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Standard Practice for Developing Accelerated Tests to Aid Prediction of the Service Life of Building Components and Materials[1]

This standard is issued under the fixed designation E 632; 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 steps that should be followed in developing accelerated tests for predicting the service life of building components and materials. Although mathematical analyses needed for prediction of service life are not described in detail, either deterministic or probabilistic analysis may be used.

NOTE 1—Comparative testing is an alternative to the steps identified in this practice; it involves qualitative comparison of the results of a test component or material with the results of a similar control component or material when exposed to identical conditions.

1.2 This practice outlines a systematic approach to service life prediction, including the identification of needed information, the development of accelerated tests, the interpretation of data, and the reporting of results.

2. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *aging test*—a test in which building components or materials are subjected or exposed to factors believed to cause degradation.

2.1.2 *accelerated aging test*—an aging test in which the degradation of building components or materials is intentionally accelerated over that expected in service.

2.1.3 *biological degradation factor*—any of the group of degradation factors that are directly associated with living organisms, including microorganisms, fungi, and bacteria.

2.1.4 *building component*—an identifiable part of a building that may include a combination of building materials, such as a wall or a roof.

2.1.5 *building material*—an identifiable material that may be used in a building component, such as brick, concrete, metal, or lumber.

2.1.6 *critical performance characteristic(s)*—a property, or group of properties, of a building component or material that must be maintained above a certain minimum level if the component or material is not to lose its ability to perform its intended functions.

2.1.7 *degradation mechanism*—the sequence of chemical or physical changes, or both, that leads to detrimental changes in one or more properties of a building component or material when exposed to one or more degradation factors.

2.1.8 *degradation factor*—any of the group of external factors that adversely affect the performance of building components and materials, including weathering, biological, stress, incompatibility, and use factors.

2.1.9 *durability*—the capability of maintaining the serviceability of a product, component, assembly, or construction over a specified time.

2.1.10 *incompatibility factor*—any of the group of degradation factors that result from detrimental chemical and physical interactions between building components or materials.

2.1.11 *in-service test*—a test in which building components or materials are exposed to degradation factors under in-service conditions.

2.1.12 *performance criterion*—a quantitative statement of a level of performance for a selected performance characteristic of a component or material needed to ensure compliance with a performance requirement.

2.1.13 *performance requirement*—a qualitative statement of the performance required from a building component or material.

2.1.14 *predictive service life test*—a test, consisting of both a property measurement test and an aging test, that is used to predict the service life (or compare the relative durabilities) of building components or materials in a time period much less than the expected service life.

2.1.15 *property measurement test*—a test for measuring one or more properties of building components or materials.

2.1.16 *serviceability*—the capability of a building product, component, assembly, or construction to perform the function(s) for which it is designed and constructed.

2.1.17 *service life (of a building component or material)*—the period of time after installation during which all properties exceed the minimum acceptable values when routinely maintained.

[1] This practice is under the jurisdiction of ASTM Committee G-3 on Durability of Nonmetallic Materials and is the direct responsibility of Subcommittee G03.03 on Simulated and Controlled Environmental Tests.

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2.1.18 *stress factor*—any of the group of degradation factors that result from externally applied sustained or periodic loads.

2.1.19 *use factor*—any of the group of degradation factors that result from the design of the system, installation and maintenance procedures, normal wear and tear, and user abuse.

2.1.20 *weathering factor*—any of the group of degradation factors associated with the natural environment, including radiation, temperature, rain and other forms of water, freezing and thawing, normal air constituents, air contaminants, and wind.

3. Significance and Use

3.1 It is difficult to develop accelerated aging tests for use in predicting long-term in-service performance for the following reasons:

3.1.1 The degradation mechanisms of building materials are complex and seldom well understood,

3.1.2 The external factors that affect performance are numerous and difficult to quantify, so that many existing accelerated procedures do not include all factors of importance and those included seldom relate quantitatively to in-service exposure, and

3.1.3 The materials are often tested in configurations different from those used in-service.

3.2 Despite their shortcomings, these tests are used to provide needed durability or service life data. This practice should be useful to standards-setting groups and others who develop predictive service life tests that include accelerated aging tests.

