire models in fire risk and fire hazard assessment must be well documented. Documentation should include, as a minimum, all input, all assumptions, all modifications, and supporting information, which validates the specific application of the model.

6. Guidance for the Model Developer

6.1 The model developer should consider the proper use and possible misuse during validation and documentation of their models during the development process. These considerations need to be reflected in documents that provide guidance to identify proper use and to make misuse unlikely.

6.2 The developer should provide documentation accessible for public review that describes the known numerical and physical limitations and the assumptions inherent to the model. This should follow the guidelines of Guide E 1472.

6.3 The developer should provide documentation accessible for public review of the predictive capability of the model. A process for evaluating fire models is included in Guide E 1355.

6.4 The developer should provide documentation accessible for public review that describes the known limitations, numerical and physical, and assumptions inherent to their model.

6.4.1 A method of providing this documentation is to publish a comprehensive technical document or user's manual. A format for developing this type of document is included in Guide E 1472. One such example is the Technical Reference Guide for FPE Tool Version 3.2 NISTIR 5486.

6.4.2 Another example is to list the assumptions and limitations in a technical document and attach it with the software. An example of this type of document is "A Summary of the Assumptions and Limitations in Hazard I," which is provided with the Hazard I computer software package.

6.4.3 Another example of documenting and managing the limitations of a fire model is to include it within the computer code. The desired results can be achieved with text in the program interface, interactive warnings, or lockout of inappropriate input data.

6.5 The model developer should describe the test methods that may be used to validate the model and how data are to be developed for use in the fire model.

6.6 A description of the model should be presented in the peer-reviewed open literature.

7. Guidance for the Authority Having Jurisdiction

7.1 Often an individual or entity is responsible for the regulatory review and acceptance of an engineering assessment involving the use of fire models.

7.2 To assist in the review process, submittal of specific information can be requested of the model user.

7.2.1 The reviewer should request a copy of the model documentation and verify that it follows Guide E 1472.

7.2.2 The reviewer should request information on the predictive capability of the model and verify that it follows Guide E 1355.

7.2.3 The reviewer should request complete documentation of the analysis, including a description of the model(s), a listing of input and output, a listing of all assumptions made by the user, and a description of the known limitations of the model(s).

7.2.4 The reviewer should request the submittal of a listing of the model user's experience, education, and credentials that may demonstrate the user's knowledgeable and responsible use of the fire model. Such experience should include experience with fire models in general and experience with the specific model used in the application of interest.

7.2.5 The reviewer should request copies of the source code used in the analysis. This may be source code written by the model developer or modifications of the code by the model user (see 5.5.1).

7.2.6 The reviewer should request a sensitivity analysis to study the impact of change in input variables to the estimated fire hazard.

7.2.7 The reviewer should request additional calculations to assess the sensitivity of the assumptions and submodels.

8. Keywords

8.1 computer program; documentation; fire model

APPENDIX

(Nonmandatory Information)

X1. QUESTIONS USED FOR FIRE MODELS

X1.1 Appendix X1.1 is a list of questions that might be asked when deciding on the suitability of a fire model for a particular use.

1. How many rooms can be the model handle?
2. Can the model treat more than one item burning?
3. Can the model handle pre- and post-flashover fires?
4. What are the outputs from the model and do they include what I need?
5. What inputs are needed and are data available?
6. Can the model treat fire and smoke on more than one level.
7. Is there a height, area, or size of opening limitation on the model?
8. Is the fuel likely to produce a flame with unusual radiation? If so, does the model allow adjustment in the flame radiation fraction?
9. Is the fire likely to last long enough for the ceiling and walls to play a part? If so, does the model account for the thermal properties of the wall materials or burning walls?
10. Is the fire likely to be affected by the inflow of air from the opening? If so, can the model accommodate this effect?
11. Is the zone model assumption (all conditions in the upper hot layer are the same at any one time) adequate for addressing the problem?
12. How many gases can the model track through the building?
13. Will the fire last long enough where structural integrity of the walls or ceiling are to be a factor? If so, can the model account for this?
14. Can the model account for changes in the oxygen level surrounding the fire?
15. Will the model alert the user to unrealistic inputs or outputs?
16. Can the user select time steps that will track the effects with sufficient accuracy?