4. Procedures

4.1 The recommended procedures for developing predictive service life tests that utilize accelerated aging are outlined in Fig. 1.

I—PROBLEM DEFINITION

5. Scope

5.1 The problem definition step covers what the test should do and the degradation factors that should be included in the aging test.

6. Definition of In-Service Performance Requirements and Criteria

6.1 The expected in-service performance requirements and criteria define the minimum acceptable levels of performance, or the degradation from the initial performance level. The performance levels should be based upon the functions the component or material shall perform under expected service conditions.

7. Characterization of the Component or Material and Identification of Degradation Mechanisms

7.1 Characterize the component or material to be evaluated as thoroughly as possible in terms of structure and composition, critical performance characteristics, properties that can serve as degradation indicators, the range and type of degradation factors to which it will be exposed, and all possible mechanisms by which the degradation factors induce changes in the properties.

7.1.1 *Identification of Critical Performance Characteristics and Properties*:

7.1.1.1 Properties to be used as indicators of degradation may be the same as the properties critical to performance. Fig. 2 is an example of a matrix that may be useful in identifying properties that can indicate degradation. Similar matrices can be developed for all building components and materials.

7.1.1.2 The vertical axis of the matrix includes an alphabetical letter for each element or material in the component. For example, a wall component may include an exterior coating (A), an exterior substrate (B), a structural member (C), insulation (D), an interior substrate (E), and an interior coating (F). The interfaces between each pair of materials can then be designated, for example, A-B, B-C, A-C, etc.

7.1.1.3 Consider the characteristics of each material and interface in the evaluation. The horizontal axis of Fig. 2 is labeled "Observable Changes." It lists changes in properties that may be useful as measures of degradation, such as observable changes in an exterior coating (chalking, crazing, cracking, checking, flaking, scaling, blistering, changes in color [Δ color], changes in gloss [Δ gloss], etc.).

7.1.2 *Identification of Type and Range of Degradation Factors*:

7.1.2.1 Identify the type and range of degradation factors to which the component or material will be exposed in service. A list of some degradation factors is presented in Table 1. This list is not exhaustive and other possible important factors should be sought in each specific case. The listed factors include weathering, biological, stress, incompatibility, and use factors.

7.1.2.2 Weathering factors include radiation, temperature (elevated, depressed, and cycles), water (solid, liquid, and vapor), normal air constituents, air contaminants (gases, mists, and particulates), freeze-thaw, and wind. Some quantitative information on weathering factors is available from published weather and climatological data. These data will usually be sufficient to indicate the ranges of intensities to which the component or material will be exposed in service.

7.1.2.3 Biological factors include microorganisms, fungi, and bacteria.

7.1.2.4 Stress factors consist of sustained stress, such as those developed by the weight of a building, and periodic stress, such as wind loads. The intensities of stress factors can be estimated from engineering calculations.

7.1.2.5 Chemical and physical incompatibility between dissimilar materials include corrosion caused by contact between dissimilar metals or stress caused by the different thermal expansion coefficients of rigidly connected dissimilar materials.

7.1.2.6 Use factors include the design of the system, installation and maintenance procedures, normal wear and tear and abuse.

7.1.2.7 It is difficult to quantify the in-service intensity of biological, incompatibility, and use factors, but upper limits

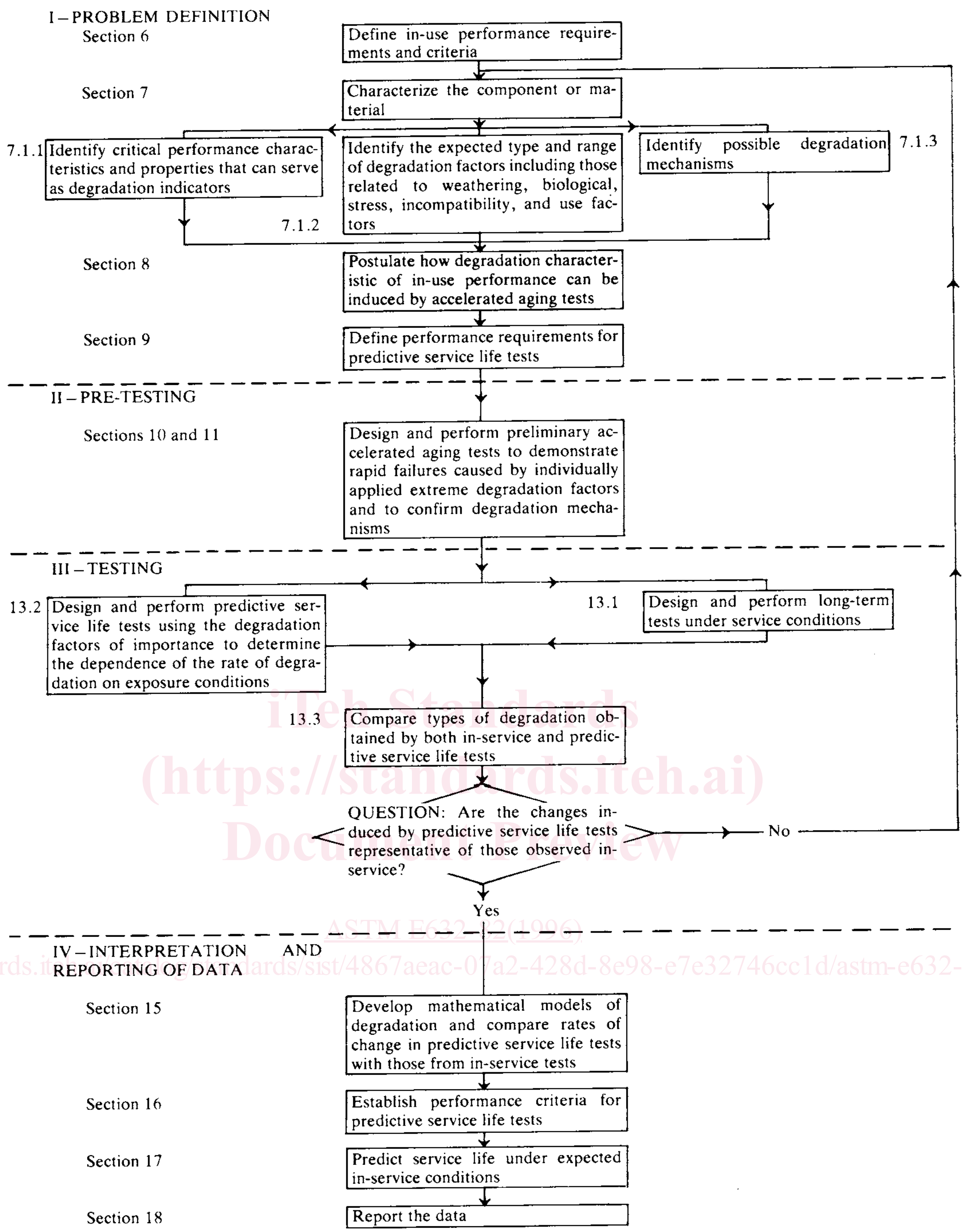

FIG. 1 Recommended Procedures for Developing Predictive Service Life Tests

within the normal range can usually be established by conservative judgment. Consider each of the degradation factors that may affect the performance of a building system component or material in designing predictive service life tests.

7.1.3 *Identification of Possible Degradation Mechanisms*—The final step of the characterization procedure is to identify all reasonably possible mechanisms by which the identified degradation factors induce changes in the properties of the component or material. The mechanisms can be defined at various levels. If much is known about the chemistry of the material(s), it may be possible to identify mechanisms based upon specific chemical reactions, such as hydrolysis and photo-oxidation. On the other hand, if little is known about the chemical reactions of the material, mechanisms may be defined in more general terms, for example, thermal decomposition, volatilization of constituents, constituent diffusion, corrosion, shrinking/swelling, etc. Limitations on the knowledge available will always exist. However, it is important to identify as many degradation mechanisms as possible. This reduces the possibility for error and improves the basis for establishing that mechanisms induced by the accelerated aging tests are representative of those that occur in service.